REPORT
OF
INVESTIGATION
OF
FOREIGN
LABORATORIES

F. G. BENEDICT

CARNEGIE INSTITUTION
OF WASHINGTON

NUTRITION LABORATORY
BOSTON

MAR. - JULY
1907

Archives

Confidential

REPORT OF A VISIT TO FOREIGN LABORATORIES

IN THE INTEREST OF THE

NUTRITION LABORATORY OF THE CARNEGIE INSTITUTION OF WASHINGTON.

Francis G. Benedict

Boston, Massachusetts, 1907.

LIST OF INSTITUTIONS VISITED.

Place	Name	Directors of laboratories and associates whose work was personally viewed.*	
Bonn	Tier-physiologisches Institut	Hagemann	3
	Physiological Laboratory, University of Bonn	Pflüger Schöndorff	43
Heidelberg	Physiologisches Institut	Cohnheim	44
Basel	I Medical Clinic	Jaquet (Staehelin)	51
	Pharmacological Laboratory, University of Basel	Jaquet	87
Berne	Physiological Institute (Hallerianum)	Kronecker Asher Gamgee	92
Munich	Physiological Institute, University of Munich	Voit Cremer Weinland Heilner	105
Vienna	Hospital Clinic	v. Noorden Falta Eppinger	119
	Prof. v. Noorden's Sanatorium	v. Noorden	131
	Physiological Institute	Exner v. Kriedel v. Fürth	136
	Hochschule f. Bodenkultur	Durig	138
Budapest	Agricultural Experiment Station	Tangl	147
	Medical School Laboratory	Tangl	162

---

* A name in brackets indicates that the person was not in the laboratory at the time of my visit but that the laboratory and experimental researches were shown me in detail by some associate.

St. Petersburg	Institute for Experimental Medicine	Pawlow	165
	Imperial Medical Academy	(Albitzsky) Kartaschefsky Awrorow	167
	(Woman's Medical College)	Likhachev	176
Helsingfors	Physiological Institute	Tigerstedt	178
Stockholm	Karolinska Institute (Laboratory of Physiology)	Johansson Landergren	198
	Laboratory of the Department of Health	Sondén	215
Copenhagen	Physiological Institute, University of Copenhagen	Bohr Krogh	222
	Laboratory of the Experiment Station	Henriques Hansen	225
Edinburgh	Laboratory of Physiology, University of Edinburgh	Schaefer Watson	228
Liverpool	School of Tropical Medicine	Ross	230
	Thompson Yates and Johnston Laboratories	Moore Roak Edie	231
Sheffield	University of Sheffield, Laboratory of Physiology	Macdonald	233
London	Guy's Hospital Medical School	Pembrey Haldane**	238
	Lister Institute	(Haldane) Cathcart	243
	St. Thomas's Hospital Medical School	Leathes	245
	London Hospital Medical College	Hill Greenwood	246
Lyons	University of Lyons, Physiological Laboratory	Dubois	250
	Ecole Nationale Vétérinaire	Arloing Maignon	251

**Prof. Haldane was lecturing at Guy's Hospital Medical School at the time of my visit.

Liége	University of Liége, Institute of Physiology	(Prof. Fredericq) Sainmont	257
Paris	Museum of Natural History	Chauveau Tissot Mansion	260
	Boucicault Hospital, Respiration Laboratory	Letulle Pompilian	284
	Marey Institute	Carvello Bull	286
	Pasteur Institute	Bertrand Abt	287
	Sorbonne, Chemical Laboratory	Dastre	290
Berlin	I Chemical Institute	Fischer Abderhalden Wrede	296
	Physikalisch-Technische Reichsanstalt	Lindeck (Jaeger)	306
	Imperial Health Bureau	(Rost) Franz	308
	Physiological Institute	Thierfelder Mueller	309
	Charité, Chemical Laboratory	Magnus-Levy	310
	Hygienisches Institut	Rubner Kisskalt	311
	Agricultural High School, Institute for Zootechny	Lehmann Voeltz Mueller	327
	Agricultural High School, Institute of Animal Physiology	Zuntz Loewy Oppenheim Caspari	335

Introduction.

While the experience obtained in the conduct of experiments with the respiration calorimeter and accessory apparatus in the chemical laboratory of Wesleyan University was invaluable in planning the general construction of the new Nutrition Laboratory, it was felt that the experience of the many European investigators in the construction of laboratories could well be considered in the equipment of the new Nutrition Laboratory. Arrangements were accordingly made so that the Director of the Nutrition Laboratory should go to Europe and make an extensive tour of the foreign laboratories in which research in nutrition was most actively prosecuted.

In making this tour, the first thought was to secure all possible suggestions regarding the interior equipment of laboratories especially fitted for investigations in metabolism, calorimetry, and physiological chemistry. The second important commission was to enable the Director to become acquainted and, so far as feasible, to become familiar with all existing forms of apparatus for studying gaseous exchange, animal calorimetry, and general methods of research into human and animal nutrition. Incidentally, he was to meet all the co-workers in nutrition, discuss with them the details of the construction of the laboratory and its equipment, and profit by their counsel. Opportunity was thus afforded for a general discussion of the whole project of the establishment of a nutrition laboratory, including a survey of the field for research.

In the report as here presented, care has been taken to discuss in detail all questions which bear upon any of the points outlined above. Much of the information and all of the destructive criticism of others were given me in confidence and hence is here regarded as only for private use. As most of the suggestions are of practical value, they are presented in detail, since this is the only complete report of this tour of inspection.

A large number of photographs were taken to illustrate the construction of laboratories, equipment and apparatus and copies of all of the photographs are included in this report. Shortly after the selection of the laboratory site in March, 1907, and after conference with the architects to enable the plans of the laboratory to be prepared, I proceeded directly to Bonn, Germany, where the first laboratory was visited.

In arranging this tour, it was highly desirable to visit each laboratory during the semester, when the Director was present in person. Owing to the differences in the lengths of the semesters and differences in the dates of beginning the summer term, it was found impossible to include all of the laboratories in one direct tour and hence it was necessary to retrace steps during a part of the trip. Some idea of the extent of the tour, the number of laboratories inspected, and the co-workers personally visited, may be obtained from the subjoined list. The tour lasted from March 20 to August 1st, 1907, or four and one-half months.

BONN, GERMANY.

Laboratory of the Tier-physiologisches Instituts

Prof. Oscar Hagemann, Director.

Several years ago Prof. Hagemann visited America prior to the construction of his new Institute and spent considerable time at Middletown, studying the construction of the respiration calorimeter. As it is his intention to enter the field of animal nutrition, with special reference to the calorimetry of the subject, his laboratory is primarily designed for the study of problems of animal nutrition similar to those we propose to study in the nutrition of man in the new Nutrition Laboratory.

In this laboratory investigations with the respiration calorimeter and with the calorimetric bomb are being carried out, with special reference to problems of animal physiology and especially to the physiological side of animal nutrition. Prof. Hagemann states that he intends to make his first experiments with men and then, having mastered the apparatus, to make a study of animals.

The calorimeter is installed in a specially constructed calorimeter house which adjoins the large Institute. The apparatus is of enormous size, permitting the study of oxen, horses, etc., and is sufficiently deep to allow the use of a tread-mill horse power which may be inclined so as to include the work of ascending a hill.

Present status of investigations in Prof. Hagemann's laboratory.--Through the Minister of Agriculture, Dr. Thiel, Prof. Hagemann has succeeded in obtaining large grants for the construction of this laboratory which is fully equipped with the most expensive and elaborate apparatus.

In spite of the expenditure of a great deal of time and money, the results thus far obtained with the Bonn apparatus are very unsatisfactory. In April, 1907, Prof. Hagemann was still testing the apparatus by burning known amounts of alcohol in the chamber and attempting to adjust manipulations so as to secure satisfactory results. No check experiments had been made in which the carbon dioxide had been satisfactorily determined. Obviously, the other factors which it is possible to measure with this apparatus, namely, heat and water vapor, had not been determined. Several tests in which heat had been developed inside of the apparatus by electricity had been made and satisfactory results obtained in experiments in which there was no ventilation.

Future outlook.--So far as I can see, there is not a very bright prospect for immediate success in determining all three factors, namely, carbon dioxide, water, and heat. The main criticisms are that the whole apparatus is extremely complicated and of immense size: there is a great inequality in the accuracy attempted in the measurements with the various parts: and the dearth of well trained assistants. An extremely well trained mechanician makes up in large part for the unsatisfactory assistance. Dr. Stein, the first assistant, was absent during my stay in Bonn and hence the problem of assistance during the conduct of experiments was temporarily even more complicated. It is difficult to see how satisfactory results in experiments with men, especially with men at rest, can be obtained with this apparatus in its present form. For resting experiments with men, a small sized chamber is highly desirable. The chamber at Bonn is about six or seven times the volume of the chamber at Middletown and for rest experiments, the Middletown chamber was distinctly too large for the best results.

One point of special interest to the Carnegie Institution of Washington is that Prof. Hagemann told me that he applied to the Institution for a grant to study the metabolism of man during fever. This ~~grant~~ application was wisely rejected for, in my judgment, the apparatus is far from being in a condition to warrant experiments on fever with men. It is interesting to note that Prof. Hagemann estimated that the problem could not be thoroughly studied without an appropriation of not less than $30,000.

Description of the apparatus.-- Designed primarily for experiments with large animals, one is impressed at first sight with the immense size of the respiration chamber, the cubical contents being not far from 35 cubic meters as against 5 cubic meters in the Middletown chamber. Prof. Hagemann has profited in construction by the experience of Prof. Armsby of State College, Penna., and his chamber resembles very strikingly that of Dr. Armsby. In the bottom of the inner chamber, provision is made for the introduction of a rolling treadmill. Structural iron is made use of to a considerable extent in constructing the framework to which the outer wooden walls are attached. An elaborate series of drawings of all of the details of the apparatus which were used in the construction have been prepared and Prof. Hagemann has had blue prints made from these drawings and a complete set is on file at the Nutrition Laboratory in Boston. Several general views of the calorimeter house and the Institute were also obtained.

As with the Middletown calorimeter, the inner wall is constructed of copper but very thick, i.e., two millimeters. Instead of attaching the copper wall to the wooden framework by strips of copper soldered to the copper and then screwed to the wood, Prof. Hagemann has, in my judgment, made a serious mistake by boring holes through the copper wall and screwing the copper directly to the wooden framework. This necessitates a large number of holes through the inner copper wall. Since it is absolutely essential that this inner copper wall should be wholly intact, with no opportunity for leakage of air through it, it can readily be seen that each of these screw heads must be very carefully covered with solder and absence of leaks demonstrated. It is a very difficult thing to prove the absence of leaks in a chamber as large as this.

Suggestion. In constructing the new chambers, I would suggest that we use copper flat headed bolts, the flat heads being soldered to the outer side of the copper wall and then these bolts attached to the wooden framework.

Bearing in mind that every precaution must be taken to avoid the leakage of air, it seems as if there were a large number of openings through the walls, including the main door through which the animal enters the chamber, openings for the introduction of food and drinking water, and for the removal of feces and urine. Obviously with an apparatus constructed for the use of animals, the cooperation of the subject cannot be taken advantage of as in the case men but it would appear that there is a larger number of openings through the walls than is absolutely necessary. The means to effect a tight closure of these openings are not above criticism. The large rear door is of a refrigerator construction, bevelled, and rubber strips about two millimeters thick are attached to the edge in such a way that the door is closely pressed against them when shut. A system of lever handles, such as is used on refrigerator doors, presses these doors firmly (?) into place. It is admittedly not absolutely tight. Prof. Hagemann has apparently taken great care in closing certain of the other apertures and yet has neglected others. On the whole, I should consider that it would be impossible with the present form of construction to make his apparatus air tight. In the large rear door, there is a small glass window and on one side (the side nearest the observer's table) there is a large window through which the observer can watch the movements of the animal or man.

Of especial value in connection with our new laboratory is the very intelligent use of angle iron and other structural iron in the construction of the framework of the apparatus, as well as the interior parts. This is well worth a careful study.

Fig. 1. Rear view showing the doors of the calorimeter in Prof. Hagemann's laboratory.

There are three doors. The inner one, shown in the photograph as closed, is covered with zinc. The black wires show the thermal junctions and the piping shows the cooling circuits for water. The lever handles used to close the door are not in position. Through the glass window is seen the alcohol lamp which is used for testing the calorimeter. The middle door, shown half closed, has likewise levers, thermal junctions, cooling pipes, and heating wires. The outer door shown open at the left has no special fittings upon it.

Water cooling circuits.--Water is used in the calorimeter for two purposes, for taking away the heat given off by the subject and for cooling the outer air spaces. A constant flow of water is necessary for the successful manipulation of the heat measuring appliances inside the calorimeter. This constant flow is not essential for cooling the outer air spaces. All the water in Prof. Hagemann's apparatus is brought from a constant level tank in the top of the building. One criticism of the piping is of interest. The water comes down from this tank and branches in a Y near the calorimeter. One arm of the Y is used to supply water for the interior of the calorimeter. The other arm of the Y is used to supply water for the cooling of the outer air spaces. Obviously, any change in the rate of flow in one arm of the Y, made necessary by the variations in the cooling of the outer air spaces, must cause a change in the rate of flow in the water of the other arm. It is highly important that all water used for the interior of the calorimeter should be taken from a constant supply and no water withdrawn from the pipe other than that used in the calorimeter chamber itself.

A practical point ~~worth copying~~ is the fact that all the water pipes running to the various cooling circuits surrounding the outer walls of the calorimeter are painted different colors. This is worth copying to a certain extent.

In piping the cooling circuits, Prof. Hagemann uses a divided circuit instead of a continuous circuit and assumes that the water entering one header passes equally through all the pipes running from this header. See Fig A. In fact, the attempt is

Fig. A

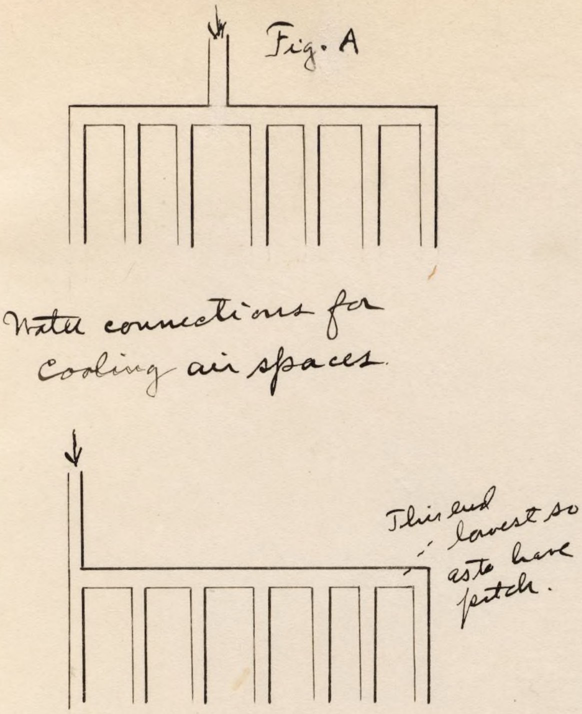


Fig. B.

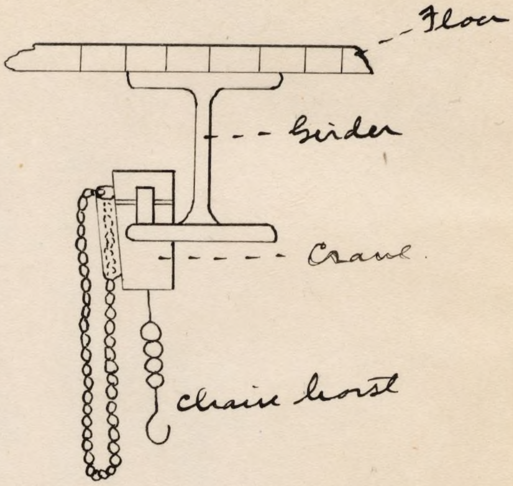


Fig. A. Scheme showing the connections for cooling the air spaces in the Hagemann calorimeter at Bonn.

In some instances the water is placed in the centre of the header and in some instances at the end. In the latter case, the further end is lowered so as to have a pitch and thus an attempt made to equalize the distribution of the water throughout the branches.

Fig. B. Scheme for girder and travelling crane in the Hagemann laboratory.

made to give the pipes a pitch so as to accomplish this result. The assistants are also cautioned to open these pipes for only a second or two at a time and thus endeavor to replace the warm water with cool. From a careful examination of the system of piping, it seems to me that it is not satisfactory and that the check valve employed at Middletown, whereby the water drains out of the pipe, is much better.

For cooling the water for the calorimeter chamber and the water used for cooling the outer air spaces, Prof. Hagemann has a parallel system of pipes, one containing brine from an ammonia machine and the other containing cooling water. For the experiments he has thus far made, this system has been very satisfactory. I doubt if it could be successfully applied to our work.

Zones for temperature measurements.--There are five zones about the calorimeter chamber in which the temperature measurements are taken and the apparatus for cooling or heating the various sections is sub-divided to control independently any one of these zones. There is a top section, bottom section, and three zones on the sides of the chamber, ~~outer~~ upper, middle, and lower. No special precautions are taken to sub-divide the air spaces next to the zinc wall with partitions.

One very practical point of great value is the distribution of the electrical resistance thermometers inside the chamber. Prof. Hagemann has three sets corresponding to his three zones, one near the top, one about half way up, and a third near the bottom. This distribution of theremometers would be of great value in studying the thermal gradient in our apparatus for oxygen. In such a study, however, it would be of prime importance to note the effect of the influence of the proximity of the body of the subject. In any event, a regular distribution of the thermometers, such as Prof. Hagemann has, is infinitely better than the irregular system used in the Middletown apparatus.

The electrical connections for the resistance thermometers, thermal junctions and heating circuits are likewise divided to correspond to the water circuits.

Thermal junctions.--A great deal of trouble has been experienced with the thermal junction wires slipping out of the grooves in the wood. Prof. Hagemann attributes this to the fact that they cannot get as good wood in Germany as we have in America. A duplicate set of thermal junctions is distributed all over the chamber as is done in Prof. Armsby's apparatus. It would appear to me that if the apparatus is constructed so as to be easily accessible in all parts, the duplicate set of thermal junctions is hardly necessary. If properly installed, the junctions should last indefinitely. If the junctions are continually giving trouble, the accuracy and solidity of the whole apparatus must be questioned. The junction system in Prof. Hagemann's apparatus is certainly open to grave criticism. The junctions have been patched, painted and repaired ad infinitum and look very unsatisfactory. Judging from his experience, the utmost care should be taken in the construction and installation of all thermal junctions in an apparatus of this kind.

Heat measuring appliances.--The temperatures of the ingoing and outcoming water current are measured by two large mercurial thermometers made by Geissler and calibrated by the Physikalische Technische Reichsanstalt. In construction they are very similar to the ordinary Beckmann thermometer and are bent at right angles like the bent thermometers used in the Middletown calorimeter. They have the column calibration of a milk scale and the mercurial column is in a fine capillary tube inside of a glass envelope. They are very long and fragile and very hard to transport, although Prof. Hagemann has had two sets shipped to Berlin and returned without being broken. Special transportation cases were made for them. They were graduated from -1.0° to +20.0° in 1/100th degrees.

The method of reading the thermometers is very ingenious and worth copying. Two telescopes are mounted on a sliding rod. These are adjusted with two mirrors so that there is a maximum illumination of the mercurial column, a great convenience in reading. Naturally, the use of the telescope also avoids the errors of parallax. The only objection is that the telescope must be focused each time by each new observer.

Fig. 2. Details of thermometer and telescope adjustment.

The thermometers are mounted so that the scale is parallel to the front wall of the calorimeter but the two mirrors are adjusted to reflect the image into the eyepiece of the telescope. The lower part of the thermometer is covered with rubber tubing and one protecting box is removed to show where it enters the chamber. At the left of the photograph are shown the electrical resistances for heating the air spaces; on the right, the millimeter scale in the galvanometer hood.

Prof. Hagemann has likewise attempted to measure the differences in temperature of the water current by resistance thermometers. The water at Bonn is extremely unsatisfactory, containing a great deal of sediment and with the thermometers he has tried, ~~it~~ the thermometer soon clogs up and becomes short-circuited.

Suggestion. The new platinum resistance thermometers of Heraeus, enclosed in fused quartz tubes, should be especially advantageous for measuring the temperatures of the ingoing and outcoming water current. According to Wrede in Berlin, these resistance thermometers are extremely sensitive. Their use is to be thoroughly investigated in the construction of our new chambers.

Temperature of air current.--In order to measure the difference in temperature between the ingoing and outcoming air current, Prof. Hagemann uses both thermal junctions and resistance thermometers but the latter were, at the time of my visit, out of order. He feels very dissatisfied with the thermal junctions. Very long junctions are used and Prof. Hagemann feels convinced that there was heat conducted along the junction wires through the vestibule and hence there was an error. His present system is very complicated and I fail to see that it is any more effective than that we were using at Middletown.

I suggested a scheme we have in mind for the new apparatus of having the ingoing air ~~go in~~ enter in a tube encircling the outcoming air and thus use the outcoming air as a regulator of the temperature of the ingoing air.

For regulating the temperature of the air, Prof. Hagemann has a large water cooling tank such as was used in the Middletown apparatus, very much enlarged. He also has an electrical heating apparatus for heating the air. When the cooling water is very cold, as in winter, he has an arrangement whereby the water entering the large temperature regulator may be warmed so that the cooling effect may not be too great. This apparatus is based on the principle of the electric heater but at the time of my visit had never been used. It seems to me unnecessary for our use. Prof. Hagemann is very anxious to avoid the use of gas for heating in any part of his laboratory as he is fearful of obtaining unburned gases in the air. The large quantities of marsh gas given off by ruminants makes the problem much more complicated with animals than with men and hence he is perfectly right in his efforts to avoid any use of gas heating in appatus used in the calorimeter chamber.

Water meters.--The water meter used in this laboratory is very much like that in Prof. Armsby's laboratory, an enlargement of the old Middletown water meter. He assumes that all the water is measured at 15° C and the meter is calibrated accordingly. A millimeter scale is fastened to the back of the water gauge tube and the level of the water is read or estimated to millimeters. Each millimeter equals about 126 cc.

An interesting addition is the introduction of a small sized water meter, such as is used in houses, in the water current leaving the respiration chamber. In Prof. Hagemann's apparatus, this is introduced after the water leaves the chamber and before it enters the regular large meter. It would be better to introduce it before the water enters the chamber, thus eliminating any resistance.

This apparatus was designed to be a rough check on the larger meter but Prof. Hagemann finds that it fills with mud and does not work satisfactorily. The adoption of some such plan in our apparatus might be worth considering.

The valves on the large water meter are thrown by hand. Each can holds about 100 liters and a very ingenious electrical device tells when the cans are full and also when the cans are empty. See Fig C A continuously ringing bell is connected with the valve in such a way that it continues to ring until the valve is thrown, deflecting the water current to the second can when filling. It also rings when the can is empty until the valve is closed again. An ordinary electric annunciator board, situated over the observer's table is used with great success to indicate the filling of the meters and other electrical contacts. This is worth incorporating in our work. The electrical alarm on the float of the water meter is subject to the uncertainty of all such contacts and the question always remains as to how much reliance can be placed upon electrical contacts of this nature.

Suggestion. The use of the vacuum mercury switch that I saw in Durig's laboratory in Vienna may be advantageously employed for all electrical contacts, since with this switch there is no danger of oxidation of the surface of the mercury and thereby better contacts are obtained.

Fig. C.

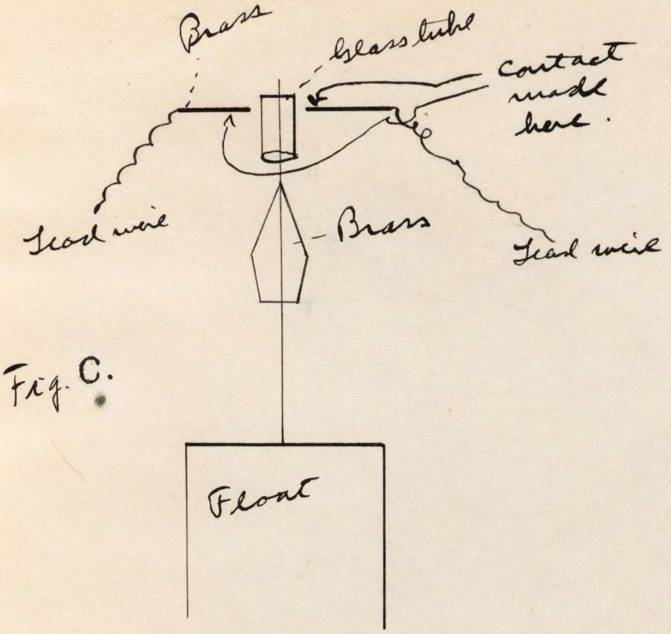


Fig. D.

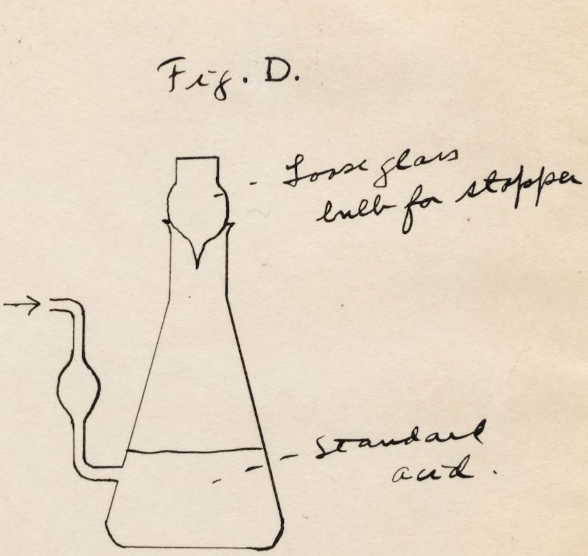


Fig. C. Scheme for closing the electric contact by water float in the Hagemann laboratory.

A brass cone is soldered to a wire at the upper end of the float. As the float rises, the cone is wedged between two brass pieces and the contact closed. A piece of glass tubing over the wire prevents electrical contact when the float is lowered.

Fig. D. Vessel for absorption of ammonia in the Hagemann laboratory.

The standard acid is placed in the bulb and the ammonia distilled through the side inlet.

Observer's table.--The observer's table has many interesting electrical connections and shows a great deal of study and care. Most of the apparatus was obtained from Hartman & Braun in Frankfort, and while Prof. Hagemann had some modifications made, doubtless most of the apparatus is regularly listed. A sliding contact key or switch is used for most of the thermal junction circuits. Difficulty was experienced in the contacts and hence Prof. Hagemann has used a connection made through five flat springs pressing against a platinum face on each contact point of the switch. This is of special construction. Two such switches are employed, one for the inner circuit, namely, for the thermal junctions between the copper and the zinc, and the other for the connection between the two air spaces. For measuring the electromotive force between the two elements, the connection is made with a milli-voltmeter ~~inside~~ instead of the galvanometer. This instrument was also furnished by Hartman & Braun. The use of this voltmeter is certainly worth inquiring into for our investigations.

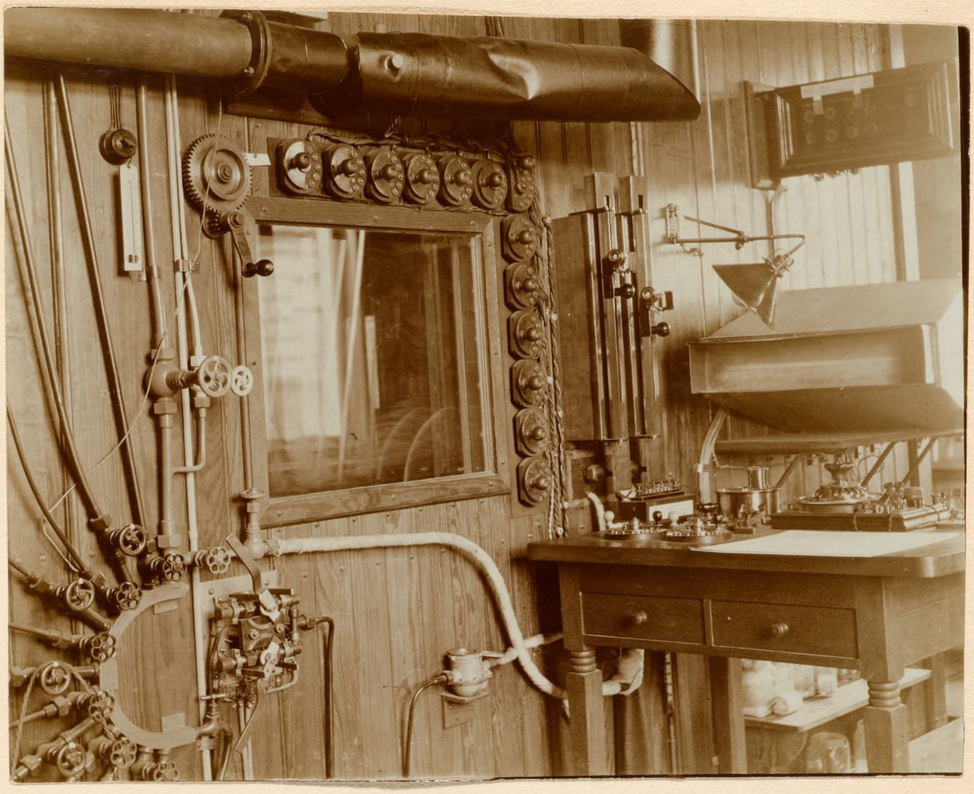


Fig. 3. Details of observer's table, thermometers, electrical resistances, and water cooling pipes.

At the upper right hand corner is seen the electric annunciator, below the galvanometer hood, and on the top of the observer's table are the Wheatstone bridge, milli-voltmeter and electrical contacts. Immediately below the window is seen the small water meter in the water cooling circuit. The black pipe in the top of the photograph is the air pipe for the incoming and outgoing air, the air entering at the right hand side. The gear wheels with handle at the left of the window are for raising and lowering the shields inside the chambe At the lower left hand side of the window are two lever valves used for deflecting the air current in the analysis of samples of air. The horseshoe shaped casting at the left, with numerous valves, is used for the distribution of cool water to the outer circuits.

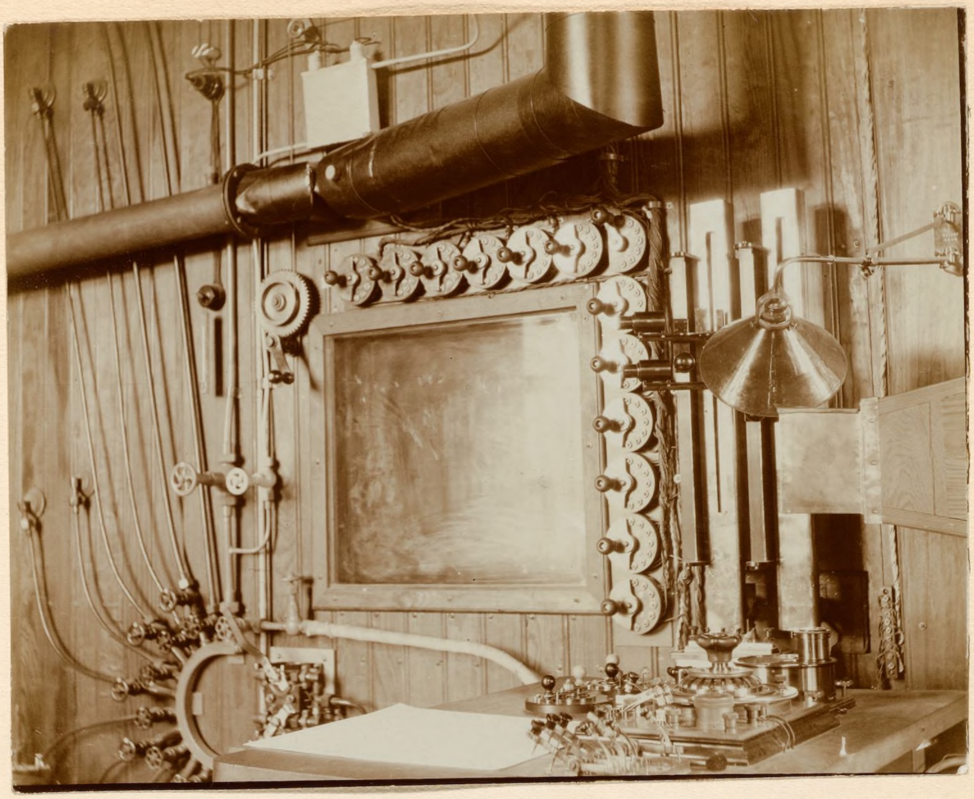


Fig. 4. View of observer's table, window, and electrical resistances.

In the immediate foreground are shown the mercury contact keys for the resistance thermometers. The Wheatstone bridge and millivoltmeter are shown at the right on the top of the table.

The temperature measurements are all made by a Wheatstone bridge shown in Hartman & Braun's catalogue and likewise shown in the centre of the photograph, Figure 5.

Fig. 5. Details of apparatus on observer's table.

At the right are the mercury contact keys for use with the Wheatstone bridge. The Wheatstone bridge is in the centre of the table; at the left of the bridge is the milli-voltmeter. Two keys near the front edge of the table are for the thermal junctions. The instrument between the milli-voltmeter and these two keys is a compensating connection of especial use in balancing the thermal junction circuits. The details of these connections I am unfamiliar with. A resistance box at the left is used for inserting the large resistance in the galvanometer circuit.

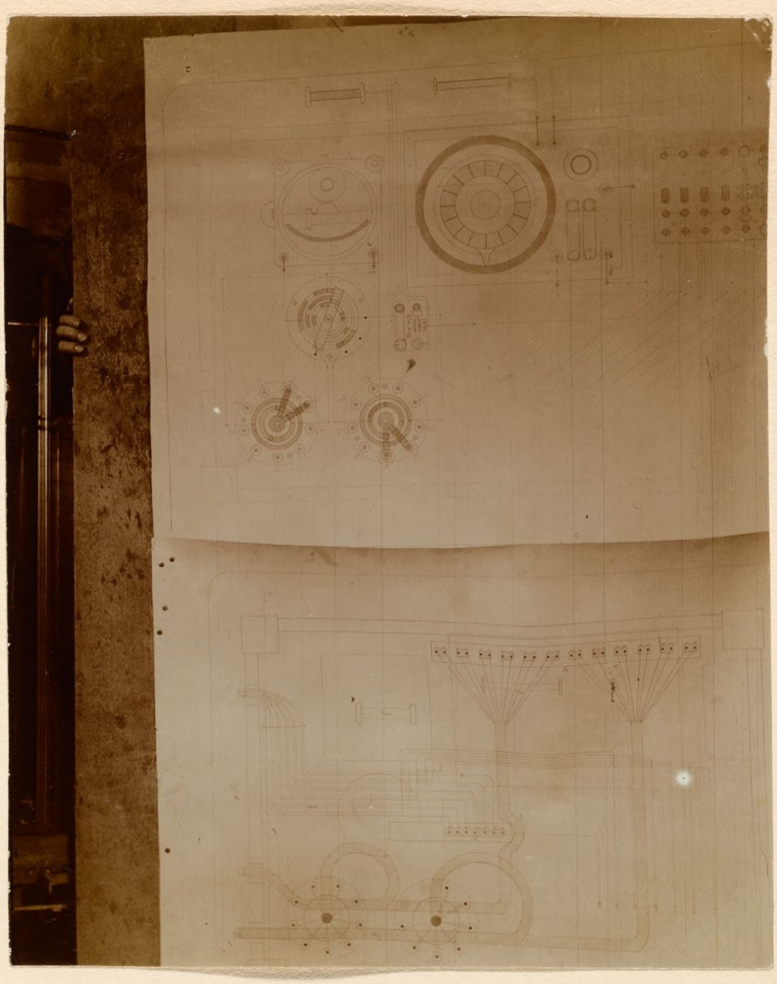
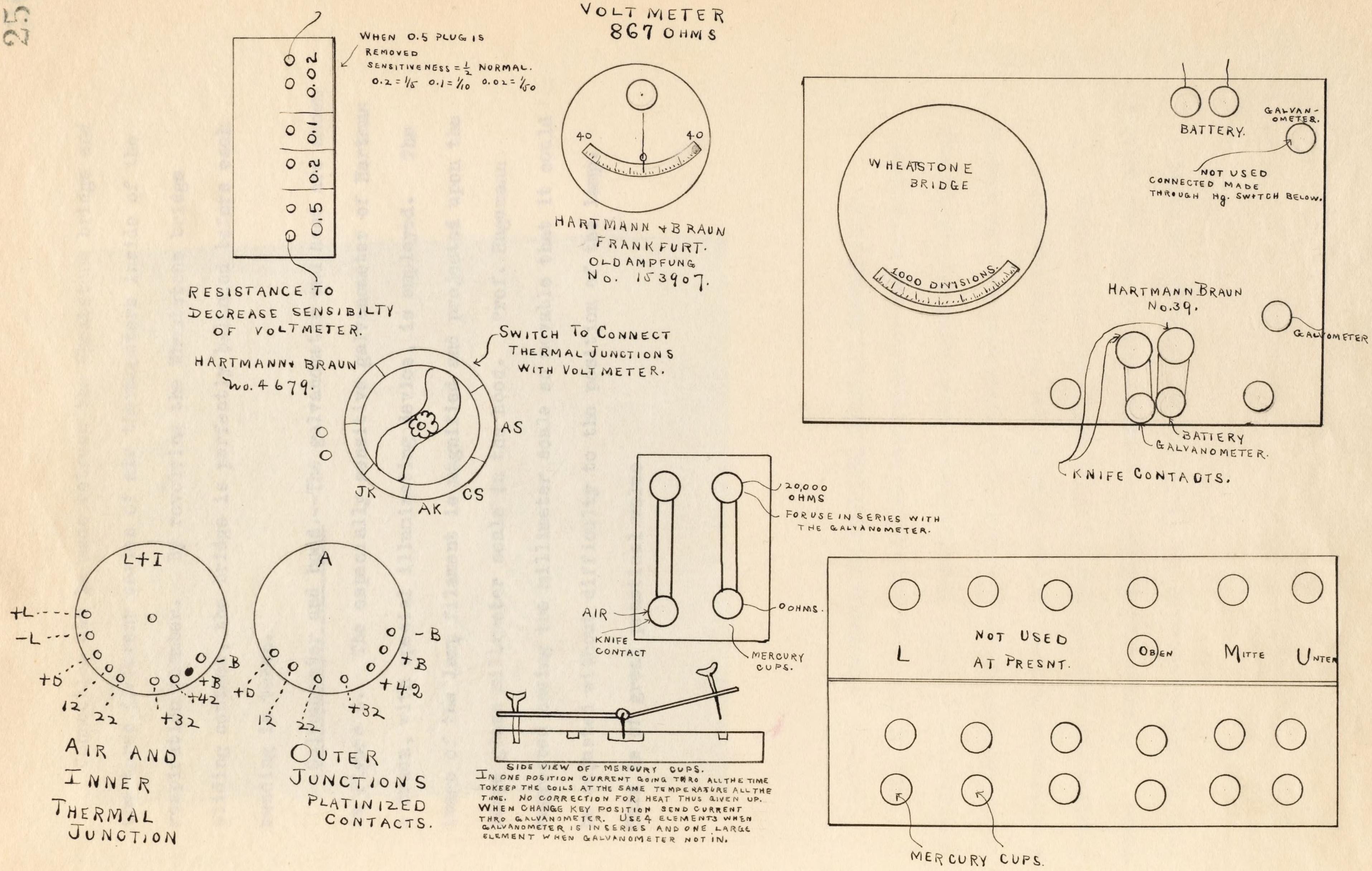


Fig. 5 a. Schematic drawings of electrical connections on the observer's table.

The position of the milli-voltmeter, Wheatstone bridge and circular keys for the thermal junction circuits are easily recognized in the upper diagram. In the lower diagram, the cables running to the two keys for the thermal junction circuits are easily placed.



IN ONE POSITION CURRENT GOING THRO ALL THE TIME TO KEEP THE COILS AT THE SAME TEMPERATURE ALL THE TIME. NO CORRECTION FOR HEAT THUS GIVEN UP. WHEN CHANGE KEY POSITION SEND CURRENT THRO GALVANOMETER. USE 4 ELEMENTS WHEN GALVANOMETER IS IN SERIES AND ONE LARGE ELEMENT WHEN GALVANOMETER NOT IN.

Fig. E. Diagram of observer's table in the Hagemann laboratory.

Connection can be made between the Wheatstone bridge and the three different series of air thermometers inside of the respiration chamber. By revolving the Wheatstone bridge sliding contact, the bridge is perfectly balanced before each reading is taken.

Galvanometer and hodd.--The galvanometer and hood are shown in Figure 6. The especially sensitive galvanometer of Hartman & Braun, with special illuminating device, is employed. The image of the lamp filament is magnified and projected upon the large glass millimeter scale in the hood. Prof. Hagemann suggested having the millimeter scale so movable that it could be adjusted without difficulty to the position of the lamp. This is of great practical value.

Fig. 6. Galvanometer hood and electric annunciator.

Beneath the hood are various batteries for the resistance thermometers. Prof. Hagemann uses a continuous current through these thermometers in his temperature measurements. By keeping a continuous current through them, he has the heat evolution constant and does not have to delay until the wires become warm. (I cannot understand the significance of this and believe that the depreciation of the batteries may introduce an error.)

Sensitiveness of electrical instruments.--I had no opportunity to find out the sensitiveness of either the galvanometer or the voltmeter but from the calibration of the air thermometers, I should judge that they were unable to measure temperature differences less than 1/100 of 1°, hence for practical purposes, they were no better than the Middletown arrangement. The possibility of using a milli-voltmeter should be thoroughly discussed in connection with the new apparatus.

Alcohol lamp.--The alcohol lamp used is the form commonly used in Germany to burn denatured alcohol. Prof. Hagemann's mechanician has made a somewhat different font but on close examination, there was very little that would help us in any way. It was necessary to weight the font both before and after the experiment and note the time at the beginning of each experiment, and the result is that each alcohol check experiment is accompanied by a great deal of unnecessary labor and sub-division into periods is practically out of the question. This form of lamp vaporizes the alcohol and uses the gas to heat a small Welsbach mantle. It burns about twice as much alcohol per hour as the lamp used in Middletown.

Prof. Hagemann thinks that there are very considerable amounts of unoxidized gases in the products of combustion of alcohol. He has found tremendous amounts of unoxidized gases in ordinary air but on close examination of the methods of analysis, I am inclined to question these as the basis of the assertion that there are large amounts of unoxidized gases in ordinary air.

Travelling crane system.--A very practical point in the use, construction and repair of apparatus of this nature is the system of travelling cranes that Prof. Hagemann has installed in his laboratory. By means of girders fastened to the top of the room and a crane, the removal of panels or any heavy portions of the calorimeter is readily facilitated. The details of the crane are shown in Figure 7. and Fig. B.

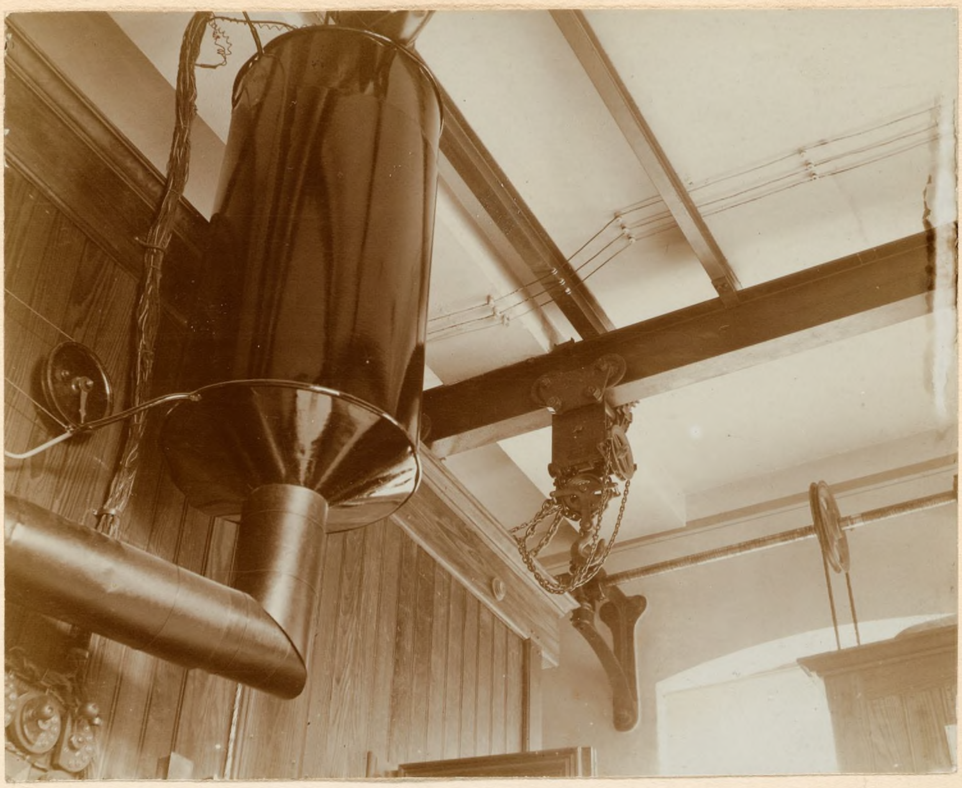


Fig. 7. Travelling cranes for handling heavy parts of apparatus and air pre-cooling device.

The top of the electric annunciator is shown at the bottom of the photograph.

The cranes are provided with chain hoists and run on beams and girders overhead. They are used principally for removing large panels, lifting platforms, and during construction they were of very great value in handling wooden joists, iron construction of parts, etc. With the chain hoist and friction clutch or catch to hold up the weight until tripped, the largest pieces could be handled most easily. Provision has been made for installing this system in the new laboratory.

Meter pump.--A meter pump, the precise counterpart of that used by Prof. Armsby at State College and by Prof. Tangl in Buda Pesth, is used in Prof. Hagemann's laboratory. It is enclosed in a wooden house with glass doors. It is based upon the Blakeslee principle but was constructed by Hart of Poughkeepsie. In both Bonn and Buda Pesth, its construction is severely criticised as the valves are not tight.

Air pump.--For drawing the samples of air through the various U-tubes for analysis, a partial vacuum was needed. Prof. Hagemann has installed for this purpose a Geyrk vacuum pump. This is a very expensive pump but it runs in oil and requires no attention. There is an independent motor driven with an enclosed worm gear. The motor is almost noiseless and there is no sound save for the clicking of the valves. It is also piped so as to compress the air. The compressed air is used for the stirring of the brine in the water cooler.

Of especial interest were the motor transmission and the worm gear reduction which may be of value in our new unit respiration apparatus with an independent motor.

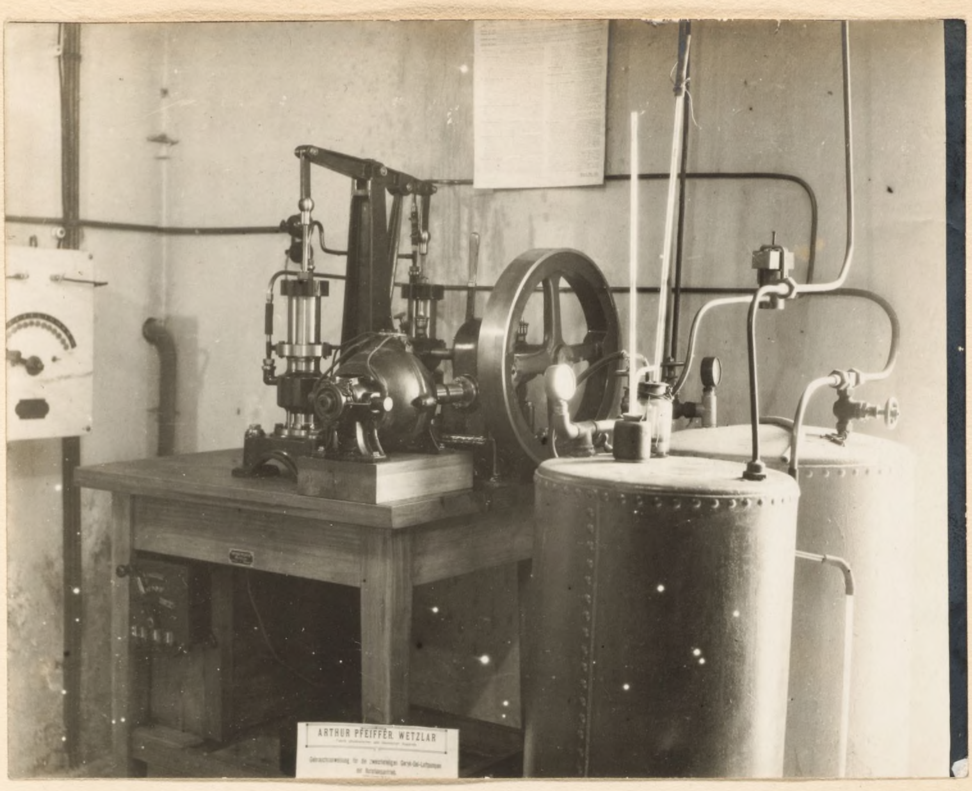


Fig. 8. Geyrk air pump for drawing air samples through U-tubes and for compressed air.

A vacuum is maintained in one and compressed air in the other of the two cylinders at the right.

Analysis of air.--Prof. Hagemann has performed a great many experiments in attempting to get the unburned gases in the air. This of course is of especial value in experiments with ruminants and must positively be provided for in any system of air analysis. As at present arramged, the air is delivered from the meter pump into a sample collecting pan provided with a rubber top. From this pan it is sucked by a Geyrk pump through a series of U-tubes, the first containing sulphuric acid, the second, phosphorus pentoxide, then three ~~common plain~~ U-tubes, containing soda lime, then a pair like the first two containing sulphuric acid and phosphorus pentoxide respectively. The system of air analysis tubes is shown in Figure 9.

Fig. 9. Air analysis tubes.

The air passes from right to left, passing through successively sulphuric acid, phosphorus pentoxide, soda lime, sulphuric acid and phosphorus pentoxide.

Fig. 9. <u>Air analysis tubes.</u>

The air passes from right to left, passing through successively sulphuric acid, phosphorus pentoxide, soda lime, sulphuric acid and phosphorus pentoxide.

After leaving the U-tubes and having been deprived of its moisture and carbonic acid, the air is caused to pass through a series of combustion tubes heated by an electrical furnace and filled with platinized kaolin. In its passage through this furnace, it is considered that any unburned gases, such as marsh gas from the intestinal tract of ruminants, will be completely oxidized and accordingly the air is again passed through a set of U-tubes arranged as above described. It finally passes into an Elster dry gas meter which simply acts as a check on the number of samples taken by the meter pump. The air is analyzed in duplicate and there are therefore two samples of air coming from the pans. The air entering the respiration chamber is similarly analyzed. The amount of sample taken is measured not by the meter pump but by the air passing through the Elster meter. As connected at Bonn, I think there is a chance for error since the air must be under considerable diminished pressure to draw it through so many U-tubes, hence when measured in the Elster gas meter, it may well be considered subject to considerable error.

Combustion room.--In the basement of the building, the electric combustion furnace was placed and the U-tubes through which the air is drawn after passing through the combustion furnaces. The details are shown in Figure 10.

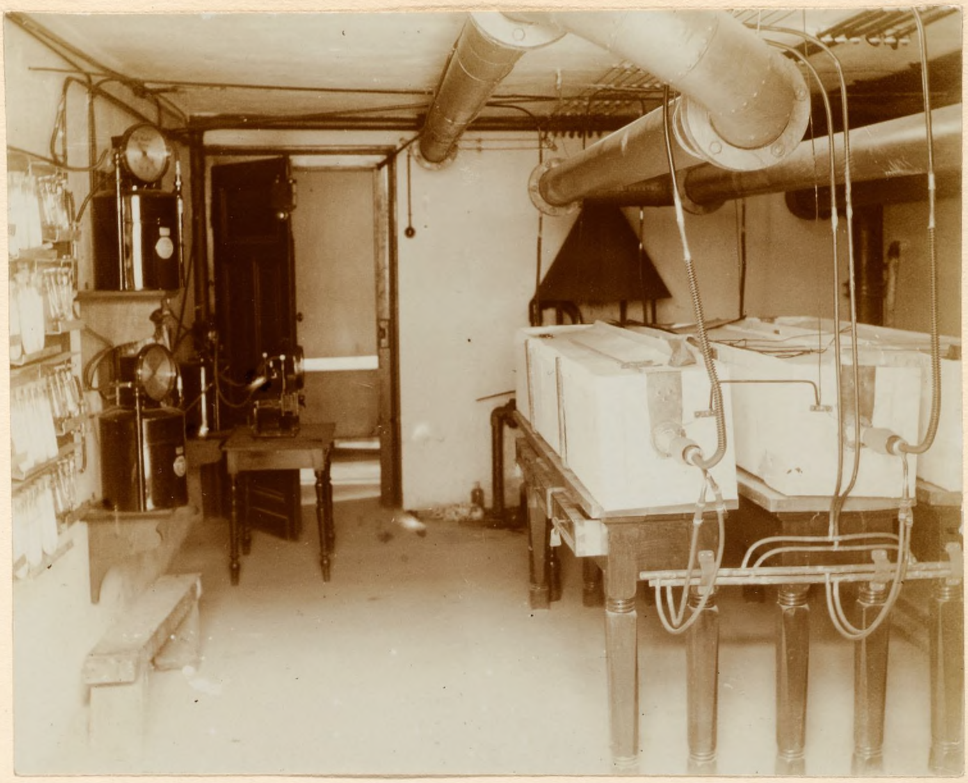


Fig. 10. Combustion furnaces, U-tubes, and Elster gas meter.

Three combustion furnaces at the right containing tubes filled with platinized kaolin. At the left may be seen the set of U-tubes through which the air passes after leaving the combustion tubes, also the Elster gas meter.

Absorption of moisture in U-tubes.--I discussed at considerable length with Prof. Hagemann the use of phosphorus pentoxide. He uses sulphuric acid of about 92 per cent H_2SO_4 as he maintains that the concentrated acid dissociates and gives off sulphur trioxide. He claims that the 92 per cent will absorb water just as thoroughly as the concentrated. The acid and also the soda lime are changed in each U-tube after each period. Air is drawn through the U-tubes at the rate of 3 to 4 liters per minute. The tubes are made to order and are a modified form of a U-tube he found in an apparatus factory. The phosphorus pentoxide is placed in exactly the same kind of a tube as is used for the sulphuric acid. Prof. Hagemann uses a glass case with rubber gloves sealed into the walls so that the tubes can be filled with the phosphorus pentoxide without its deliquescing. The sides of the case are glass and dishes of sulphuric acid are placed inside to dry the air. The phosphorus pentoxide tubes are placed in a rack in the case, allowed to stand over night, and are filled the next day, a glass spoon being used. Prof. Hagemann lays great stress on the fact that if any water is taken up by the phosphorus pentoxide, one can see it immediately, while with sulphuric acid, there is no such guarantee of efficiency. When I pointed out that with the form of soda lime he was using, he has no guarantee of complete absorption of carbon dioxide, he maintained that he changed all three tubes every period and put in fresh reagent.

This brings up the old discussion as to the degree of desiccation to which this air should be subjected. One may say that there are various degrees of desiccation. Fused calcium chloride will dry air to a certain degree of dryness; sulphuric acid will certainly dry it somewhat more; and phosphorus pentoxide will remove a greater degree of the water vapor than sulphuric acid. Yet it is true that boron tri-fluoride will desiccate air to an even greater degree than phosphorus pentoxide. It is, then, a question of the different levels of the desiccation. I fail to see why the sulphuric acid level is not as practical for an investigation of this nature as is the phosphorus pentoxide level. Even admitting the fact that Prof. Hagemann must determine the small amounts of moisture resulting from the combustion of marsh gas, etc., I fail to see why the sulphuric acid level is not practical.

A special analytical balance for weighing U-tubes.---A special analytical balance for weighing U-tubes, constructed by H. F. Kuhlmann of Hamburg, was used in Prof. Hagemann's laboratory. All five U-tubes are weighed at once by using a counterpoise~~s~~. This apparatus was modified by Prof. Hagemann. While it is a very fine piece of mechanism and although Prof. Hagemann is very enthusiastic regarding its use, I fail to see any special reason for our adopting it at present. The balance is shown in Fig. 11.

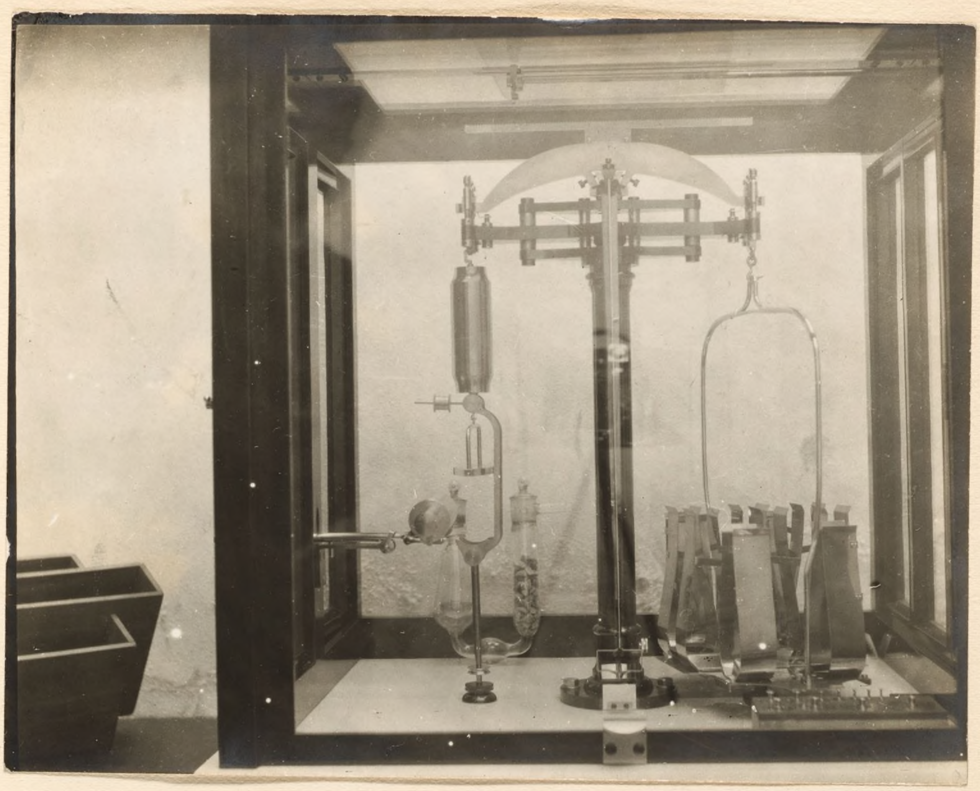


Fig. 11. Special balance for weighing U-tubes.

On the right hand pan, five U-tubes can be suspended at once, namely, one with sulphuric acid, one with phosphorus pentoxide, and three with soda lime. One of the U-tubes is shown in detail in the rear of the balance case. The greater proportion of the weight is taken up by the counterpoise which can be added to the left hand beam of the balance.

Device for filling sulphuric acid tubes.--Prof. Hagemann has made use of an automatic pipette for delivering the requisite amount of sulphuric acid for filling his U-tubes. The U-tubes are constructed with very short arms. In one arm is free sulphuric acid and in the other pumice stone drenched with sulphuric acid. The air must bubble through sulphuric acid and while this has a great advantage in determining the flow, it has the great disadvantage of increasing the resistance. The use of an automatic pipette for filling the sulphuric acid tubes may be worth introducing into our laboratory.

Rheostats.--As was the case with the apparatus in Prof. Armsby's laboratory and at Middletown, Prof. Hagemann uses a series of electric lamps for resistance in heating circuits. The lamps are placed in banks up against the wall and the rheostat consists of a series of contact circular switches grouped around the window in the side of the calorimeter nearest the observer's table. See Figs. 3 and 4. This arrangement does not seem to me particularly valuable.

For the most part the observers stand up, finding it easier to work in this position than while sitting. The observers work in four-hour shifts, four hours at the table and four hours at the U-tubes, so as to change the nature of the work. As yet, Prof. Hagemann has had no very long experiments, so no routine has been developed.

Watt meter in electrical check tests.--Prof. Hagemann uses a watt meter furnishing a direct reading of watts. It was marked "Elektricitätszahler No. 67797, System Aron, 50 amp., 130 volts" for direct current. This he has found very satisfactory and he was contented with its accuracy. Subsequent discussion of the accuracy of this watt meter at the other laboratories I visited has led me to believe that one cannot rely upon it for accurate work.

Incidental apparatus.--A Zuntz apparatus for experiments on sheep is in constant use. Prof. Hagemann has a mask that he maintains is air tight. Unfortunately no experiments were being made at the time I was there. He uses phosphorus to absorb the oxygen and employs a wet Elster gas meter in connection with this apparatus.

Desk tops.--Prof. Hagemann uses lead for the tops of many desks but recommends strongly the lava tops which have just been installed in Prof. Heymann's laboratory in Ghent.

Sand bath dishes.--Enamelled iron sand bath dishes are used and copper filings are placed in the bottom instead of sand as the metal conducts heat better and distributes it more evenly.

Blow pipe table.--This has a lead top which is very practical as the laying down of the hot glass tubes always burns a wood top.

Kjeldahl apparatus.--Prof. Hagemann uses very large sized digestion flasks and a special automatic measuring pipette for measuring the concentrated sulphuric acid such as was used for the U-tubes. No special pipette was used for strong caustic soda but a graduated ~~pipette~~ as is our custom.

He titrates sulphuric acid against caustic soda. Each cubic centimeter of acid corresponds exactly to .003 grams of nitrogen. He distills hot and is sure no acid is lost. He uses a special form of collecting vessel with bulbs at the side designed by himself See Fig. D. A loose fitting stopper or plug prevents the acid from bubbling out. Methyl orange or better coralin is used as an indicator. He uses automatic pipettes for measuring ~~off~~ the standard sulphuric acid solution.

Photographs of Prof. Armsby's apparatus.--When in America Prof. Hagemann had taken a large series of photographs of Prof. Armsby's apparatus at State College. Arrangements were made with him whereby a complete collection of photographs from these negatives was obtained. They are now on file in the Nutrition Laboratory in Boston.

General criticism of Prof. Hagemann's laboratory.--The apparatus and methods are in every detail far too complicated. Prof. Hagemann has sought to obtain the highest degree of accuracy in certain manipulations with an apparent utter disregard to the influence of other factors. No expense has been spared in equipping the laboratory and in many cases large sums of money were spent with but little return. The installation of a very expensive storage battery for securing a regular electric current to be used for warming air currents is perhaps the most striking illustration of this point.

Prof. Hagemann's natural ingenuity and mechanical ability has led him to attempt to modify almost every piece of apparatus of whatever construction in use in connection with his laboratory.

Inasmuch as this laboratory is the most central one in Europe in which calorimeter experiments similar to those carried on in America are contemplated, it has been visited by a number of European specialists and I found in my subsequent visits to other laboratories that it was well known. Unfortunately with a very large majority of European physiologists the laboratory, and still more unfortunately, the apparatus itself was not well thought of. The enormous expense that Prof. Hagemann had been to stood in the way of the apparatus being adopted in other laboratories and, indeed, seemed to preclude in the minds of other physiologists the possibility of ever introducing calorimetric work in physiological laboratories in general. Fortunately I was able to counteract to some extent the unfortunate impression made by the lack of success thus far attained with the Hagemann apparatus and thereby somewhat clarify the situation in the minds of other physiologists. There is no reason why an apparatus of the size for man should not be installed complete for between $2000 and $2500. On the other hand, Prof. Hagemann's equipment was stated to me by several Europeans to have cost nearly $65,000 to $80,000. This of course includes his Calorimeter building.

Physiological Laboratory of the University of Bonn.

Professor E. Pflüger, Director.

The historical interest connected with this laboratory warranted a visit to it and although Prof. Pflüger was about to leave, he introduced me to Dr. Schöndorff who took me through the laboratory. Prof. Pflüger has for many years been especially interested in the question of glycogen in the body and consequently many of the researches in this laboratory have been upon this subject.

Of special interest, aside from the experiments in progress, was the large collection of historic apparatus which unfortunately is not as satisfactorily exhibited as it should be. I think it would be worth while to provide for the preservation of apparatus during its development in the new Nutrition Laboratory for exhibition in future years. Many valuable suggestions can often be obtained by inspecting older apparatus.

A large number of other physiological chemists do not hold to Prof. Pflüger's views regarding glycogen katabolism and, indeed, his methods of analysis are seriously questioned. It nevertheless remains a fact that the chemical work done by Prof. Pflüger has stimulated, perhaps more than any other work done, our knowledge regarding glycogen.

HEIDELBERG, GERMANY.

Physiologisches Institut--Professor Otto Cohnheim.

The laboratory of Physiology in Heidelberg is old and hence does not present many new features in equipment, in spite of the great amount of remarkable work that has been done here by Prof. Kossel and his associates. Of especial interest ix a plan of Prof. Kossel's to furnish gas to desks by having an upright piece with several cocks on it connected with the main supply on the desk through the plug of a large plug valve. The pipe may then be turned up against the shelves on the desks and thereby leave the whole length of the desks clear. This is of especial value in fitting up the gas supply of hoods where the space is limited. On this movable arm or pipe, there may be three or four places to attach tubes for Bunsen burners. The pipe is about 3/4 inch, regular size. I think the cocks or plug valves through which the gas is taken from the main supply were made especially to order.

Table tops.--In the hoods, sheet lead is used;on the main desk, wood is used with a central gutter of heavy sheet lead between tables facing each other. Thus a drain goes down the whole length of the desk to the sink at the end. The end of the lead trough is so shaped that the water does not run back and wet the edge of the sink. This is of especial value in conducting the water away from distillations.

Kossel's cutting machine.--For comminuting material, especially in obtaining muscle juice, Prof. Kossel has a very ingenious machine in which the material, after being frozen with carbon dioxide, is placed in such a position that a revolving set of knives shaves it off as does the microtome. Prof. Cohnheim says that after such treatment, there is no microscopic structure left. A new machine, with modifications, is being built by F. Runne in Rohrbach near Heidelberg. The original apparatus was described by Erof. Kossel in the Zeit. f. phys. Chem., about volume 33.

Cages for animals in metabolism experiments.--A cage made by Wilh. Holzbauer in Marburg is used. These cages have glass sides, galvanized iron rods for the floor, and a zinc trough beneath and a tube for the collection of urine. Prof. Cohnheim recommends them very highly and says that the urine can be rinsed out with a minimum amount of water.

Operating table.--Prof. Cohnheim especially emphasizes the importance of having a very small operating table. He uses a long hard wood plank, about four feet long, 18 inches wide, and about 1½ inches thick. This is placed on legs about four feet from the floor. A large number of holes, about 3/8" in diameter are bored through the plank, through which may be passed cords to hold the animal in any desired position. It is very easy to clean.

Researches.--Prof. Cohnheim has performed many experiments with dogs with Pawlow fistulas. In general, female dogs were used and to facilitate in catheterizing, the ureter is connected with the rectum by making a slit in the rectum. After the operation it is very easy to catheterize the dogs. The animal houses, however, looked very bad and unsanitary. Prof. Cohnheim says that the roof is much better but that the dogs make so much noise that the public complain and they have much difficulty with anti-vivisectionists.

Comments on nutrition experiments.--In an informal discussion of matters pertaining to metabolism, Prof. Cohnheim expressed many interesting opinions.

Rubner's book.--Prof. Cohnheim, like Prof. Hagemann, said that Germans found this book very hard to read and to understand and that a much clearer presentation of the doctrine of the dynamic action of protein and glandular work, etc., is given in a Programme of the University of Marburg he (Cohnheim) in an article by Rubner, also in a Festschrift for Ludwig about 1886. Rubner's argument is based upon the experiment that when dogs are studied at 33° and at 10°, it is found that with dogs at 10°, there is no increase in the heat output over fasting when food is given while at 33°, there is a marked increase. Prof. Cohnheim thinks that there is no specific dynamic action of the food stuffs, particularly protein, but that the whole is a result of glandular activity. At 10° chemical regulation is present and cuts down the heat output but is compensated for by the glandular work.

Muscular activity of dogs in Rubner's calorimeter.--Prof. Cohnheim says that at 33°, the dogs are very warm, stretch themselves out and remain very quiet. His dog (Arch. f. Hygiene, LVII, p. 401 (1906)) was very quiet but the glass window of the calorimeter was so dirty that he could not see her but he mentions the quietness of the animal in his article.

If, as Prof. Cohnheim says, the whole thing is glandular activity and not the work of digestion, experiments should show some difference with smaller amounts of food but not necessarily in proportion.

In discussing the muscular activity of the dogs, Prof. Cohnheim says that Rubner's apparatus has a so-called volumeter which should indicate restlessness on the part of the dog, as it indicates variations in the volume of the air inside the chamber. As near as I can make out, the dog is in the bulb of a large air thermometer and any restlessness would cause an increase in the volume of air by virtue of the increased heat production.

Muscle juices.--By means of the Kossel cutting machine and the saefte presse of Buchner he (Cohnheim) has obtained 60 per cent of fresh muscle in a clear juice without the addition of any water. From liver he obtained but 40 per cent.

Woman with a Pawlow fistula.--Dr. Bickel in Berlin has a woman who has a Pawlow fistula who would be willing to come to America for experiments on artificial feeding if paid. She may prove a second Alexis St. Martin.

Heat of hydrolization of proteins.--Prof. Cohnheim thinks that the heat of the hydrolization of the proteins is very small, perhaps three or four per cent. The main thing in protein metabolism is the oxidation of the amino acids. If we feed meat extract, we should have no hydrolization to speak of as the meat extract is to a large extent, at least, excreted unchanged.

(I called his attention to Prof. Folin's claim that under certain conditions, creatine was retained in the body.) Prof. Cohnheim thinks that the small amount of meat extract used played no role in the true digestive process and the experiment should be nearly comparable to the artificial feeding (Scheinfutterung) experiments.

Acetone in breath.--Regarding acidosis during fasting, the head of the insane clinic told Prof. Cohnheim that he had only to smell the breath of the patients each day to see if they are fasting instead of taking their regular meals as by this means he can note the acetone odor.

Pflüger's work.--Prof. Cohnheim criticises this very severely, saying that his glycogen determinations are not satisfactory. Prof. Cohnheim considers that his experience in glycogen determinations warrants his criticising Pflüger as strongly as he does.

Tangl's work.--This also was adversely criticised by Cohnheim.

Modification of Rubner's calorimeter.--Some men in Kiel (?) have reported experiments with cold blooded animals in Pflüger's Archiv (about vol. 73), in which they determined the heat production of these animals with a modification of Rubner's calorimeter. Many interesting modifications were incorporated but singularly enough, the apparatus is no longer in existence. A careful study of the construction of this apparatus should be made and kept on record in the Nutrition Laboratory.

Remarks on researches in the new Nutrition Laboratory.--I showed the plans of the new Nutrition Laboratory to Prof. Cohnheim and he commented on the fine opportunity for research in nutrition and implied that he would be very glad of an opportunity to work in this laboratory. This is in line with the hope that we may have some of the best of the foreign investigators with us each year and make our laboratory of international scope. If such men as Prof. Cohnheim would consider a proposition of this nature, it seems as if there should be no difficulty in obtaining a good man each year. The stimulus of having such a man in the laboratory with us can hardly be over-estimated.

Heat of combustion of urine.--Prof. Cohnheim stated that when in Rubner's laboratory, a large amount of work which is as yet unpublished was carried out on the heat of combustion of urine by the moist combustion process. Prof. Cohnheim worked on this, also, using sulphuric acid and potassium bichromate. He removed the hydrochloric acid fumes (from the sodium chloride) by passing the gas through hot lead dioxide. The carbon dioxide was passed into baryta water of known strength and titrated with oxalic acid with great success. The moist combustion process takes a long time, fully as long as the regular Liebig combustion. With pure urea solution, it took 45 to 60 minutes.

Criticism of Zuntz's apparatus.--Prof. Cohnheim maintains that the Zuntz respiration apparatus requires a trained man , the best results being obtained with Zuntz and his co-workers in his laboratory. Zuntz has a new scheme for breathing through the nose and exhaling through the mouth. Some of his assistants have trained themselves to do this successfully. Prof. Cohnheim also cited Durig's criticisms of Zuntz's apparatus. The Zuntz apparatus for animals is particularly unsatisfactory since with a shake of the head, all is lost. Many of the experiments reported with animals have lasted less than six minutes.

General impression of Prof. Cohnheim's laboratory and researches.--Prof. Cohnheim is an unusually brilliant physiologist whose chemical basis is unfortunately not as sound as his physiology. As a chemist, probably many of his methods and manipulations would be subject to adverse criticism when carefully investigated. He is full of ideas, very enthusiastic, and has a very strong idea of the spriit of research.

BASEL, SWITZERLAND.

Laboratory of the First Medical Clinic.

Professor A. Jaquet.

Although recently transferred to the department of pharmacology in the University of Basel, as director of the pharmacological laboratory, Prof. Jaquet's work of greatest value to nutrition was carried out in the laboratory of the First Medical Clinic in Basel. For a number of years, Prof. Jaquet has studied the mechanics of respiration and circulation and the effect of altitude on metabolism, and has constructed much apparatus of interest to students of physiology. He is primarily a technician and is personally interested in a very fine mechanical shop where physiological apparatus is constructed and all of his apparatus shows the hand of a trained mechanician.

Of special value to our work is his respiration apparatus which, unfortunately, he has described in a seldom seen publication, Verhandlungen der Naturforschenden Gesellschaft in Basel, Bd. XV, Hft. 2.

The apparatus is in principle an open circuit apparatus in which the outgoing air is analyzed very exactly and the oxygen content determined as well as the percentage of carbon dioxide. The incoming air is assumed to have 0.03 per cent carbon dioxide and carbon dioxide and water free air is assumed as having 20.96 per cent oxygen. The special feature of this apparatus is that while Pettenkofer determined only carbonic acid, in the open circuit apparatus Jaquet, by means of refined methods of chemical analysis has attempted to determine the amount of oxygen consumed by man by determining the oxygen in the outcoming air. Reference to the article mentioned above in the Verhandlungen der Naturforschenden Gesellschaft in Basel will be made in these notes under the title of J.R. The respiration chamber is shown in a drawing in J.R. (Fig. 1) in the plate.

The size and form were decided upon only after the most careful plabning as to how much room a man needs to sit and lie and also with a view to making the door fairly large so that patients would not become worried over the thought of entering it. This idea of dealing with patients has controlled practically all of Jaquet's work. He has always in mind the fact that he is working not with trained scientific assistants but with a nervous unscientific patient. On the description of his apparatus given me by Prof. Jaquet and on file in this laboratory are indicated with great exactness all of the measurements and dimensions of this chamber. A series of photographs, Figures 12, 13, 14, and 15, give different views of the apparatus as it now stands.

Construction of the chamber.--The apparatus is not a calorimeter but a respiration apparatus of the open circuit type. This calls for an absolutely air-tight box but not heat-proof. As Jaquet paid but little attention to the variations in composition of the air inside of the chamber at the end of the experimental periods, the exact temperature of this air and the volume need not, for his purposes, be known. Another item in the construction of the box which was controlled by the fact that it was to be used by patients was the rather liberal introduction of glass windows.

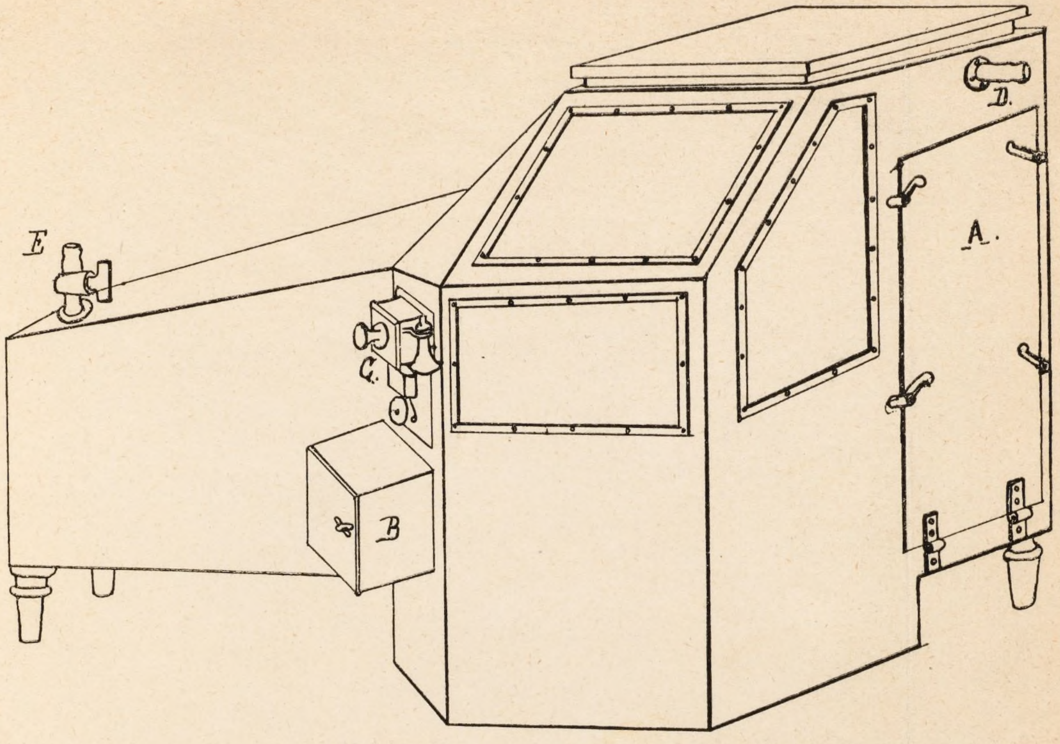


Fig I.

Fig. I. Diagram of Jaquet respiration apparatus.

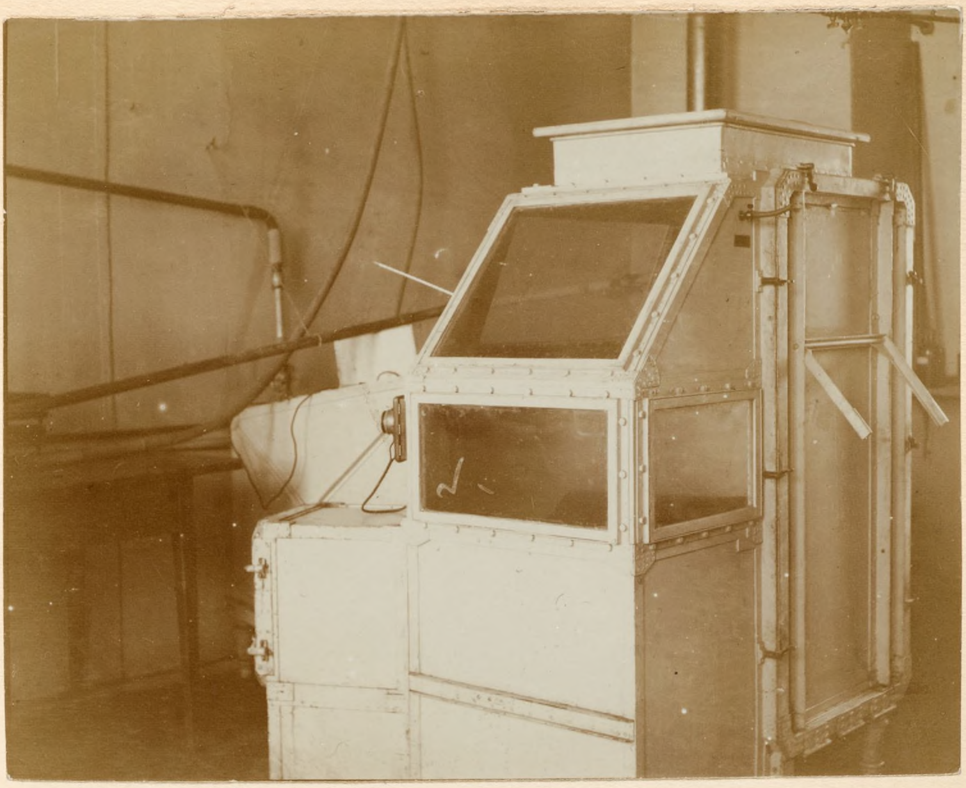


Fig. 12. General view of the Jaquet respiration apparatus.

At the right is the door which is hinged at the bottom. At the left of the glass windows is the telephone and immediately beneath the telephone is the box through which food and feces are passed. Back of this box is seen the extension for the legs of the man when lying down. The ribbed bracing mentioned in the text is seen running diagonally on this extension.

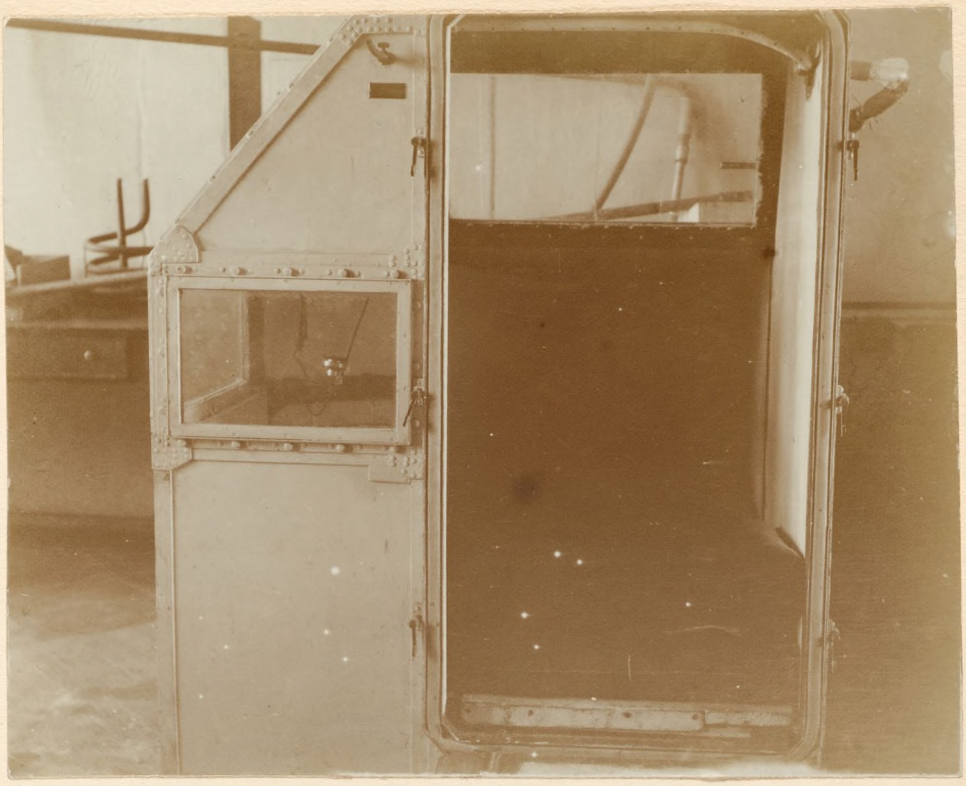


Fig. 13. Front view of the Jaquet respiration apparatus.

The door is open, showing indistinctly the cushions at the bottom. Inside at the left is the telephone; in the dark background is the extension where the legs are placed when the subject is lying down. The ventilating current of air leaves the chamber at the top of the door. Inside the chamber, the air pipe is filled with a number of holes to withdraw the air at different points. The rubber gasket against which the door is drawn is seen in the groove running around the opening of the door.

The walls are of sheet iron, black, not galvanized, thoroughly well painted white, within and without. The seams are all riveted together. There are hundreds of rivets in the apparatus. The larger panels of the walls are stiffened by ribs or braces running diagonally the length of the largest sides. The ribs are made of small T iron, with the top of the T against the sheet iron. The windows are set in with white lead, paint and putty of some kind. They look very leaky. Prof. Jaquet says that when he experimented with the apparatus, it was tight, but there was red lead paint over each seam and around the window frames, showing where his successor had tried to get it tight during his experiments. The laboratory assistants said that they found lots of leaks in it when testing it with soapsuds, especially around the glass windows. The door is nearly the full height of the apparatus. The windows are shown in part in the diagram in J.R. and wholly in the photographs. Near the top and at the left of the door a small cock is situated, from which small samples of the air can be drawn, also a manometer can be attached so as to note the interior pressure. With a ventilation of about 40 liters per minute and with the certainly inaccurate closing of the door and windows on the day that I was in Basel, I found there was a diminished pressure of about 7 mm. of mercury inside the chamber.

The drawing in J.R. shows the air coming out of the chamber just above the door (D, Fig. I). This is not so as it is now arranged. As shown in the photograph on the plate with the two exposures (Fig. 15), the air comes out on the side at the right of the door. The glass door (A) shown in J.R. as irregular in shape is, as a matter of fact, as shown by the photograph, rectangular.

The cubical contents of the chamber is not far from 1300 liters. Prof. Jaquet described the box to me as a cube with several frustums of irregular pyramids attached to it, one for the legs of the subject when lying down, one for the table and food aperture, and one for the head.

Contents.--When the door lets down, a rolling bed can be rolled out on to it, two legs on the outer part of the door swinging out and forming a rest for the bed when it is rolled out. The two legs are seen in Figure 12. The bed is provided with cushions and there are also other cushions for the arm and back so as to make a very comfortable arm chair. A man can sit as shown in the photograph (Figure 14) with perfect comfort in a fairly well lighted chamber. Usually the man sits in the position shown in the photograph and by re-arranging the cushions, he can put his legs down in the long part of the chamber and sleep very comfortably. The box is not high enough for a man to ~~sit~~ stand up. A small folding table lets down in front of the window immediately in front of the man when sitting. This table is hinged to the wall and is held up by a catch. A telephone connects with the outside. Inside of the chamber in the box on the floor are two dry cells for the battery.

The construction of the cushions is interesting as they can be used either for pillows or for making arm cushions for the chair. On the side of the chamber ~~through~~ to which the telephone is attached (see Fig. 15) there are two openings just above the telephone, one for the mercurial thermometer and the other can be used for a manometer or for taking samples. The mercurial thermometer is graduated only to degrees and the temperature of

Fig. 14. Jaquet respiration apparatus, with subject.

This photograph shows the position of the subject while inside the Jaquet chamber. The arm rests are formed by cushions. The arrangement of the windows shows the chamber unusually well lighted.

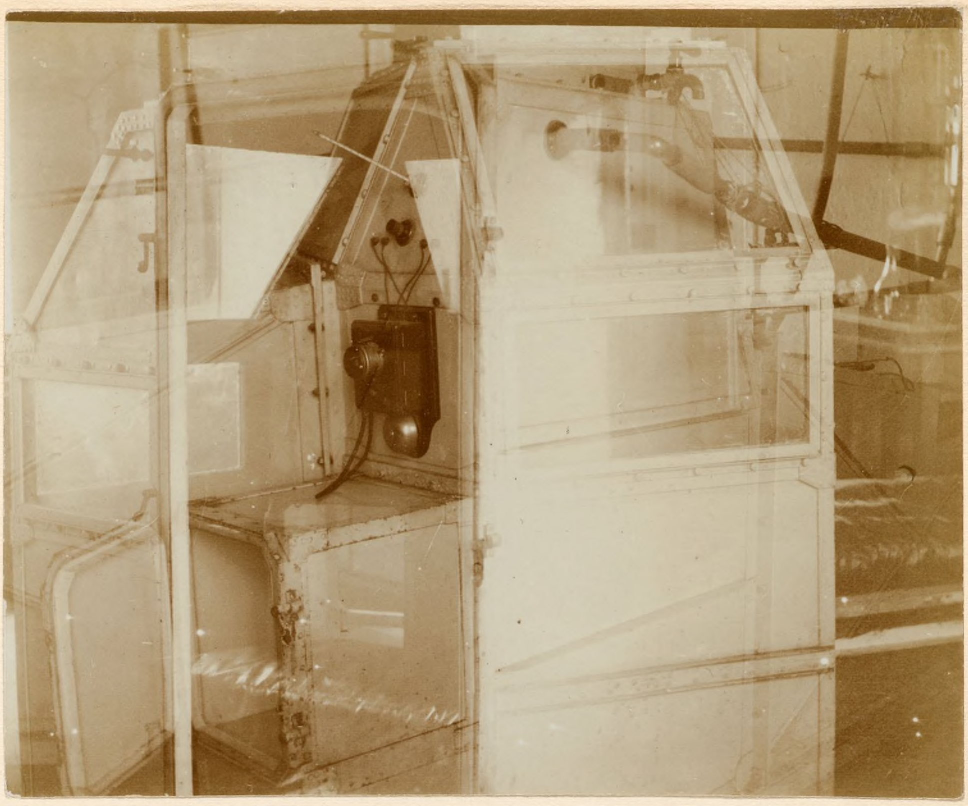


Fig. 15. Jaquet respiration apparatus.

A double photograph, two negatives being taken on the same plate, showing two views of the apparatus in almost diametrically opposite positions. Immediately beneath the telephone is seen the food box with door open. At the upper part of the picture is seen the air pipe on the opposite side of the chamber, where the air leaves, also a cock above this which connects with the tank on the top of the chamber which is intended to be filled with cold water in case the heat is not radiated fast enough through the walls. In the lower right hand side of the picture are seen the cushions furnishing the bed which has been rolled out from the chamber. This part belongs to the view taken opposite the telephone. There is also distinctly seen the horizontal cross-ribbing of the extension for the feet, this view belonging to the view taken of the extension for the feet, and water cock. The closure for the food box door is similar to that for the main door.

the chamber taken for no particular purpose. The temperature record does not enter into the calculations.

The extension to the chamber provided for the legs of the man is sufficiently large so that the man can turn over in bed and draw up his knees with some degree of comfort. This extension was also expressly designed so that some small machine could be inserted later so that a man may be made to work kicking his legs while lying down on his back. At present the only muscular work that a man can do is to pull on handles attached to the under side of the long extension.

Prof. Jaquet has described in an earlier publication an apparatur for exercising the legs during climbing. This apparatus is based upon a cylinder filled with oil which is opened and closed as the weight is shifted from one leg to the other. He is now modifying this apparatus and introduced some improvements. His idea was ultimately to have some apparatus that could be used while the subject was lying down but as his work is now largely with respiration experiments of another kind, it is questionable if he ever devises anything for use inside the respiration chamber.

Food aperture.--This as shown in the figures is a double-doored box which is closed in a very unsatisfactory manner, using a rubber gasket with no especial provision for tightness.

Window glass.--The glass in all of the windows is thicker than ordinary window glass but not as thick as plate glass. Evidently much difficulty has been experienced in securing tightness between the casing and the iron.

Rolling bed.--When the door is opened and the legs are of course in place, the bed can be rolled out very easily on the door which serves as a support. There is a little track fastened on the inside of the door and castors or rollers on the bottom of the bed guide it as it moves out on this track.

Tests for tightness.--In this as in other respiration chambers, the chamber should be very tight but the tests are unsatisfactory. No tests are regularly made. The doors were formerly closed by an pneumatic tube packing such as is used on a bicycle and such as was used around the food aperture in the Middletown apparatus. By means of a pump, this tube could be expanded and a tight closure effected. At present the apparatus has only a piece of rubber tubing, with the ends cemented together. Unquestionably at present it is not tight. Tests with the manometer show that there must be a marked leak into the box. Since, with the present method of piping, there is always a decreased pressure into the box at all times, it follows there must be a leak from the room into the chamber during the conduct of an experiment.

Ventilator.--Formerly Prof. Jaquet used a water turbine which acted a blast bellows with intermittent movement. He is somewaht inclined to think now that an intermittent movement of the air current is more accurately measured than is a constant air current though his reasons were not apparent. At present, an enclosed electric fan is used. This is evidently readily obtained in Germany. It gives a slight positive action and also a slightly diminished pressure. Prof. Jaquet did not know how high a vacuum could be obtained with it. As a matter of fact, since the rate of ventilation is not far from 40 liters per minute, the ventilator as now connected with the electric motor draws more air to the system than is desired and hence a Y-tube is placed in the pipe just before the air enters the ventilator and by opening one branch of the Y, room air can be allowed to enter and less air drawn through the respiration chamber. The apparatus runs very easily and does the work well. Probably it would not give more than 20--30 mm. of water pressure of air, so it is of no use for forcing gas through acid such as is done with our blowers.

Piping system.--The air is taken from a special pipe about one inch in diameter from the street side of the laboratory. Formerly Prof. Jaquet took the air from the court side, i.e., the space enclosed by the hospital building, but under these conditions he found noticeable fluctuations in the composition of the air from day to day. He considered that in the court the air became more or less stagnant while in the street it always circulated well and the air was of constant composition.

(This contention is in marked contrast to Haldane's experience with air in London. There he seemed to find that the ventilation was in a vertical direction rather than horizontal.)

The air passes through about 18 feet of pipe into the chamber, or did formerly. There are at present a great many turns back and forth as Dr. Staehelin tried to lead the air through ice and salt and calcium chloride and obtain water-free air. A large number of elbows, joints, couplings, tees, etc., are in the pipe. Each one of these connections causes a break in the flow of the gas and produces more or less resistance of itself. Prof. Jaquet criticises this arrangement severely. Even with the ordinary union, where there is a break in the continuity of the interior of the pipe, according to Prof. Jaquet, there is a chance for a vortex motion of the air inside the union, thus producing resistance. After the air leaves the chamber, Prof. Jaquet had but about seven feet of pipe between the chamber and the meter; now Dr. Staehelin has some thirty or fifty feet. I made some tests of the resistance and found that when the ventilator was running so as to draw 40 liters of air per minute through the apparatus, the pipe from the chamber to the meter showed 23 mm. of water suction at a point just before the meter. A test of the diminished pressure of the ingoing air just before going into the chamber showed 6 mm. Simultaneously, the manometer showed a diminished pressure of 11 mm. inside the chamber, so there is a diminished pressure in the box at all times. This must have been the case even when Prof. Jaquet had shorter pipes from the outside of the building to the chamber and from the chamber to the meter. Obviously, the resistance in this last pipe does not influence the resistance of the air inside the chamber itself. Some idea of the resistance of the pipe can be seen when it is stated that the suction just before the gas entered the meter when the chamber is opened is 12 mm., while when it is closed, it is 23 mm. Thus the section of the pipe between the meter and the chamber gave this resistance, amounting to ~~23~~ 12 mm. of water.

Meter.--The air was passed through an experimental Elster gas meter marked for 15 lights, No. 245811, and made in 1898. The meter with connections is shown in Fig. 16. It differed in no wise from the ordinary meters used in connection with the Zuntz apparatus. A letter from Elster to Prof. Jaquet stated that below 30 liters per minute, the error is less than 0.5 per cent per minute; between 40 to 50 liters per minute, the error is 1 per cent; and from fifty to sixty liters per minute, the error is 1.5 to 2.0 per cent. The dry meter of Elster, according to Elster himself, is not accurate to within 5 per

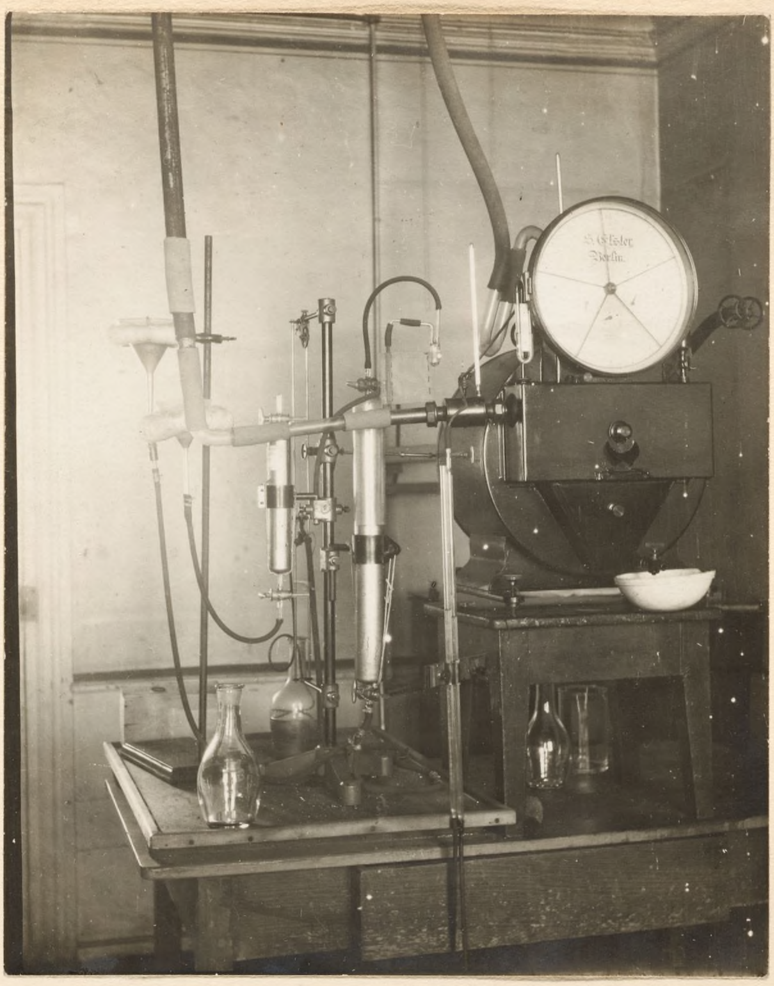


Fig. 16. Gas meter and air sampling apparatus used in connection with the Jaquet respiration chamber.

At the right is the gas meter; at the left, the gas sampling apparatus. The air enters the meter through the large pipe at the left and leaves through a pipe attached to a large glass U-tube at the back of the meter. This pipe is seen extending towards the ceiling. Just before the air enters the meter, a sample is collected in the large cylinder with stop-cocks at each end, clamped in an upright position in the centre of the picture. Subsequently, this sample of air is transferred to a small sample collecting cylinder such as is shown at the left of the large cylinder. The gas manipulations are all conducted over mercury.

cent. Prof. Jaquet never used more than 40 liters per minute. The meter dial is marked so as to show 10 liters for one revolution. Usually water is used as a fluid inside the meter to sub-divide the different gas portions as the drum revolves but Dr. Staehelin has introduced paraffin oil for two reasons: first, to prevent rusting, and second, there is no evaporation in the meter with the paraffin oil. There are several objections to the use of oil and Prof. Jaquet says that he personally would go back to the water. With regard to the first of the reasons given by Dr. Staehelin for using oil, the new Elster gas meters are being made of copper instead of tin and hence with the new meter there will be no danger of rusting. In regard to the second reason, there may be and probably is at times a considerable condensation of water inside the meter. This may be erroneous in itself but with the oil, there is the still greater disadvantage that ~~it~~ the air is never measured under constant conditions. With the Elster meter, the air is measured always saturated with water vapor at the temperature of the meter itself. With the use of paraffin oil, it may be measured when partly saturated and the degree of saturation is never constant.

Collection of sample.--The ventilating current of air after leaving the chamber~~s~~ enters the Elster meter where it is measured. It then passes through the ventilator and out into the room. Just before the air enters the meter, a sample is taken. The method of collecting the sample is very similar to the ingenious device of Loewy in which the mercury ~~out of~~ in a large collecting cylinder is allowed to flow out at a regular rate by lowering a rubber tube connected with the bottom of this sample cylinder and allowing water or mercury to flow out of the tube. If the tube is lowered at a rate proportional to the rate of ventilation the sample is collected in the sampling tube proportional to the rate of ventilation. Obviously when a very small fraction of the total air current is to be used for a sample, it is necessary, in order that this sample be as representative of the whole as possible that it be collected with proportional speed for it is conceivable that at the beginning of the experimental period there may be a large amount of carbon dioxide in the ventilating air current and at the end a smaller amount. Under these conditions, unless the sample is taken with great regularity, there may be marked differences in the composition of the sample and it would not represent thoroughly the composition of the total volume. In order to insure this regularity of collection, Prof. Jaquet has attached to the drum of his meter a universal joint which,in turn, connects with a shaft fitted with a gear wheel on the end. This gear wheel is connected with a large toothed wheel and by means of a system of pulleys, the tube out of which the mercury flows may be lowered at a greater or slower speed. The sample collecting tube, as seen in Fig. 16, is about 70 cm. long and the gearing system of pulleys will enable the end of the rubber tube to be lowered at such a rate that this sample tube may be emptied of mercury and filled with the air sample in either one, two, or four hours, as the case may be.

Some of the details of this system, although unfortunately rather dimly printed, can be seen in Fig. 17. The rubber tube connecting with the bottom of the large sampling pipette ends in a small jet which in the photgraph is shown as pointing into a small funnel to which a rubber tube is attached, and the other end of the tube is placed in a flask containing some mercury. This jet is held by a little travelling carriage which is raised and lowered on two guide rods. As the mercury falls out, obviously gas is sucked into the large sampling tube

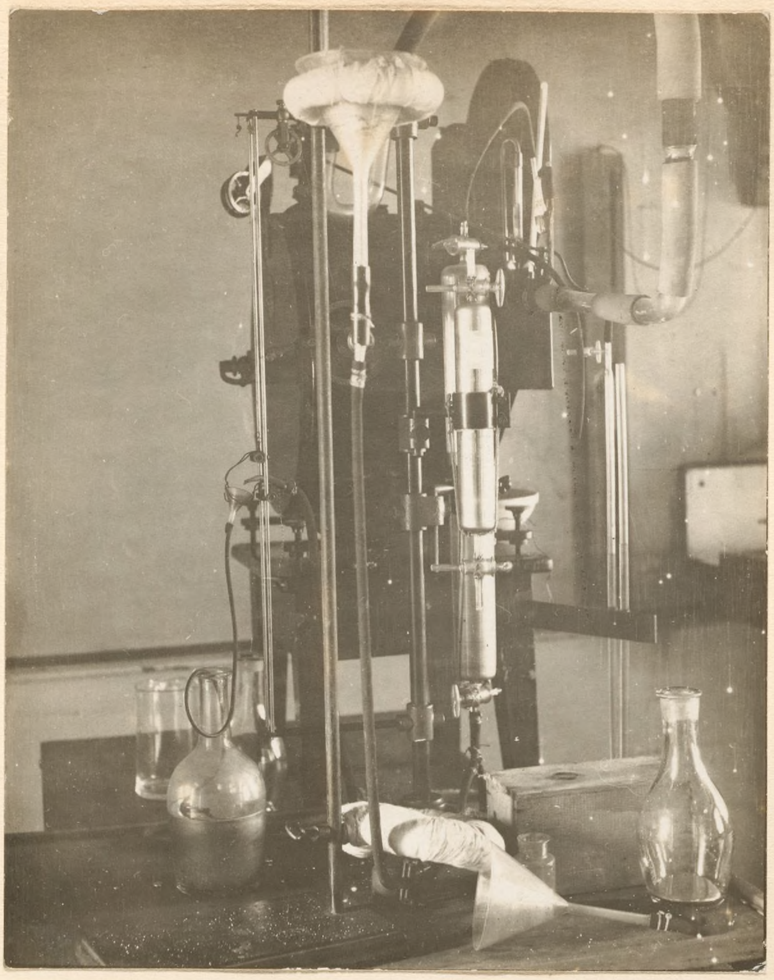


Fig. 17. Details of air sampling device, Jaquet respiration apparatus.

Air enters the meter at the right through a glass elbow and rubber joints. The large collecting cylinder with the small sample cylinder immediately in front are shown at the right of the standard. At the left is a large funnel supported in a ring wound with cloth which holds the mercury for filling the large sample pipette. At the back of the meter can be seen the universal joint with small gear, and immediately back of the lower end of the large funnel can be seen the toothed wheel of the large gear. The delivery pipette with small funnel leading to the mercury flask is seen behind the meter at the bottom. The two parallel glass tubes at the right of the picture are the thermo-barometer of Zuntz.

and Prof. Jaquet believes that the suction is always sufficiently rapid so that the sample in the glass collection tube does not diffuse back into the main air current. Dr. Staehelin, his successor, has evidently not felt so certain of this so he has inserted a small trap with paraffin oil between the sample cylinder and the point where the sample is taken out of the main air current. This small trap is shown in Fig. 16. It is immediately above the union at the left of the meter. The large collection pipette holds just one liter and as the pulleys are ordinarily arranged, it fills in two hours, when the rate of flow is 40 liters per minute. It is necessary to check the rate of ventilation with a watch from time to time and regulate the main ventilating air current by opening or closing the stopcock on one arm of the Y-tube on ~~one arm of~~ the ventilator. While the details of the ratchet system are unfortunately but poorly shown in Fig. 16, there is a rough sketch in note-book No. 1, on file in the laboratory, page 8, which shows the matter much more in detail. See also Fig. F. There is also on page 8 a sketch of the paraffin oil trap between the main ventilating air current and the air collecting cylinder.

While the system of collecting samples in this way is essentially that of Loewy, evidently Prof. Jaquet had to substitute for the pulleys and cord used by Loewy a gearing to stand the heavier wear and tear of an apparatus which has to raise and lower mercury rather than water. A friction clutch provides for the rod adjustment of the end of the delivery pipette at any height without changing the gearing in any way. A schematic outline of the connections of the meter, sample pipette, and gearing are shown in Fig. II of the article by Prof. Jaquet called J.R.

Method of taking sample.--The large collection pipette holding 1000 cc. is filled with mercury by raising the large funnel shown in

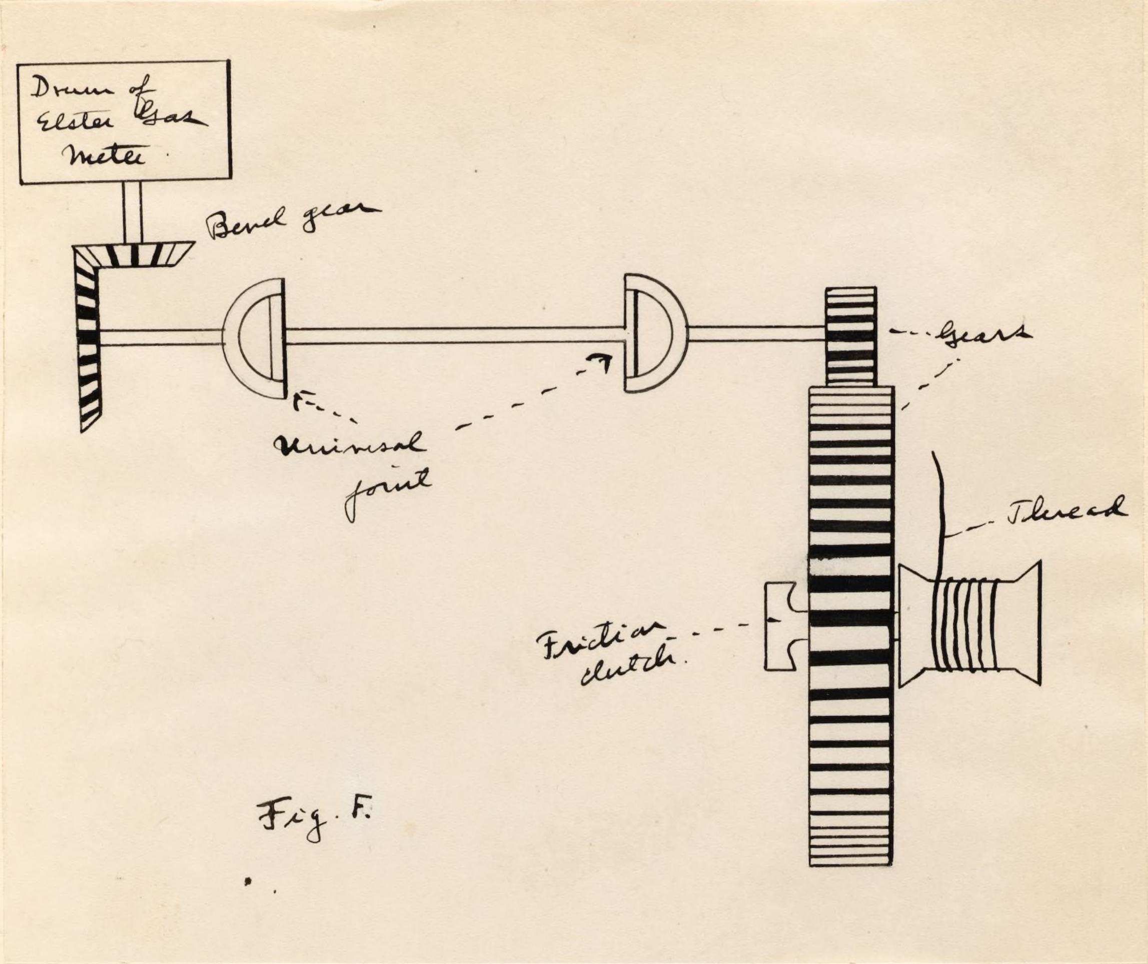


Fig. F. Scheme of bevelled gears for lowering the collection pipette in Jaquet's apparatus, Basel.

By adjusting a system of pulleys on the thread, the rapidity with which the pipette is lowered can be adjusted. The whole attachment is connected to the axle of the drum of the Elster gas meter.

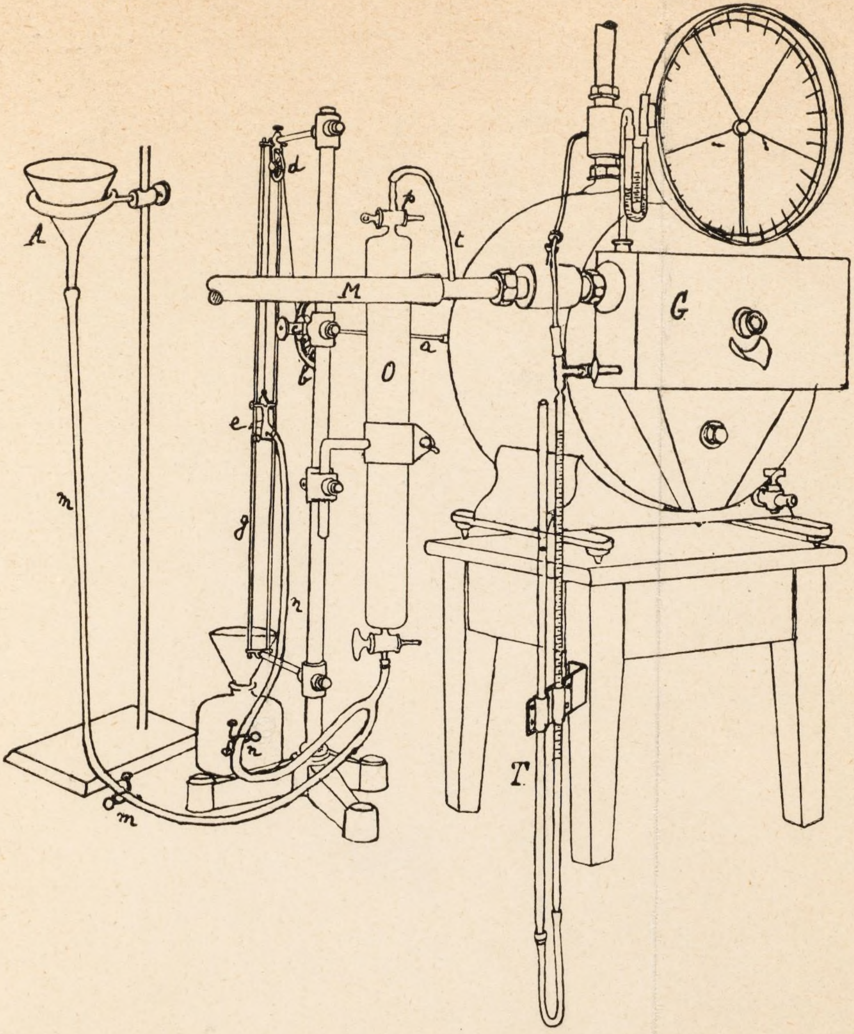


Fig. II.

Fig. II. Diagram of Elster meter and sample collecting device, Jaquet respiration apparatus.

Figs. 16 and 17. The funnel must be raised until the mercury fills the neck of the stopcock. All stopcocks are made on the principle of having a hole through the long part of the stopper as well as the usual hole directly through the stopper. With this form of stopper, it is possible to clear out the dead air spaces, i.e., the "schädliche Raum" and thus prevent contamination of the pure sample with any small amounts of air left in the connecting pipes.

After the ventilator has been running a sufficiently long time to insure uniformity in the air sample (in the experiments made by Prof. Jaquet, usually 45 to 60 minutes) and it is desired to begin the experiment, the Elster meter is read and the taking of the sample is begun. In order to take the sample, the delivery pipette, the so-called "ausfluss" pipette, must be raised by means of the friction clutch spool a little above the upper stopcock p of the sample collecting cylinder O. (See Fig. II, J.R.) Thus the mercury will stand somewhat above the stopcock. This is important for if when the screw clamp connecting the sample pipette O with the "ausfluss" pipette is opened, the mercury is lower, there will be a sudden fall of mercury and a very rapid suction of the sample in the pipette. Thus the first portion of the sample will not have been taken in proportion to the rate of flow of the main air current.

A short piece of rubber tubing should be placed upon the side outlet to the stopcock p and the cock then turned so that by sucking the air with the mouth, the air in the sample pipette leading to the main air current can be replaced with a fresh sample directly drawn from the ventilating air current. This sweeps out the dead air spaces very well. The stopcock should then be turned so that the rubber tube upright t connects the sample tube with the main air current.

The pinch cock n, connecting the sample collecting pipette O with the "ausfluss" pipette should then be opened and if the "ausfluss" pipette has previously been adjusted to the proper height, the mercury ought to rise a little in the upright part of cock p.

The set screw c, which connects with the large gear wheel, is then adjusted and the mechanism begins to work in such a way that the "ausfluss" pipette opening is gradually lowered and the air sample slowly drawn over into the large cylinder. A small funnel attached to the rubber tube leading into a bottle below conducts the mercury as it drops from the "ausfluss" pipette. As the "ausfluss" pipette is being lowered, it occasionally happens that the rubber tube containing the mercury may become kinked. Obviously this is very disastrous to the regular collection of the sample and it is important to adjust the rubber tubing to the mechanism of the "ausfluss" pipette in such a manner that it is impossible to kink the rubber tube.

Back diffusion of sample.--While the utmost care has been taken by Loewy and later by Prof. Jaquet in providing for the regular collection of the sample, yet I have always felt that as the apparatus has been commonly used by Zuntz and his associates, there has been an opportunity for backward diffusion of the sample. While, as is generally the case, the carbon dioxide production during the progress of the experiment with the Zuntz apparatus is relatively constant during the whole experiment, with the Jaquet apparatus there may be noticeable differences during experiments continuing two or three hours. Hence, the question is perhaps even more important here than with the Zuntz apparatus. As stated above, Prof. Jaquet is not inclined to take the matter seriously but Dr. Staehelin evidently disagrees with him. The trap is certainly no disadvantage save in making a slight increased tension which is required to draw the air into the collection pipette.

Use of mercury.--Prof. Jaquet objects to the use of water as a liquid over which respiratory gases are to be collected. There is always danger of absorption of carbonic acid but less of absorption of oxygen. He discusses this matter somewhat in his article J.R. He has tried calcium chloride solution but prefers mercury.

Transfer of sample from collecting pipette to storage pipette.--Many experiments with the Jaquet apparatus continue for several periods of two hours each and hence it is desirable to collect the air sample, not for the whole experiment, but for periods of one or two hours. By adjusting the pulley system, the collection pipette can be filled in one or two hours. When the pipette is filled, it is necessary to drive a portion of this large sample into a storage pipette of smaller size for subsequent analysis. The storage pipettes are constructed exactly as is the large pipette, only much smaller (250 cc.) One is shown attached to the standard in both Figs. 16 and 17.

In order to have the collection of sample from the main air current as continuous as possible, rapid manipulation is necessary to transfer the air from the large collection pipette to the storage pipette. (Suggestion. It would be much better to have two large collection pipettes and use them alternately.)

The small pipettes have stopcocks at each end bored through the stopper as well as crosswise. An iron band devised by Prof. Jaquet to be used for supporting the heavy pipette when filled with mercury is so constructed that it may be attached to a rack and standard. The details of this standard and band are shown in Fig. 18.

The small pipette is first completely filled with mercury by raising the mercury reservoir attached by means of the rubber tube to the lower end. By means of stopcocks, all the space can be filled

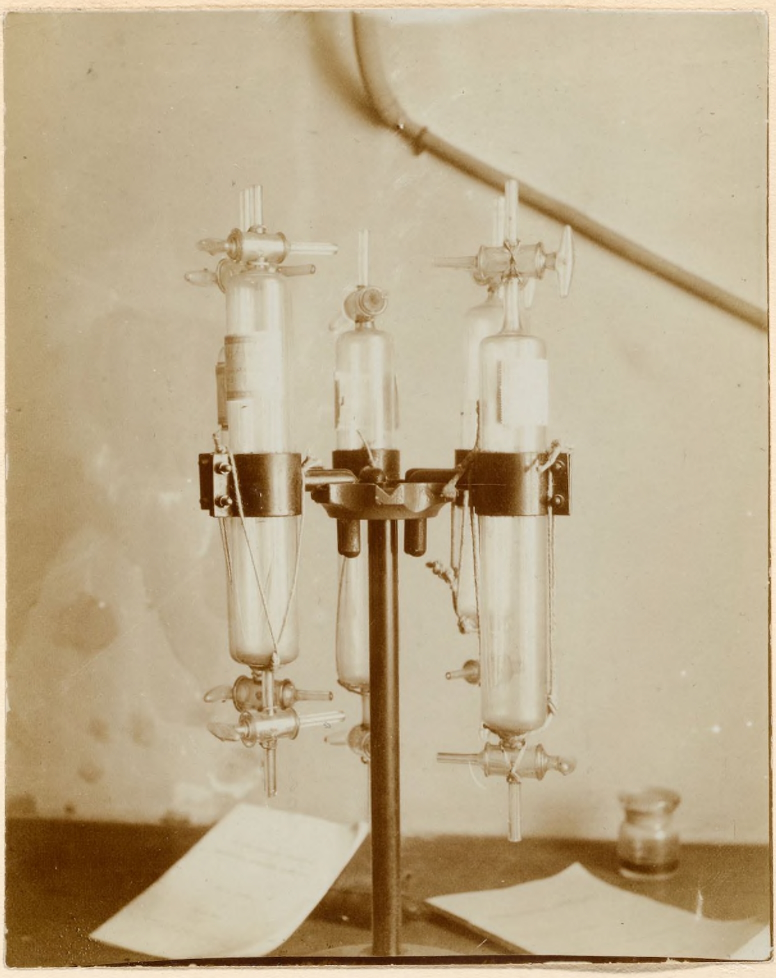


Fig. 18. Support for sample pipettes, Jaquet respiration apparatus.

The pipettes can be taken out of the central support or stand and attached to a large standard as shown in Fig. 16. To help out on the strain when filled with mercury, the bottom of the pipette is suspended with stout cord. The pipettes hold about 250 cc. each.

with mercury. The sample in the large collecting cylinder O is then compressed to two-thirds of its original volume by raising the reservoir connected with the lower end of O. A rubber tube is then used to connect O with the small storage pipette. By opening the upper stop-cock in O, a small amount of compressed gas can be driven through the rubber tube and connections, sweeping out all dead air. This is allowed to run usually until the gas in O is at atmospheric pressure but as soon as this is reached, the stop-cock is instantly shut off. There still remains in O, however, plenty of air and more than enough to fill the small pipette. The stop-cocks are then turned so as to make a clear passage between O and the small pipette and the air is drawn into the small pipette by opening the stop-cock in the bottom of the small pipette and allowing the mercury to flow into a vessel, thus drawing air in at the top. The mercury is allowed to run in at the rate of about 10 cc. in three seconds. Simultaneously, provision must be made for allowing mercury to flow into O as fast as it runs out and it is necessary to keep the supply funnel of O well filled with mercury and to the proper height. When the mercury is nearly out of the small pipette, the lower end is closed but the mercury is still allowed to run into O until there is a pressure of over 10--15 cm. of mercury left in the bottom of the small pipette. This acts as a seal to the lower stopcock. The air is now under pressure and it is best to snap a small rubber band over the cocks to hold them in as they are liable to blow out. The small pipette may now be transferred to the sample rack shown in Fig. 18.

The large pipette is then rapidly filled with mercury for taking another sample. The laboratory assistant was able to sub-sample, re-fill O, and start a second sample in about ten minutes but I still think it would be better to have a second collecting pipette for alternate use.

Routine for stopping the taking of the sample.--At the end of each experimental period, the taking of the sample must be stopped and the large sample sub-sampled. In order to stop the sampling, close stop-cocks at the top and bottom of O and adjust the mechanism so as to stop the lowering of the "ausfluss" pipette. The stop-cock on the tube leading from the Y at the bottom of O to the "ausfluss" pipette is then closed. The large funnel is filled with mercury, the lower end which is connected with the short arm of the Y is then opened, and the stop-cock opened so that the mercury can flow into O, compressing the air, therefore, as described above. Meanwhile the small pipette should be filled with mercury from the funnel attached by means of the rubber tube at the lower end.

Use of gas analysis apparatus.--The Jaquet principle of determining the amount of oxygen consumed in respiration by the difference in the oxygen content of the ingoing and outcoming air is possible only with the most delicate gas analysis apparatus. While there are numberless methods for the determination of small amounts of carbon dioxide with great accuracy and while the amount of carbon dioxide normally present in air is very small, with oxygen on the other hand methods for determining this gas with great accuracy are relatively rare. With the conditions of ventilation ordinarily obtaining in respiration chambers, the percentage of oxygen rarely falls from that of the normal (which we can assume for this discussion to be 20.96) to 20.16 or 0.80 per cent. Obviously, the method for gas analysis must be so accurate that the oxygen can be determined to 0.01 per cent in order to obtain an error not greater than one part in 80 or 1.2 per cent of the total. The ordinary Bunsen or Zuntz method for gas analysis will not permit of

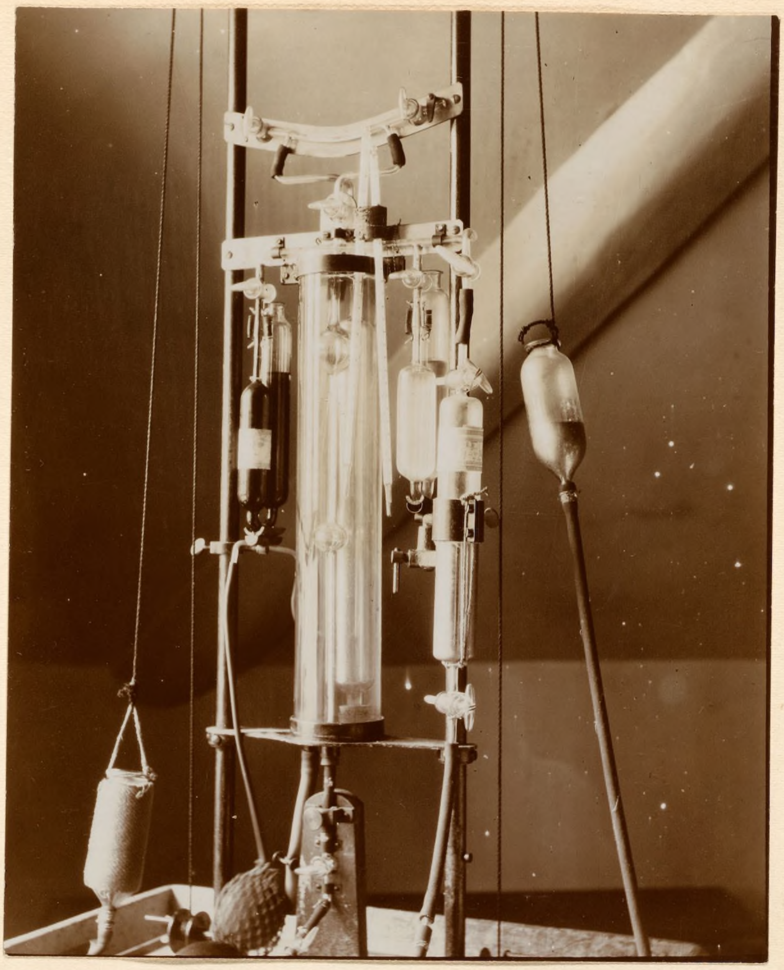


Fig. 19. Pettersson gas analysis apparatus for use with Jaquet respiration apparatus.

The gas burette is divided into two parts, one graduated for the determination of carbon dioxide and the other for the determination of oxygen. The apparatus is described in detail in the article by Jaquet referred to in the text as J.R. The gas pipette is surrounded with water. At the right is a laboratory vessel containing caustic potash for the absorption of carbonic acid and at the left is a vessel containing pyrogallic acid for absorbing oxygen. The sample storage pipette is attached to the frame at the right.

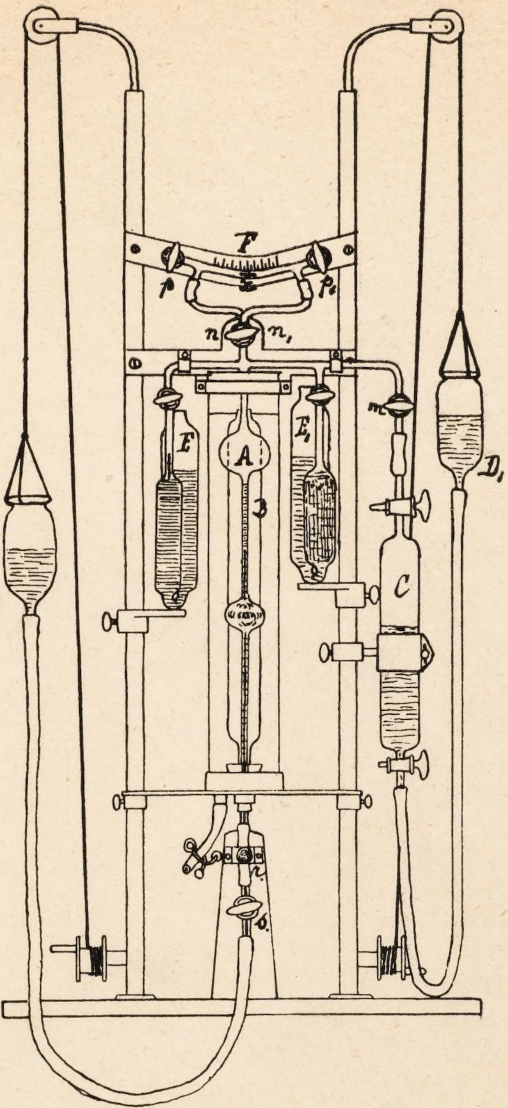


Fig. III.

Fig. III. Diagram of the Pettersson gas analysis apparatus for use in connection with the Jaquet respiration apparatus.

Corrections for Haldane's Burette.

0-1	.97	-.03
	1.001	
1-2	1.971	-.03
	1.006	
2-3	2.977	-.02
	1.001	
3-4	3.978	-.02
	.998	
4-5	4.976.	-.02
	1.000	
5-6	5.976	-.02
	.997	
6-7	6.973	-.03
	1.011	
7-8	7.984	-.02
	.994	
8-9	8.978	.02
	1.009	
9-10	9.987	-.01
	1.013	
10-11	11.000	—
	1.01	
11-12	12.010	+.01
	1.022	
12-13	13.032	+.03
	1.005	
13-14	14.037	+03
	1.005	
14-15	15.042	+.04
	.999	
15-16	16.041	+04
	1.005	
16-17	17.046	+.05
	1.004	
17-18	18.050	+.05
	1.000	
18-19	19.050	+05
	1.056	
19-20	20.106	+.11
	504	
20-20.5	20.610	+11
	499	
20.5-21	21.109	+11
	500	
21-21.5	21.609	+11
	498	
21.5 to 22	22.107	+11

+20

20-21 – 20.106
1.00
20.[illegible]

☒ ☒

507
507

50

2069)01000(

507
507
498
498
4)2008
1500

100
75
1000
2000

5C
20.69
15.268
20.69)5.422
4.1 3
1 2 8 4 0 (26

75 gm a 5CC

75 1000

100
20
2000

100

100
10
100

50)1000

50/1000 = 5/20 = 1/4

1400

50

2

50
20

1000cc
500cc

.20
.50
1.00

this degree of accuracy. Thanks to the Scandinavian investigators, Pettersson and Sondén, it is possible to use a method which with experience will give results to within .01 ~~0.1~~ to .02 ~~0.2~~ per cent. Prof. Jaquet has used a modification of the Pettersson apparatus made by Geissler in Bonn and illustrated in Fig. III of the article J.R. Although it was not easy to obtain a satisfactory photograph of the apparatus, owing to its position near a window, I took two negatives, prints of which are given in Figs, 19 and 20. The principle is described in J.R.

Cleaning.--It is of vital importance with an apparatus of this delicacy that it should be absolutely clean. Cleaning all of the Pettersson apparatus is a very delicate and tiresome operation. It must be cleaned both with alcohol and ether. (See J.R. for a discussion of this point.) The stopcock *n*, J.R., Fig. III, is first removed and cleaned thoroughly, using hens' feathers, and the capillary tube leading from this cock is also cleaned. It is lubricated with a wax made in Prof. Jaquet's laboratory of vaseline, wax Gebex, and a little caoutchouc. The wax is a little thicker than vaseline. The greatest care is necessary in lubricating as many analyses are lost on account of grease plugging the cocks. It is necessary to clean every time the cocks and bored parts the cocks fit into. The lowest stopcock, *s*, must have only a minimum amount of grease. This stopcock is always surrounded with mercury on the inside and hence there is almost no chance for leakage.

Filling with mercury.--To fill the apparatus with mercury, cocks E and E' and *m* are closed and cock *n* is removed. Open cock *s* and raise the reservoir *D*. Mercury is thus allowed to rise in *A* up to the opening where cock *n* was inserted. The air in the two side branches of the cross is enclosed since the cocks E and E' are both closed. One drop of water is then placed on the top of the mercury in the cock opening and the mercury reservoir is lowered, thus moistening the walls of the tube and insuring that the gas when measured is moist. The stop-cock opening is then cleaned again, and the stopper with a little grease on it re-inserted. After closing this cock, open the cock at the top of E'. Fill the KOH vessel E' with a strong solution of KOH (made by dissolving one kilo of stick caustic potash, Kali Hydric Pur., in two liters of distilled water.) The vessel is filled to a special mark on the neck. A small pipette must be used to fill the larger portion of the vessel which is immediately back of it care must be taken regarding the capillarity since the liquid must stand exactly at the mark. One-half of the vessel E' contains glass tubes to give larger surface for absorption.

Filling with potassium pyrogallate.--The vessel at the left in the drawing in J.R. (E) is used for the pyro solution. This is made by making a potassium hydroxide solution, then adding the pyro. The laboratory assistant stated that he had found that if the potassium hydroxide solution is not allowed to stand after it is made, i.e., if the pyrogallic acid is added as soon as the potassium hydroxide is cold, the pyro solution may be used the same day and good results obtained. Evidently, if the potassium hydroxide is allowed to stand exposed to the air before adding the pyrogallic acid, it does not work as well. In filling the pyrogallic acid vessel, fill with the solution nearly to the mark and then pour on a layer of paraffin oil in the rear vessel until the level in the capillary tube is just at the mark. The use of paraffin oil in the rear chamber of E protects the pyrogallic acid from the action of the air. Be careful not to put on too thick a layer of oil as it may overflow when the front vessel is subsequently filled with the air sample.

Blank air analysis.--It is first necessary to make a blank air analysis which, however, need not be quantitative in any sense, the main object being to fill the apparatus with the inert gas, nitrogen. Air is drawn into the apparatus through the stop-cock n, Fig. III, J.R., which is not connected with the sample pipette C. The reservoir D is lowered and by opening stop-cock s, mercury flows out of the graduated gas burette A, drawing in air behind it. The mercury level is carefully adjusted at the lower mark by raising or lowering the reservoir D and closing stop-cock s. The final adjustment must be made by moving the screw pinch-cock r which is attached to a rubber tube between the stop-cock s and the gas burette. This pinch-cock is clearly shown at the bottom of the apparatus in Fig. 19.

(The details of construction of a much more delicate apparatus for adjusting this mercury level are shown in Fig 63 on page 190.)

This adjustment permits of very careful levelling of the mercury in the capillary tube. When the level is properly adjusted, the stop-cock n is closed and the gas is then ready to be driven into one of the laboratory vessels, E'. The stopcock s must be closed, reservoir D raised somewhat before opening the stop-cock leading into vessel E'.

Under no circumstances must potassium hydroxide solution be allowed to enter the capillary tubes between the stop-cocks and the burette A. By raising the reservoir D, a certain pressure of gas is produced in A and thus there is no chance for the potassium hydroxide to be sucked into the capillary tube. The gas is completely driven into the potassium hydroxide chamber until the mercury rises to the cross branch immediately beneath the stopcock n. It is then drawn back into the burette a by lowering the reservoir, unusual care being taken not to draw the alkali in E too far into the capillary neck. This operation is re-

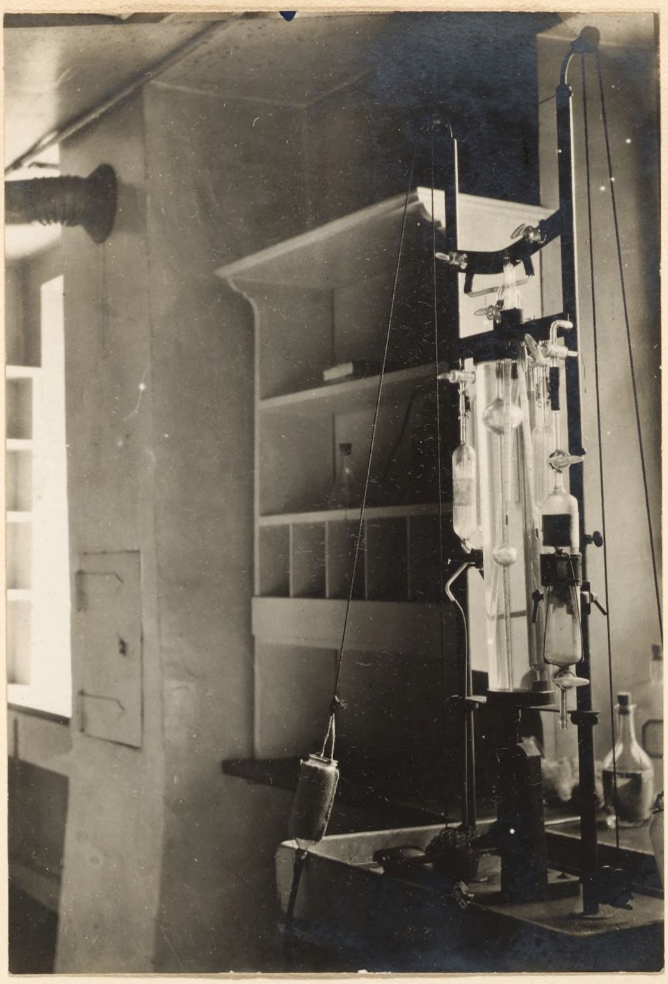


Fig. 20. Pettersson gas analysis apparatus, another view.

Another view of the Pettersson gas analysis apparatus with the laboratory vessels emptied and showing a little more clearly the construction of the gas burette.

repeated five times, always watching most carefully the level of the potassium hydrozide solution. It is not necessary at each of these operations to adjust the level of the gas absolutely, since it is done primarily to insure the complete absorption of gas and only the final measurements need be made exact. The laboratory assistant who performed these experiments was a typical diener and I tried to tell him that he could fill the apparatus with pure nitrogen with half this trouble. His reply was of interest and is a good standard for all routine analysts to work by, namely, that he never considered varying the operation by a hair's breadth at any time.

A similar procedure is carried out for the absorption of the oxygen in the potassium pyrogallate solution. The final adjustment of the level for the potassium hydroxide in the capillary portion of E and E' is made by the screw clamp in R.

The oxygen is absorbed by passing the gas back and forth over the pyrogallic acid solution 10 times, then it is alternated with the potassium hydroxide solution four times, i.e., four times over each. This absorbs any carbon monoxide that may have been formed so Prof. Jaquet thinks, and he has secured very good results with the method.

Supply of pyrogallic acid.--For keeping the large supply of pyrogallic acid solution, the liquid is placed in a two-necked Woulff bottle and a layer of paraffin oil poured over it. A rough sketch on page 36 of Note Book No. 1 shows the details. A double bent glass tube with a jet on the end in which is inserted a rubber stopper is put in one neck of the Woulff bottle and in the other a glass elbow through which air can be blown. The whole apparatus is on the principle of a wash bottle. The paraffin oil, of which there is a layer of about 1 cm., protects the solution thoroughly and the diener says that it keeps very well indeed in this flask.

Length of experiments.---With the Jaquet respiration apparatus the experiments last usually 12 hours but some have been made of 24 hours. With an apparatus constructed for dogs, Drs. Staehelin and Falta made a 5-day experiment with a dog which, however, was removed from the chamber one-half hour each day for catheterization.

Respiration chamber for dogs.--A chamber much smaller in size was used by Staehelin and Falta for experiments with dogs. A rough sketch of this chamber is given on pages 2 and 3 of Notebook No. 1. The cover was placed on the top of the chamber and a deep flange on the cover set in a rim around the edge of the chamber. This rim could be filled with water or paraffin oil. Prof. Jaquet suggested that calcium chloride brine would be better than water or oil as it has a very low coefficient of absorption for carbon dioxide.

Suggested improvements for the construction of the chamber.--With regard to the apparatus for men, I believe it is possible to make the chamber absolutely tight by sealing glass in with wax on the principle adopted at Middletown. The door is unquestionably too large. Half the present size would admit of the patient being rolled in on a bed and then once inside the chamber, he could sit up if he wished. A large piece of plate glass may be sealed in the opening. Another method would be to have an opening in the top and seal as Staehelin and Falta did the opening in the dog calorimeter. The pipe connections could be much improved. The supply pipe to conduct the incoming air should be very large so as to decrease resistance. The resistance between the chamber and the meter is of very little trouble as there would be no leaks if tight but on the other hand the incoming air must have very low resistance as otherwise there would be very low resistance inside the chamber. One must look out and not have the incoming air pipe so large as to cause backward diffusion and loss of carbon dioxide.

Composition of the air in the system.--The carbon dioxide content of the air inside the chamber is kept down by a ventilation of about 40 liters per minute to about 7 per mill. instead of 0.3. This is about 23 times normal. The air is very moist, soon saturated with water vapor, so Prof. Jaquet says, and condenses on the glass windows. The temperature of the chamber is not far from 17°, rarely over 20°. In a test experiment with the subject inside the chamber, the glass very soon became covered with moisture. The air enters the chamber near the feet of the man when lying down and several times men have felt cold from the incoming air current and had to wrap the feet at night.

Effect of leak.--As the pressure inside the chamber is diminished, there will always be a leak from the room into the chamber and consequently air from the room instead of air from the street would be taken into the system. In the room, the carbon dioxide content is probably somewhat higher than three parts per 10,000. Possibly, also, there would be some error in assuming that the per cent of oxygen in water- and carbon dioxide-free air as it might vary somewhat in the room. Consequently, it is of the greatest importance to eliminate as far as possible all leaks.

Carbonic acid content of ingoing air.--Prof. Jaquet assumes that the carbon dioxide is 0.03. I question the accuracy of this but nevertheless since the amount of carbon dioxide increases so materially during the progress of the experiment, a slight error in this assumption would not be very great. However, for the most accurate work, carbonic acid should be determined continuously.

Oxygen content of ingoing air.--A fundamental criticism of the Jaquet method for determining the respiratory exchange is based upon the fact that as at present carried out, it is necessary to assume a definite oxygen content of air. Prof. Jaquet at present assumes this value to be 20.96 per cent, based, he says, upon the work of Zuntz and his co-workers. In describing his results in J.R., page 265, he shows a value of 20.934 per cent and he refers to Pettersson as giving 20.94 per cent. Obviously, when the difference between the composition of the incoming and outgoing air is but 20.96, − ~~minus~~ 20.11, or 0.85 and the first figure is not certain to within 0.02, the error in assuming this figure is over 2 per cent of the total. If the analytical error be .2 per cent, there is a possible maximum error of nearly 4 per cent. Prof. Jaquet says that since his results are generally for comparative work, it is not so important to know the absolute content of the ingoing air. I discussed this point very carefully with Prof. Jaquet and feel that for the most accurate work, it would be necessary to make a continuous analysis of oxygen of the ingoing air, and preferably with the most accurate method possible. If results are not desired closer than 5 per cent, the Jaquet method would be all that could be asked for. Perhaps for clinical work, this may do.

Importance of pure mercury.--Very pure mercury must be used. Prof. Jaquet does not distill it but he purifies it by allowing it to flow in a very fine spray through 20 per cent nitric acid in a vertical tube with a capillary siphon at the bottom.

Extraordinarily pure oxygen.--I saw in the laboratory of the medical clinic a catalogue of the firm in Lucerne using oxygen of 99 per cent pure oxygen. The firm was A. Gmür, Sauerstoff u. Wasserstoff Fabrik, Lucerne, Switzerland. We are sending for a catalogue to see if it is not electrolytically prepared.

Pharmacological Laboratory of the University of Basel.

In his new ~~institute~~ laboratory, Prof. Jaquet has already installed a Speck spirometer ~~for~~ and his gas analysis apparatus. He also has a portable gas analysis apparatus for use in work in high altitudes.

Prof. Jaquet's criticism of the Zuntz apparatus.--In the Zuntz apparatus the gas is collected over water and the water may absorb appreciable amounts of carbonic acid. The rubber tubes at the top of the Zuntz apparatus are not capillary and hence a considerable error may occur in driving the gas back and forth. The use of phosphorus in absorbing oxygen is also very unsatisfactory. Hempel discusses this thoroughly. The last traces of oxygen are hard to remove with the use of phosphorus. Prof. Jaquet thinks that there may easily be an error of 10 per cent in the Zuntz method, especially in the work with a portable gas meter. The dry Elster gas meter is very inaccurate. The error in the meter itself may be 5 per cent.

Suggestions for improvement.--One great trouble is with the inaccuracy of the gas meter. This can be helped by calibrating by the new method in use in our laboratory and possibly we can insert the blower or ventilator between the respiration chamber and the meter and thus measure the gas under more normal conditions in the meter. Possibly it will be advisable to saturate the air with water vapor before it goes into it.

Jaquet favors the original Speck scheme.--The arguments in favor of the Speck method are that all the air breathed can be analyzed. Prof. Jaquet has a specially constructed Speck spirometer, holding 150 liters, which he can read accurately to 200 cc. He allowed for the temperature of the gas but considers that the temperature expansion of the metal of the gas holder would play no role. I am not so sure of this and would like to see it computed. For mountain researches, the Zuntz method is unsatisfactory. If one glass tube is broken, the whole experiment is at an end. It is impossible to transport a wet gas meter and so Prof. Jaquet uses a Speck spirometer which he can transport to any point he wishes to go in the Alps and carries with him a portable gas apparatus described by some one in Bohr's laboratory in 1895.(?) It is also described in the Skand. Archiv. This apparatus is very accurate and is made by the successor of Geissler. A special feature in the construction of his spirometer, showing again Prof. Jaquet's technique, is an aluminium balance wheel, on which the cord which suspends the gas meter rolls. This is constructed so that as more metal comes out of the water, more metal in the wheel is moved over the dead point on the balance wheel and thus the weight is exactly counterpoised. Prof. Jaquet showed me that when breathing into it, there is absolutely no pressure inside, as the compensation is so perfect. A wooden wax circular disc is placed on the inside of the spirometer to keep the gas away from the water and lessen the degree of absorption of the carbonic acid by the water.

Comment on mouth and nose breathing.--Prof. Jaquet prefers a mouthpiece as the nose is not as good since it is very irritating. With most patients, it is impossible to use even the mouthpiece. It takes a long time to train a subject into using the mouthpiece properly. Some never learn to use it properly; others only after weeks of practice. Thus it is hard to use it with patients as they are a circulating population,--here one day and the next away. Prof. Jaquet believes that the mouthpiece gives good results with trained men such as himself and with Zuntz and his co-workers. It can be used in the laboratory with regularly trained assistants but for clinical work, it is necessary to use some form of apparatus eliminating irregular breathing. Consequently, the chamber is by far the best. In his own mouth piece experiments, he always precedes his regular experiment with a 20-minute rest, sitting quietly on a very comfortable sofa or reclining chair, breathing through the mouthpiece. He observes, unbeknown to the subject, when the respiration rate becomes regular and the respiration normal. Usually he watches a button on the vest to see the rise and fall. He thought that perhaps a pneumograph might be used with a trained assistant but patients are frightened at any extra harness. He believes that the Speck valves made out of the intestines of a calf are the best valves. He keeps them in a salt solution and when well cared for, they last for years.

Comments on the respiratory quotient after work.--Prof. Jaquet has found repeatedly that after work there is a low output of carbonic acid but a large consumption of oxygen. He considers it not a storage of oxygen but the formation of a large amount of partially oxidized products such as lactic acid, etc. The observations on which this statement was based were made generally as the result of mountain climbing.

Water balance.--Prof. Jaquet does not take much stock in a water balance, at least when determined with his apparatus. His successor, Dr. Staehelin, worked a long time on it and Prof. Jaquet says that even with the body under the most constant conditions as regards diet, exercise, etc., there is a great difference per day in the total amount of water output, amounting to over 200 grams. He says this very greatly affects Rubner's calculations.

(Our experiments would not agree with Prof. Jaquet's statement that there is a marked difference in the water output under like conditions of the body. Just how it affects Rubner's calculations, I do not readily see.)

Prof. Jaquet was very critical of Rubner and says that his work is wrong because the value for the hungerwerthe is not correct. This affects all of Rubner's calculations. Prof. Jaquet also thinks that Zuntz's school is all wrong as they depend upon the hungerwerthe. Magnus-Levy's experiments on fat men were all wrong as the hungerwerthe used was only determined after 12 hours of fasting.

(This does not agree with statements in the separate sent me by Magnus-Levy.)

Prof. Jaquet says that the hungerwerthe in man can be secured by people with quick digestion in 12 hours but with fat people, he found by actual experiment, it was not obtained in even 18 or 20 hours, or even 24 hours.

(The actual fasting value in hungerwerthe is probably not reached until the second or third day of fasting, as shown by our recent work.)

General criticism of Prof. Jaquet and his apparatus.---Of all the men that I met on my tour, Prof. Jaquet impressed me as being one of the keenest, especially in lines involving technique and the art of the instrument maker. He is full of ideas and it would be of great benefit to the Nutrition Laboratory if Prof. Jaquet could be induced to come to us for a part of the year. I personally feel that the principle he has so interestingly outlined in his apparatus is capable of most wonderful development, giving an extremely accurate method for determining oxygen. (We have now, thanks to Pettersson and the other Scandinavian investigators, a remarkably accurate method for determining carbonic acid.) The respiratory quotient could be determined with great accuracy. For an unusually accurate eudiometric method of determining oxygen, see discussion of apparatus in Chauveau's laboratory, page 260. An apparatus of the Jaquet type will be constructed, elaborated, if necessary, and carefully tested in the new Nutrition Laboratory. The possibility of its introduction for clinical use should not be lost sight of.

BERNE, SWITZERLAND.

Physiological Institute (Hallerianum).

Professors Kronecker and Asher and Dr. Gamgee.

Influence of high altitudes on metabolism.--In common with many of the other Swiss investigators, Prof. Kronecker has studied the question of the effect of high altitudes on respiratory exchange and the mechanics of respiration, as well as mountain sickness. A study of the carbonic acid excretion during muscular work was also made. He has a peculiar respiration apparatus which is described in the dissertation by Emil Buergel and published in the Archiv f. Anatomie u. Physiologie (1900).

Mouth-piece.--Prof. Kronecker says that he went all through the mouth-piece hunt before Zuntz did and is very much dissatisfied with it, especially with those mouthpieces which have a projecting piece between the teeth. He thinks this tends to stimulate the flow of saliva. He used the Zuntz mouth-piece years ago without the two projections and although he still gets some saliva, he has a little trap to catch it. He objects strongly to the Zuntz analysis system as only an aliquot sample is taken. Prof. Kronecker, on the other hand, determines the total carbonic acid output ~~by the Wendling method~~, using glass absorbers containing fused soda lime, the whole of the expired air being passed through these absorbers. To avoid friction in breathing which is caused by the resistance of the soda lime, he has a man walk behind the person experimented upon and work a hand pump which forces the expired air through the soda lime after having forced it through sulphuric acid to dry it. As a matter of fact, he gets abnormally high results for a man at rest. In one case, with a man weighing 98 kilos (fat, to be sure), he obtained in ten minutes about 10 grams of carbonic acid or nearly twice what we get with our men at rest.

Prof. Kronecker maintains that he gets better results than the Zuntz method because he gets more carbonic acid than the Zuntz method does.

Prof. Kronecker says that he knows no laws of nature, is never surprised at what he finds and thinks we are too much governed by what we expect to find. There is a certain element of truth in this but Prof. Kronecker's abnormal results are probably due to errors in the method rather than to the fact that all of the other investigators are wrong. He is very right in saying that we have given too little attention to intermediate metabolism.

Respiration experiments on rabbits.--A rabbit was placed in the glass vessel of a Mosso ~~physt~~plethys-mograph and the rabbit connected with a tracheal canula with a bell jar containing a caustic potash solution. As the oxygen was absorbed by the animal and the carbon dioxide by the caustic potash, free nitrogen was admitted. At the end of three hours or thereabouts (Prof. Kronecker was not sure about the time) the rabbit was still alive and the air he was breathing contained practically no oxygen (about 2 per cent). Prof. Kronecker thinks that the difficulty in respiration is the presence of carbonic acid and that if pains were taken to remove the carbonic acid, there would be no trouble and the animal might live a long time with very little or no oxygen. (This reminds one of Pfluger's experiments with a frog's muscle. See also the discussion of Weinland's experiments on ascaris in the discussion of the Munich laboratory.) Prof. Kronecker's results are to be published soon in the Ztsch. f. Biologie. He expects ultimately to see how long animals will live with small amounts of oxygen and considers the field very wide.

Dr. Gamgee criticises Prof. Kronecker's chemical work very severely.

Experiments on the influence of pressure on the lungs.--The tracheal canula employed in the above described experiments with rabbits was used primarily for the study of the supplementary problem of the effect of different pressures on the inside and outside of the lungs. Secondly, rabbits are very sensitive to the presence of increased carbon dioxide in the air. It acts reflexively on the nose mucous and closes the nose so that regular nasal breathing could not be employed.

With regard to the pressure on the lungs, he found that if there was a difference of 30 mm. of mercury in either direction, it would kill the animal. If there was a diminished pressure on the outside of the body, the animal would become distended and actually blow up. A study of this problem was possible only with the canula.

Researches on the heart.--Prof. Kronecker is especially interested in problems of intermediary metabolism and thinks we have been all wrong in devoting our time to work involving only measurement of the end products of metabolism. He was led to this work by his studies of mountain sickness. He thinks that mountain sickness is the physical effect of the pressure on the lungs and does not agree with the ideas regarding the influence of the variations in percentage of oxygen, carbonic acid, etc. Going back to the old experiments of Hermann and Pflüger, he finds that a muscle dan work for some time in a carbon dioxide free atmosphere, or indeed, in a vacuum, i.e., does not need any oxygen. Prof. Kronecker has washed out a frog's heart and let fresh blood pass through it and the heart worked. If a solution of glycogen was passed through it, the heart refused to work. With serum globulin, the heart worked, but not with serum albumin. If he allowed ferments to act on the blood and regenerate serum globulin, then the blood which formerly would not nourish the heart did so again. Prof. Kronecker believes that all the proteids are resynthesized in the wall and surrounding coat of the intestine to serum globulin and can then nourish the body. Oxygen is not necessary. The carbon dioxide is split off and becomes poison but when removed, the metabolism is normal. Prof. Kronecker finds that he can nourish a heart from which all the gas has been pumped, and believes that the important thing in the blood is the serum globulin and not the corpuscles. In the dog, he removed all but one-fiftieth of the blood and replaced it with horse serum. (Dog serum will kill the dog and horse serum will kill some dogs.) The dog lived and in a few weeks it had recovered the normal number of blood corpuscles. All of Prof. Kronecker's experiments go to show that oxygen is not necessary.

Prof. Kronecker opposes Mosso's theory regarding the cure of mountain sickness by the administration of more carbon dioxide. He says that if that is the case, then the subject had better simply stop breathing and if breathing is stopped when on a mountain, the feeling becomes still worse. He also maintains that if Mosso's theory is correct, the subjects ought to feel better with severe work as more carbonic acid is produced. As a matter of fact, it was found that if a person worked hard on a mountain and produced more carbonic acid, then the mountain sickness became more aggravated. Prof. Kronecker admits, however, that this is not a very good argument.

<u>Glycogen in the heart</u>.--In discussing Prof. Kronecker's experiments

on the transfusion of serum through the heart, I asked him if he had made any study of the amount of glycogen present in the heart muscles. This he had neglected to do. Prof. Kronecker contends that the work of the heart is done at the expense of the breaking down of the serum globulin of the blood as it passes through. It would seem that he must prove the absence of any loss of glycogen first. It is conceivable, for example, that serum globulin may stimulate the muscles to work and that the real source may be the glycogen after all. This is not in any way against the idea that the glycogen solution is insufficient for the working heart but contrary to the Kronecker idea that it is serum globulin that furnishes the nourishing portion. I think that the serum globulin may simply stimulate to the assimulation of the glycogen.

Internal thermometers.--Many years ago, Prof. Kronecker studied the temperature of the intestinal tract. Mercury thermometers were devised so as to be swallowed and then withdrawn to give the stomach temperature, and swallowed and allowed to pass into the feces for the temperature of the ~~feces~~ intestine. They consisted of small glass globules with drawn out point filed off at a 45° angle so as to let the drop of mercury fall off quickly. These globules were filled with mercury enclosed in a silver capsule, and looked like a regular gelatine capsule, with three little holes in one end. These holes allowed for the expansion of the air and also allowed the mercury to escape. After having passed through the body, the capsules were calibrated by placing in water, and warming the water until the mercury rose to the top of the capillary. This point indicates the temperature to which the capsule was subjected while inside the body.

Prof. Kronecker found the highest temperature in the small intestine and a higher temperature in the pancreas than in the liver. Somewhere between the stomach and the rectum there was a locality where the highest temperature was found.

Critizism of Rubner.--Prof. Kronecker thinks that Rubner's values are false as the experiments are too short and he neglects wholly intermediary metabolism and anabolic processes.

Two books found in Prof. Kronecker's library.--Two books were found in Prof. Kronecker's library of especial interest to the Nutrition Laboratory. One was entitled "Some apostles of physiology" by Wm. Stirling, privately printed by Waterlow & Sons, Ltd., London, (1902). This was presented to Prof. Kronecker and is evidently not in the market.

The other book was entitled "Textbook of Physiology" by Isaac Ott of the Medico-Chirurgical College of Philadelphia, published by F. A. Davis Company, Philadelphia. In this book Prof. Ott describes a calorimeter for man devised by himself and states, also, that he has made a small one for animals. The ventilation was about 5000 to 6000 liters of air per hour. The man lies on a mattress in a cylinder 6 ft. long and 2 ft. in diameter, the apparatus being packed in sawdust. The interior is absolutely dark save for the light from one candle power electric lamp. Prof. Ott maintains that 14 per cent of the heat is dissipated by the lungs. With regard to the calibration, he states that in the little calorimeter for animals, the error is 5.4 per cent. He does not give the details for the large one.

Discussion with Professor Asher.

Criticism of Cohnheim's work.--With reference to the recent publication from Rubner's laboratory by Cohnheim, giving the results of experiments with Rubner's calorimeter on a dog with a Pawlow fistula and with false feeding, Prof. Asher said that inasmuch as the experiments were made in Rubner's laboratory, Cohnheim wrote the article to favor as far as possible Rubner's views. Zuntz and Rubner contend that there is no specific dynamic action of protein and Cohnheim had to write it as far as possible from the Rubner view point. Prof. Asher says that he would not have expected anything different from the experiments as made by Cohnheim than what he found. He says that Cohnheim is a very bright fellow but his chemical work is not of the best. He has a fine head, with lots of ideas, but he is a poor chemist.

At present Emden disagrees with Cohnheim on his work on glycosis. Cohnheim finds that a sugar solution ~~of~~ and the extract of pancreas gives nothing and a meat extract plus sugar gives nothing, but that a flesh extract plus pancreas extract plus sugar gives a reduction. Emden on the contrary says that work with sterile solutions gave no reduction. Prof. Asher says Emden has the best of it but the question is not yet settled.

Comments on Prof. Jaquet.--Prof. Asher speaks in the highest terms of Prof. Jaquet whom he considers a brilliant man but poorly treated in Basel., He believes that one would go a long way before finding a better man than Prof. Jaquet. He thinks the best clinical man in Germany is Friederich Mueller of Munich.

Specific dynamic action of protein.--Rubner and Zuntz are opposed to this theory. Prof. Asher maintains that we should get over the idea of a mysterious property of protein. It is a chemical compound the same as fats and carbohydrates, and there is nothing mysterious about it.

The importance of anabolic processes.--Prof. Asher considers that we have thought too little of anabolic processes in metabolism work. I called his attention to the fact that while undoubtedly theee were great qualitative changes in the products of intermediary metabolism, there can be no very great differences as far as quantitative changes were concerned. Prof. Asher gave a *feeble* assent to this, mentioning the formation of lactic acid, etc.

Discussion with Dr. Gamgee.

Research on body temperature.--At present Dr. Gamgee is engaged in a study of methods for registering photographically with a self-recording instrument the temperature fluctuations of the human body. He is using thermal junctions consisting of copper and constantan in the belief that for accurate work, the junctions should be of the same metal as the leads so as to avoid a junction effect when connecting with the leads. He has both of the terminal or binding posts on his galvanometer constructed of copper. One lead to the second or comparison junction from the galvanometer is of copper, the other of constantan.

He has constructed a very delicate thermostat to hold one of the junctions at 37° permanently. The thermostat is shown in Figs. 21 and 22. The thermostat is of special construction and he has given a great deal of thought to it. There are about eight inches of water in it so the temperature fluctuations are very slow. A toluol thermo-regulator controls the gas flow which supplies four micro-burners. An interesting turbine stirrer is actuated by an electric motor. This stirrer is an endless screw working in a tight tube and it stirs the water very powerfully. The thermometer which is shown at the left of the stirring spindle is constructed wholly of glass, including a glass scale. The graduations are on this scale so as to enable it to be photographed if necessary. The thermometer is constructed of Jena glass and the calibrations run from 34° to 43°. It is graduated in 1/50ths of a degree and is calibrated by the Physikalisch Technische Reichsanstalt. This glass thermometer is used only to hold the standard junction at a constant temperature and Dr. Gamgee intended to photograph the fluctuations of his mercurial column but since the bath is so

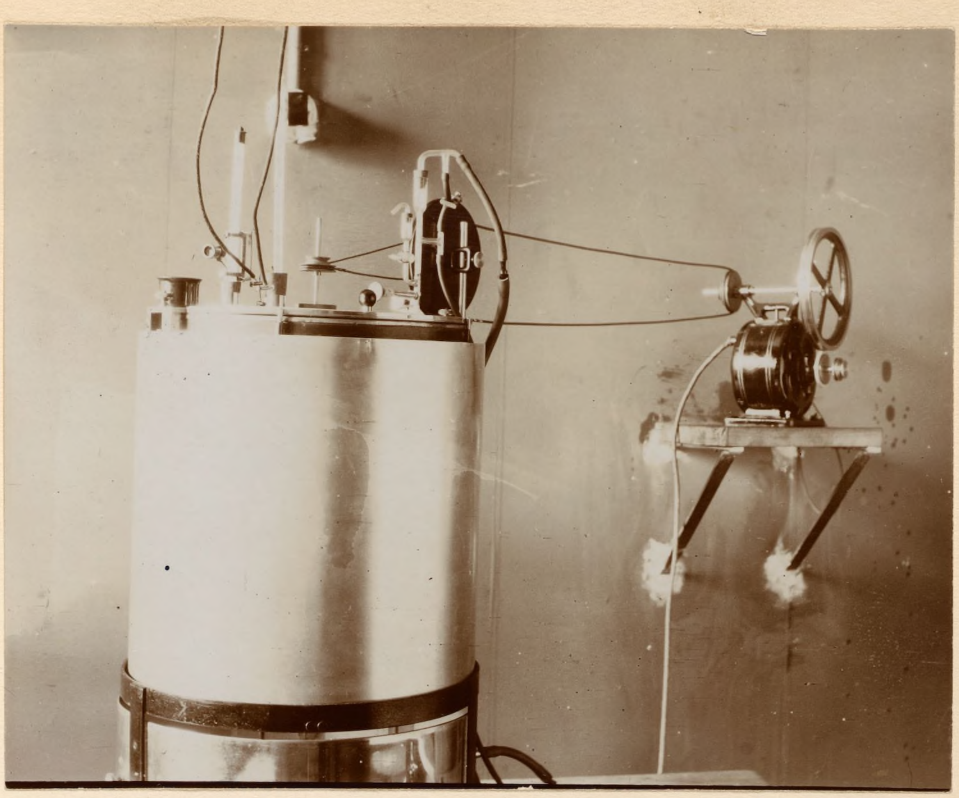


Fig. 21. Thermostat and electric stirrer used by Dr. Gamgee for body temperature work.

Of the two heavy wires coming from the top of the room, one is of constantan, leading directly to the constantan branch of the second thermal junction which is used for determining the temperature of the body. The other lead is of copper and goes directly to the connections of the galvanometer. A mercurial thermometer at the left of the centre of the apparatus with an eyepiece attached to it is used for noting the gross fluctuations in the bath when adjusting it. The thermometer nearly in the centre of the apparatus is of special construction (glass) for photographing the fluctuations in the mercurial column. A toluol gas regulator is at the right and electric motor with interesting speed reduction attached to the wheel.

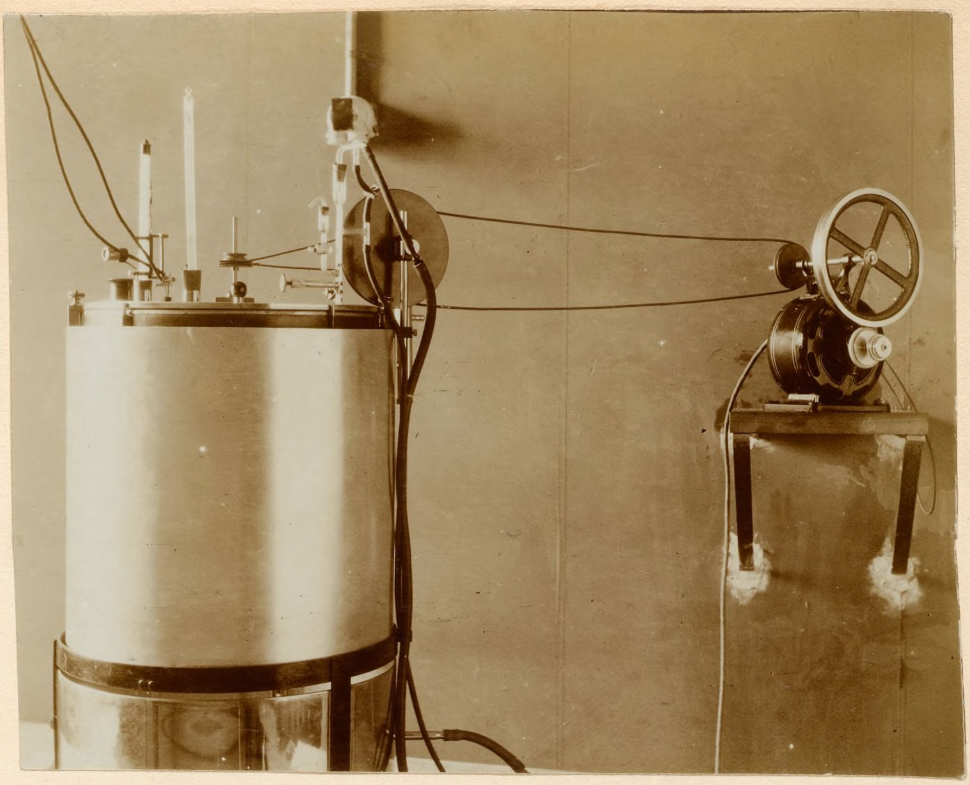


Fig. 22. <u>Another view of the apparatus shown in Fig. 21.</u>

constant, he has decided not to register the temperature fluctuations.

He has a very sensitive galvanometer made by the Cambridge Instrument Company and a Nernst lamp. The registering apparatus with photographing box and slit, as well as the method of getting the register, is described in the catalogues of the Cambridge Instrument Company and in a book written by Augustus Waller, published by John Murray, London, (1903) and entitled "Signs of Life".

Electric motor.--An interesting electric motor with reduction of speed is used in connection with this thermostat. On the armature of this motor is a rubber-tired wheel which presses against the face of a large fly wheel supported from the top of the motor by two bearings. The small motor is about the size of the one we have formerly used in Middletown for stirring the water in the bomb calorimeter, but I think this method of reducing the speed is much preferable to the worm gear, which is very noisy. I think the motor was supplied by Fritz Koehler, of Leipsic. The motor is shown in both Figs. 21 and 22.

Importance of body temperature studies for pathology.--Dr. Gamgee proposes when the method is developed to have a central room in a hospital with wires running to each bed and have all the temperature observations made at one time. He can thereby study the temperature curves in the course of a disease. Especially in phthisis does he find that patients react to exercise markedly. The rapidity with which they return to the initial temperature aft after exercise he believes of great importance in diagnosis.

Dr. Gamgee's report on nutrition.--Several years ago, Dr. Gamgee was commissioned by the Carnegie Institution of Washington to prepare a report on the status of nutrition. I found it very difficult to obtain any satisfactory information regarding the present condition of this report but I believe, as the result of many conversations with him, that nothing whatever has been done so far as writing the report is concerned, other than the translation into very fine English of an article prepared by Loewy of Berlin. Dr. Gamgee was very anxious to have his translation of this article taken up by the Carnegie Institution of Washington and published. The article was written several years ago by Loewy, the method has undergone considerable minor modifications and with numerous changes in the technique, so that I fear this article would be wholly out of date for publication at the present time. It is highly improbable that Dr. Gamgee could be induced to bring the article up to date, although with the active cooperation of Loewy and Durig of Vienna, this might possibly be done.

MUNICH, GERMANY.

Physiological Institute of the University.

Professors Voit, Cremer, and Weinland and Dr. Heilner.

Pettenkofer-Voit respiration apparatus.--The classical researches of Pettenkofer and Voit on the respiration of man were made in this laboratory and the original apparatus, although not now in an operating condition, is retained sufficiently well installed for exhibition purposes. The section of the laboratory in which the apparatus is placed, is kept in excellent order and it is evidently one of the show things in the Munich laboratory. It has not been used for many years.

Inside of the large iron chamber is a smaller wooden chamber which was constructed, I imagine, in order to have a smaller volume of air when the man was at rest. The chamber is shown in part in Figs. 23 and 24. The great gas meter which was used to measure the volume of air passing through the chamber is also shown in these two views as well as the small gas meters for the sampling of the ingoing and outcoming air current. The lighting of the laboratory room was so poor that it was difficult to secure good photographs. Fig. 25 gives another view of the large gas meter and the small meters.

While this apparatus has been most prolific of results in earlier years, it is for practical purposes ~~unusable~~ useless at the present time. Even the ventilating air pipes are not connected. The mercury valves through which the sub-samples of air were drawn are

Fig. 23. General view of the Pettenkofer-Voit respiration apparatus.

Large chamber with ventilating air pipes in the rear and the great gas meter in the foreground. The four small meters for the samples are on a table in the middle of the room.

Fig. 24. View of small meters used with the Pettenkofer-Voit respiration apparatus.

The respiration chamber is at the left, the great gas meter at the right.

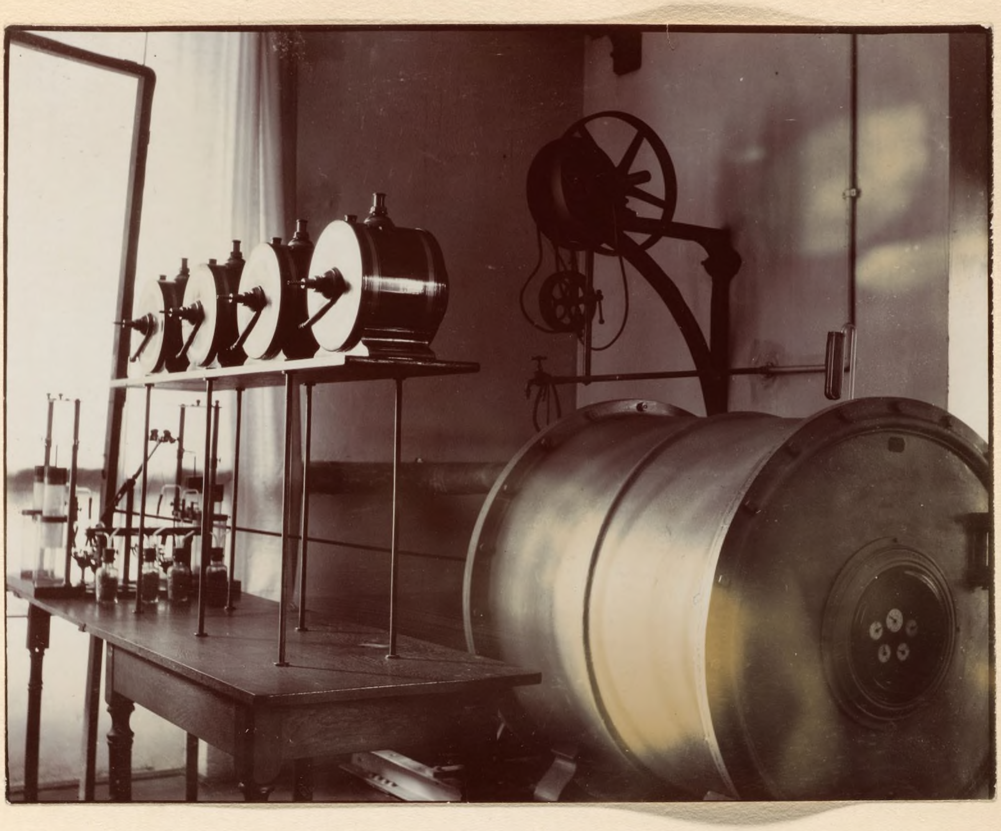


Fig. 25. Large and small gas meters of the Pettenkofer-Voit respiration apparatus.

The large gas meter was used for measuring the main ventilating air current and the small meters for the sub-samples.

only in part installed. These are shown at the farther end of the table in Figs. 24 and 25.

Apparatus for studying the effect of muscular work.--Another apparatus no longer in use but constructed many years ago is at present retained in the laboratory at Munich. This is an apparatus for studying the effect of muscular work on man. It is shown in Fig. 26. A galvanized iron box with small windows near the top has a piece of shafting with a wheel in the outside passing through the walls. The man inside revolves the shafting with a handle and the large wheel on the outside connects with a brake. The ventilation was by means of the large gas meter of the Pettenkofer-Voit respiration apparatus. So far as I know, no results of experiments made with this apparatus have ever been published.

Voit-Rubner apparatus for small animals.--In recent years the Munich laboratory has been devoting its attention to the study of the respiration of animals rather than man and Voit, together with Rubner, has constructed an apparatus for use with small animals which is based on the principle of the large one. This is shown in detail in Figs. 27 and 28. A glass-walled box is used as a chamber. A ventilating current of air is drawn through the apparatus by means of the gas meter shown at the further end of the table. The amount of air passed through is measured by the meter and small gas meters are used to take samples in duplicate of the ingoing and outcoming air. The sample of ingoing air is taken near the intake shown in the upper right hand side of the chamber in Fig. 27. The sample of gas is passed through a long tube containing barium hydroxide of known strength. This is followed by a second tube and in some cases by a third. Rarely, however, in experiments of this nature is the third tube used. The carbonic

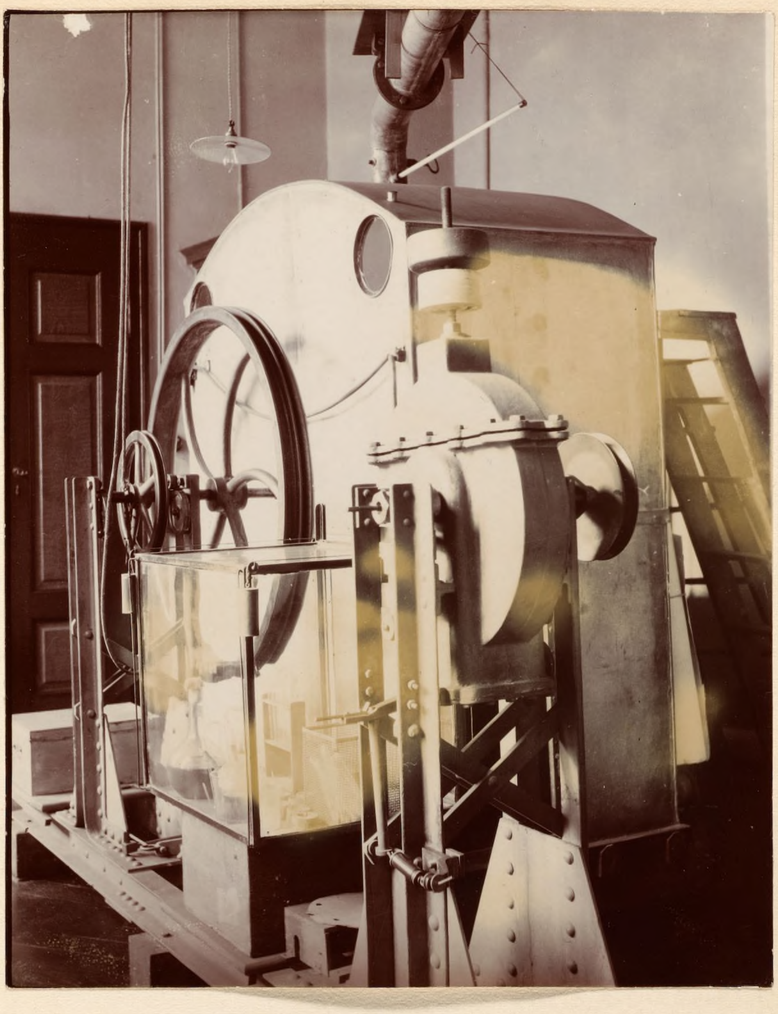


Fig. 26. Apparatus for studying muscular work on man,

This shows the galvanized iron chamber in which the man is confined. The rod to which the large wheel is attached extends to the chamber and is there rotated by the man. The large wheel is belted to the brake in the foreground.

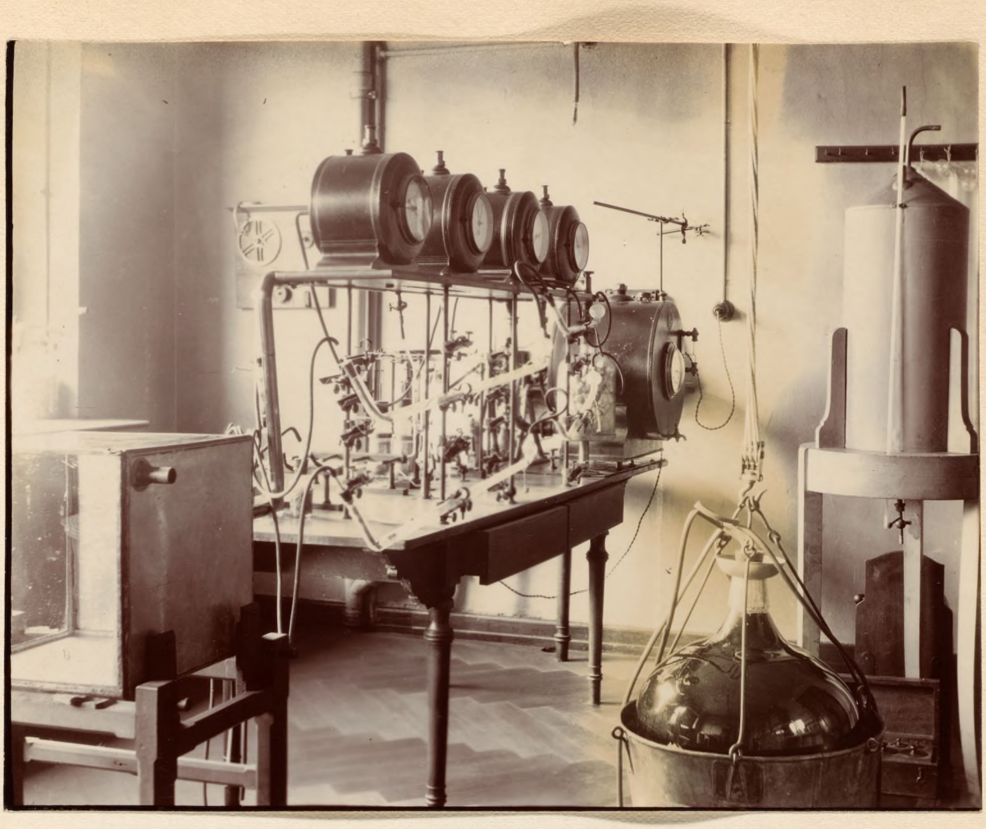


Fig. 27. Voit-Rubner respiration apparatus for small animals.

This photograph shows the glass-walled chamber at the left, large gas meter for the main air current against the wall at the rear, four small gas meters for incoming and outgoing air analyzed in duplicate at the top of the table. The long inclined tubes contain barium hydroxide. The carboy suspended on the fall and tackle and the aspirator at the right are for calibrating the meters.

Fig. 28. Another view of the Voit-Rubner respiration apparatus.

This view shows the respiration chamber and aspirator at the right. Against the walls are the barium hydroxide tubes. On the table beneath the meters are the barium hydroxide tubes clamped in an inclined position. Below the meters on the table are bottles containing pumice stone and sulphuric acid for drying the air and at the rear on the wall are the pump and valves.

acid is determined by titrating with sulphuric acid. The results are said to be very accurate. The large carboy and aspirator at the right in Fig. 27 are used for calibrating gas meters. This constitutes one of the greatest objections to this form of apparatus. The absolute accuracy of the gas meter is of fundamental importance. These meters, even though of the best construction, vary considerably in their regularity and hence must be calibrated frequently, often after every experiment. The large carboy is used to collect water which is weighed and from the weight of the water, the amount of air drawn through the meter is computed.

A row of barium hydroxide tubes which are emptied are shown hanging on the wall at the right in Fig. 28. The details of the clamps for holding these tubes and also the bottles with pumice stone and sulphuric acid for drying the air are likewise shown in this view. This apparatus has been used a great deal for experiments with rabbits and dogs. At present Dr. Heilner is using it for rabbit experiments. Dr. Heilner states that rabbits are very quiet in the respiration apparatus and also that bull dogs are very good animals to experiment on. Voit, in arguing in favor of using animals lays great stress on the fact that they can be fed a single diet without difficulty. The loss in weight of the animals is determined very accurately by means of a sensitive balance but not until the end of the experiment as no provision is made for weighing the animal while inside the apparatus. For Dr. Heilner's observations on the quiet of animals, see Zeit. f. Biol., *48*, page 177.

Rubner's calorimeter and hot air chamber.--Rubner, who was formerly an assistant in Munich, constructed his first calorimeter for dogs here. The original apparatus is shown at the right in

Fig. 29. Rubner's hot air chamber and calorimeter.

The calorimeter is at the right, showing the stopcock at the bottom for drawing off the water and the glass window at the front end. The top is screwed down with thumb screws. In the centre of the photograph is the Rubner hot air chamber in which dogs are placed with temperature up to 33°. Carbonic acid was determined but no heat measurements were made.

Figure 29.

The exact construction of the calorimeter is that of a double-walled chamber having a water jacket and the heat is absorbed by the water and subsequently radiated into the room. Rubner has a new apparatus in Berlin and I likewise found one in Tangl's laboratory in Budapest. The hot air chamber was used for the studying of carbonic acid given off by dogs at different temperatures. By means of this apparatus Rubner brought out his theory of chemical regulation and also the specific dynamic action of protein.

<u>Glycogen in ascaris</u>.--Prof. Weinland has been working for a considerable time on the glycogen content of ascaris,--an intestinal worm in the hog and horse. He finds a very large amount of glycogen in these worms, in some cases, nearly 50 per cent of the dry weight. Since many hogs contain the ascaris in large amounts, he maintains that enormous amounts of glycogen could be prepared in the Chicago packing houses. He uses Kulz's method for separating the glycogen.

<u>Life without oxygen</u>.--In his experiments with ascaris, Weinland found that they can live a long time (three or four days, I think) in a solution free from oxygen. He takes a salt solution and saturates it with carbonic acid. He finds that the ascaris live by splitting off in the molecule of glycogen a molecule of oxygen and setting free valerianic acid. Singularly enough, as a by-product they appear to eliminate a fatty organic poison which makes it difficult for one to work with these worms. The exact nature of the poison has not been studied.

Conversion of glycogen during fasting.--Voit was much surprised that in the experiments with fasting men we found so much glycogen was burned and he agreed with the suggestion made by Weinland that we ought to try a man with a fat diet beforehand, by feeding a man bacon and butter with a little succulent green food for, say, three or four days and also try a man on carbohydrate diet under like conditions. In the fasting experiments with Middletown subjects, we had to take the men as they came, with a previous diet arbitrarily selected by the men. Voit and Weinland think that we would find with a fat diet the amount of glycogen on the first day would be very much less.

Sub-cutaneous injection of carbohydrates.--In studying the work of digestion it is very important to note the effect of sub-cutaneous injections of carbohydrates as by these injections there is no necessity for the activity of the intestinal tract. Heilner has made studies with rabbits and obtained some very interesting results. He told me that Fritz Voit had injected into himself 150 grams of glucose in, I think, 500 grams of water without danger. Heilner says that this is commonly used after surgical operations to nourish the patient. This is a very profitable line of study with regard to the question of the work of digestion.

Pre-mortal rise of nitrogen.--While this is absent with dogs, Heilner finds it very regular with rabbits on about the seventh day. The nitrogen excretion for rabbits is very constant for each day of the fast so that one can almost predict its excretion. He has given results in the paper in the Zeit. f. Biol. where he also reports the results of the injection of glucose in rabbits. This paper has to deal with the work of digestion.

Drinking water experiments.--Discussing the influence of the ingestion of large amounts of water, Heilner says that when drinking water fills a physiological function, as for a subject with diabetes insipidus, the large amounts of water do not hasten the disintegration of protein. His results on rabbits go to prove this theory.

<u>Electricity in the laboratory</u>.--Prof. Cremer has a very finely equipped laboratory containing a large number of extremely delicate electrical contrivances for studying physiological problems. The most noticeable are perhaps the 8-contact Helmholtz pendulum and a very fine Saitengalvanometer of Einthoven's. He also has a very ingenious photographic representation apparatus for the registration of temperatures which allows a photograph plate to fall in front of a beam of light. He uses an electric brake as was used on the bicycle ergometer in Middletown. His apparatus is described in large part in the catalogues of the firm of Edelmann in Munich. Einthoven's articles appeared in the Ann. Phys., <u>12</u>, 1903, page, 1059, and also in the same journal, vol. 14, page 183.

<u>General impressions of the Munich laboratory</u>.--The advancing age of Prof. Voit and the uncertainty of his probable successor have contributed toward bringing the work in the Munich laboratory to a rather quiet state. Both Dr. Weinland and Dr. Heilner are conducting experiments and doing very good work, as is indeed, Prof. Cremer, but there seems to be a lack of unanimity and of a tone of research which is sad to see in a laboratory that has produced the classical researches that this laboratory has. Dr. Heilner appeared to be a very able, bright, physiologist, though with not especially good judgment. He seemed to delight in polemics but was full of ideas and keenly critical. Prof. Cremer

is most ingenious in electrical devices and believes that ultimately all titrations and all chemical laboratory work will be carried out by electrical means. He believes that it will be possible to adjust the heating of the air spaces about the calorimeter by means of the Saitengalvanometer and electrical contacts. He is free to admit that he is rather given to fantasies. One of the pleasures of my visit to Munich was the opportunity of going to the first lecture of the semester by Prof. Voit on nutrition. The activity of this remarkable old gentleman is pleasant to behold.

VIENNA, AUSTRIA.

Hospital Clinic of Prof. von Noorden.

Drs. Falta and Eppinger.

Prof. vonNoorden has but recently gone to Vienna from Frankfort and hence his laboratory is new and has just been ~~fully~~ equipped. The laboratory is located in a small wooden building nearly in the centre of the great yard of a large hospital in Vienna. Fig. 30 shows a general view of one of the tables. White tiles are used extensively in the construction, although the table tops are apparently of soapstone with white enamel stone at the end near the sink. I am not sure of the exact nature of this top.

Frequent use is made of labels with black letters on an enamelled white ground hung by chains around the neck of bottles such as is shown on the top of the rack between the tables in Fig. 30. All of the faucets have hose bibs and are so adjusted that the couplings for connecting a small rubber hose can rapidly be attached. The joints are all ground and require no washers. The plumbing is so installed that there are shut-offs underneath the desks so that repairs can easily be made.

Temperature regulating device for rooms.--In ~~all~~ Each of the rooms in this laboratory there is a temperature regulating device for controlling gas stoves. This device is shown near the top of the wall in Fig. 31. It is constructed by Rohrbecks Nachfolger in Vienna, on the principle of the expansion of metals. It consists of two U-form metal pieces which contract ~~and~~ or expand with ~~heat~~ cold and ~~cold~~ heat, and operate a valve of the gas supply. The piping and valve

Fig. 30. General view of laboratory of Prof. von Noorden's clinic.

Fig. 31. View of the temperature regulator in von Noorden's laboratory.

At the right, out of focus, are the details of the water cock with union for the adjustment of small rubber tubing.

arrangements are shown at the left of the regulator and the gas stove near on the floor. This gas regulator and stove controls the the temperature of the laboratory very satisfactorily, even in the cold weather. The use of this regulator and gas stove in the animal calorimeter room of the new laboratory may prove very satisfactory. The greater part of the heating may be done with steam and the final regulation with gas.

Hood.--A typical hood is shown at the left in Fig. 31., Inside the hood is a distilling apparatus for determining acetone and water bath and air bath. Much use is made in this laboratory of a highly compressed mixture of asbestos and cement in the form of sheets called eternit, especially in the construction of water baths and the insulation of heating surfaces in general.

Kjeldahl distillation apparatus.--In nearly every laboratory one finds a different arrangement for distillation in the Kjeldahl apparatus. The still used in vonNoorden's laboratory is shown in Fig. 32. Water is used for cooling and the long-necked flasks are used for both digestion and distillation, thereby avoiding the trouble of transferring. The caustic soda is admitted to the flask through a funnel with a glass stop-cock attached to the cork of a distilling flask. The usual safety tube at the top is used to retain any alkali carried forward mechanically. The assistants in the laboratory maintain that there is no difficulty in using this glass stopcock and funnel in introducing the caustic soda. This is contrary to the experience of almost all who have kept sodium hydroxide in glass-stoppered bottles, but inasmuch as the laboratory has not been in use for a long time, their experience is yet to come.

The ammonia liberated in the distillation is collected in a 2-necked Woulff bottle shown at the right of the still in Fig. 32,

Fig. 32. Kjeldahl distillation apparatus in use in laboratory of Prof. von Noorden's clinic.

Glass stoppered funnel for the introduction of sodium hydroxide is inserted in the cork of the flask. Ammonia is distilled into the 2-necked Woulff bottle containing dilute standard acid.

which contains the standard acid. In the central stopper of the Woulff bottle is inserted a small glass tube with glass beads in the enlargement at the end. A cork with a glass tube bent in a downward direction is inserted in the widened end of the tube. By this means there is no chance for the ammonia to escape as the beads are moistened with the dilute acid in the Woulff bottle.

At the right of the Woulff bottle is shown an ordinary bottle adjusted for distilling acetone. The acetone still is shown in Fig. 31. The bottle has a double bent glass tube and test tube, with a slot in the cork. This test tube is attached to the end of a double bent tube. By this means, the acetone vapor must pass twice through the absorbent, the small test tube acting as a safety trap. It is assumed that no ~~acid~~ acetone passes out of this tube.

Ammonia determination.--The apparatus for the determination of ammonia by aspirating air through heated urine is shown in Fig. 33. At the left in the figure is shown the ether extraction apparatus. Both are heated by electric lamps. The air is sucked ~~from~~ through the urine by a suction pipe with branch cocks for each tube. A lot of minor apparatus is in the foreground. Lying on the table at the right is a Peligot U-tube for ammonia absorption. Immediately in front of it are small test tubes and double bent tubes which are attached to the bottles for acetone distillation. At the left is a bottle of copper sulphate, then the large bottle for acetone distillation and at the left of the hood upright is the Kjeldahl distillation acid flask. The sockets holding the electric lamps for heating are shown in a horizontal position in both pieces of apparatus. A specially interesting condenser was used for the ether in that the cooling water passed through a coil of small tubing blown into the centre of the pipette-like condenser, the water traversing this coil

Fig. 33. Apparatus for the determination of ammonia in urine (right); ether extraction apparatus (left) in Prof. von Noorden's laboratory.

Electrical heating is employed and the apparatus is in large part constructed of eternit. In the foreground (from right to left) are the Peligot glass tubes, bottle for the condensation of acetone, 2-necked Woulff bottle for holding the acetone in distillation.

of small pipe and thereby condensing the ether. This is probably described fully in some instrument catalogue.

- Asbestos sheet with cement.--Both pieces of apparatus shown in Fig. 33 and constructed in large part of the mixture of asbestos and cement referred to previously as eternit. This is secured in Vienna in all sizes. It is hard, waterproof, and acts something like hard rubber but not as hard.

Respiration and minor apparatus.--In another portion of the hospital grounds is a room which is being used at present for preliminary investigations on respiration by Drs. Falta and Eppinger. In this room there is also an animal cage for dogs that have been operated upon. Dr. Eppinger has tried to substitute a hood for the nose or mouth respiration apparatus. This hood is shown lying on a table in the centre of Fig. 34. It is constructed of zinc, has a glass window in front. The intake and outgo of air are immediately in front of the mouth and nose. The hood is attached to the neck and made air-tight (?) by a rubber automobile collar. Dr. Eppinger has worn this apparatus continuously for six hours without difficulty. He maintains the current of air by pumping air through it but I did not see the pump. He proposes to use it with an ordinary Elster meter and the Zuntz apparatus for gas analysis with the Loewy sampling pipette. Another view of this hood, showing the automobile collar, is given in Fig. 35.

Hygrometers to measure water-content of air.-- In attempting to study the water output of man in respiration, Dr.,Eppinger is experimenting on the possibilities of using a hair hygrometer, inserting one before the air enters and one after the air leaves the hood. The hygrometers are enclosed in zinc boxes, one of which is shown at the left of the hood in Fig. 34. A glass window permits

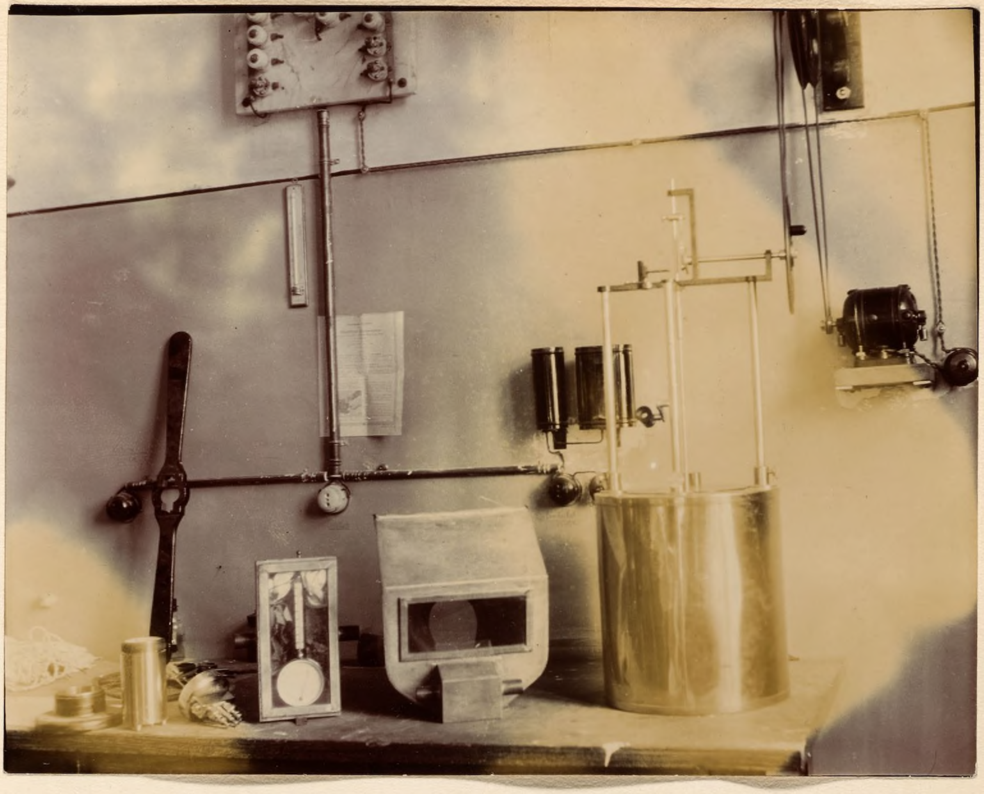


Fig. 34. Minor apparatus in laboratory of Prof. von Noorden's clinic.

At the left is the bomb calorimeter dismantled, with spanner in the background. Beside it is the hygrometer enclosed in a zinc box, with a glass window for use with the respiration hood. At the right are the respiration hood, the bomb calorimeter vessel, water mantle, and electric motor.

the reading of the ~~galvanometer~~ hygrometer without difficulty. Thus far, Dr. Eppinger has had much difficulty in calibrating the hygrometer but hopes to overcome the difficulty shortly.

Bomb calorimeter.--As in many other laboratories, the Kröker modification of the Berthelot bomb, made by Julius Peters of Berlin is used. The bomb is shown at the extreme left of Fig. 34. The cup is standing at the right; at the left is the clamp in which the bomb is held when the cap is being screwed on. In Fig. 35 the bomb is shown at the right. The calorimeter vessel and water manometer, together with stirring apparatus and electric motor, are shown at the right. in Fig. 34.

Electric motor and gear work.--An electric motor and gear reduction of possible interest in our new unit respiration apparatus is shown in Fig. 35.

Falta's discussion of the Jaquet respiration apparatus.--Falta'~~s~~ worked with Jaquet in Basel before going to Vienna and is a firm believer in the Jaquet respiration calorimeter. He believes, however, that the gas analysis apparatus of Pettersson should be so used that the air sample is always measured dry over mercury rather than over water, as there will be, theoretically at least, an absorption of carbonic acid by the water. He did not say how he was to measure the gas after the carbonic acid and oxygen were absorbed as it then would be wet, neither would he give any method of drying the gas before measurement.

Dr. Falta is a very enthusiastic worker in metabolism, has carried out some very satisfactory experiments in Basel and is actively engaged in experimental work with Prof. von Noorden. He is one of the brightest young men I met and has a keen interest in problems of metabolism. He says that it is their intention to have

Fig. 35. Respiration hood, electric motor and bomb calorimeter, Prof. von Noorden's laboratory.

The automobile collar by which the hood is attached to the neck is clearly shown, the electric motor with gear reduction in the background, and the Kroker bomb with cover at the right. In the background at the left are shown a glass animal cage and the gas heater used so frequently in Prof. von Noorden's laboratory for temperature reduction.

a respiration calorimeter for use in connection with the clinic. The possibilities of his coming to Boston to examine the respiration apparatus and become familiar with the work in the Nutrition Laboratory were discussed. Dr. Eppinger is likewise enthusiastic in metabolism experiments and especially respiration experiments. He is to continue experimenting with the hood and hygrometers and hopes soon to have a successful apparatus whereby he cam secure the normal breathing with the hood rather than using the nose piece or mouth piece.

Laboratory of Prof. von Noorden's Sanatorium.

This small, although elegantly equipped laboratory, has been but recently installed in a sanatorium of which Prof. von Noorden is the director. It was in the basement and not well lighted, but the free use of white tiling gives a very light effect to the room. A general view of the central table and the hood is given in Fig. 36.

Water faucets.--All the water faucets are of special construction with a plug shut-off between the valve seat and the nipple. This gives opportunity for any changes in the packing of the valve to be made without shutting off the water. The water distributing column for the end of the central table is shown in Fig. 36 and a plug valve is readily seen on the cock at the extreme left. A manometer arrangement is attached to the upper part of this upright and can be used for determining the degree of ~~exidation~~ rarefaction during filtration.

Shelves between tables.--Between tables which are commonly opened for passageway, Prof. von Noorden has drop shelves which can be raised and thus make one continuous table. These shelves are of wood. Gas burners are placed in the hood to accentuate the draft. The burners are shown in Fig. 36 in the background.

Arrangements for titration.--Perhaps the most elegant arrangement of standard solutions and digesting burettes seen in my whole tour is that installed in Prof. von Noorden's laboratory and shown in Figure 37. The large bottles ~~holing~~ holding standard solutions are in large clamps fastened to the wall. Enamelled labels are attached by wire or chain to the neck and the burettes are fastened in an upright position to the shelves by means of clamps below. The wall

Fig. 36. General view of central table and hood in Prof. von Noorden's private laboratory in the sanatorium.

The distribution of the water at the end of the table is of interest, showing stop-cocks with plug valves back of the regular valve. A manometer is attached to the upright for measuring the degree of rarefaction. In the rear of the room in the hood are the electric lights, well protected from the fumes in the hood.

Fig. 37. Arrangement for titrations in Prof. von Noorden's laboratory.

Large bottles containing the standard solutions are held in large clamps fastened to the wall, with enamelled labels on the necks of the bottles. Self-adjusting burettes are fastened over each of these bottles. The dark colored glass bottle at the left is for permanganate or iodine solution. Three other bottles attached to the wall contain distilled water, strong sulphuric acid and sodium hydroxide respectively.

at this point is covered with white tiling and the titrations are carried out on a slab of enamelled lava. Most of the burettes are filled by gravity but one arrangement for using permanganate solution or iodine solution in colored glass burettes is shown on the top of the table. This arrangement is supplied by the regular apparatus dealers.

A hard rubber stop-cock is used on the distilled water bottle. This has been found very satisfactory.

Minor laboratory arrangements.--In the hood the gas cocks are all placed in front. These are shown in poor focus in Figure 36. Wire gauze with asbestos interwoven in the form of a half cup is used in the bottom of the Kjeldahl flask in digestions. These are said to protect the flasks and lengthen their life materially.

Oxidizing urine.--Ordinarily copper sulphate is used but they find that diabetic urines are very difficult to oxidize, requiring several hours' heat and it is necessary to use potassium ~~boro~~ pyro-sulphate ($K_2S_2O_7$) to help out.

Personal impressions of Prof. von Noorden's laboratories.--

In spite of an enormous, ever-increasing practice and much literary work, Prof. von Noorden is actively interested in experimental researches. Personally, he is unable to perform any experiments himself but has associated with him two excellent men in Drs. Falta and Eppinger. In the sanatorium, the work is almost wholly along medical lines and routine analysis. His chemist is a diener who has grown up to it and does all the routine work. There seems to be but little active scientific investigation going on in this sanatorium laboratory.

With Drs. Falta and Eppinger, Prof. von Noorden should be able to accomplish a great deal of valuable experimental work along the lines of nutrition. In Vienna, Prof. von Noorden and his assistants are in an especially favorable condition to study diabetes as this has been a problem on which they have worked for many years.

Physiological Institute.

Profs. Exner, von Kriedel, and von Fürth.

This new institute is very ingeniously equipped with electrical arrangements which were devised and described by Durig in Pflüger's Archiv, vol. 113. Inasmuch as the Institute is primarily designed for students' use, the majority of the electrical connections are of no especial interest to us.

Floor for operating room.--The floors of the operating rooms, cage, and general dog room are made of Xylolite, which does not crack. It is somewhat like cement, is not as plastic as asphalt and consequently in warm weather does not show the heel marks. At the same time it is sufficiently flexible to give with the slight expansion of the building and not crack. This is of special value for the floor of the operating room and the cage room, where urine or blood is liable to get into the cracks and putrify.

Gas, water, etc.--In the operating room, an ingenious arrangement of the supply of gas, water, electricity, compressed air, and suction is made whereby all of these are brought from the ceiling into a standard about six feet from the floor. This is above the head and yet easily reached by the hand. One can bring all these commodities upon the operating table if desired and yet have the floor clear. The floor can be easily washed and it pitches a little towards the centre so that it will drain readily.

Animal houses, etc.--Having heard so much of the necessity for the greatest care regarding hygienic conditions for animals after operations, I was surprised at the condition of the rooms in which the animals are kept here. The room smelled horribly, was heated with gas stoves and had but little light. The yard was good but the yard for fowls was far from being in a sanitary condition.

Glass tables for titrations--In place of the white enamelled lava, heavy glass shelves, with white beneath, are used extensively in the various laboratories for titrations. These shelves are fastened to the walls with iron brackets and seem to be very serviceable. Obviously, they will not stand heat and hence the enamelled lava is much to be preferred.

Hochschule für Bodenkultur

Prof. Arnold Durig

As Dr. Durig is one of the most active workers in the metabolism of man and has a special interest in respiratory experiments, a visit to his laboratory proved unusually profitable as was to be expected. The laboratory has been installed for about five or six years and is quite well equipped.

Mercury switch.--A very ingenious switch in which the contact is made with mercury in a vacuum is of especial importance to us. Two forms of this switch are shown in the foreground of Figure 38. Platinum wires are fused through the walls of a glass tube which is partly filled with mercury. By ~~operating~~ inclining the tube in either one direction or the other, the mercury is caused to flow from one end to the other and thereby make the contact ~~and~~ of the electric circuit. The air above the mercury is exhausted and consequently there is no oxidation and a perfect contact made at each movement.

(Suggestion.--The use of this mercury switch can, without doubt be made of great practical value in closing a number of circuits in connection with the respiration calorimeter. The exact method of holding the tube and the exact location of the fused platinum wires cannot now be stated but the application of this principle will certainly prove of very great value. One of the greatest difficulties with the old mercury switch in use in Middletown was the oxidation of the mercury and copper and consequent defective connections.)

Hose bibs.--As in the von Noorden laboratory, Durig uses hose bibs, so arranged that each faucet has a connection to which a small

Fig. 38. Minor apparatus in Durig's laboratory, Vienna.

The Kjeldahl digestion apparatus may be seen in the background. The general use of the Teclu burner is here to be noted. The large glass apparatus supported on a ring stand is an automatic pipette for measuring sulphuric acid for Kjeldahl work. Prof. Durig's sodium hydroxide apparatus for delivering caustic soda is in the background. Two forms of the mercury vacuum switch are shown in the foreground and the cork boring machine at the extreme left. Note the general use of iron gauze interwoven with asbestos.

rubber hose can be attached. The joint is a ground joint and is readily connected. The use of this hose bib is universal in this laboratory.

Cork borer.--My first experience with the new cork boring machine was in this laboratory. It is shown at the left in Fig. 38. A series of these machines has been ordered for the new laboratory.

Apparatus for sodium hydroxide in the Kjeldahl determinations.--While there are innumerable devices for measuring different amounts of sulphuric acid in the Kjeldahl ~~distillation~~ digestion apparatus, one of which is shown supported on a ring stand in Fig. 38, there are few for holding strong caustic soda. Durig has devised a simple siphon pipette which is actuated by a rubber bulb, the whole being attached to a heavy-walled flask. This is shown in the centre background of Fig. 38. He has recently described it in one of the German periodicals. By pressing on a bulb, sodium hydroxide is forced from the flask up into the glass bulb until the siphon, arranged on the principle of the Tantalus cup, begins to overflow. The pressure on the hand bulb is then held constant until the siphon empties. This delivers the requisite amount of sodium hydroxide. Probably this principle can be made use of with a reservoir and pinchcock rather than the bulb but is certainly very satisfactory.

Gas burner for use in hood.--Durig uses a burner from an ordinary gas stove set upright. This produces a tremendous draft and does not clog even when in the Kjeldahl digestion hood.

Fat extraction apparatus and vacuum oven.--Electrical heating is used in which the ordinary lamps are enclosed in an asbestos lined metal cup. This obviates the necessity of having to wash the flasks after the extraction is completed. By connecting the condensers at the top and attaching a calcium chloride tube (hanging to the gas bracket in Fig. 39,) moisture is kept out of the ether. The vacuum apparatus is actuated by a water pump and by means of the surrounding water jacket, any desired temperature can be maintained. The condenser at the top prevents the undue escape of steam.

Sheep power.--This is also useful for men. Durig has a very good sheep power manufactured by W. P. Emmert, Freeport, Ill., which he thinks can be adapted for use with man.

Work on cream separators.--An extremely interesting application of the Zuntz method of studying the respiratory quotient is being made by Durig in investigating the best method of actuating by hand one of the typical foreign separators. There are two general methods for manipulating these machines, one with an ordinary handle and crank and the other with a long lever with a joint and ratchet something like the principle of the old Star bicycle. By counting the number of rotations, ~~in~~ studying the gaseous exchange and by means of numerous graphical recording machines, and computing the mechanical work done, Durig is attempting to find out which is the better method of the two for actuating this apparatus. This is an unusual scientific method of studying this problem.

Reduction valve for oxygen cylinders.--This reduction valve can be attached to the German cylinders supplied by the oxygen concerns. It is made by Draegerwerk, Lubeck, Germany. I doubt if it can be applied to the S. S. White Dental Mfg. Co. cylinders, as the valve principle is entirely different.

Modified Zuntz gas analysis apparatus.--Durig has become especially skilful in the use of the Zuntz method and Zuntz himself admits that he has far exceeded the Berlin workers in improved technique. Durig

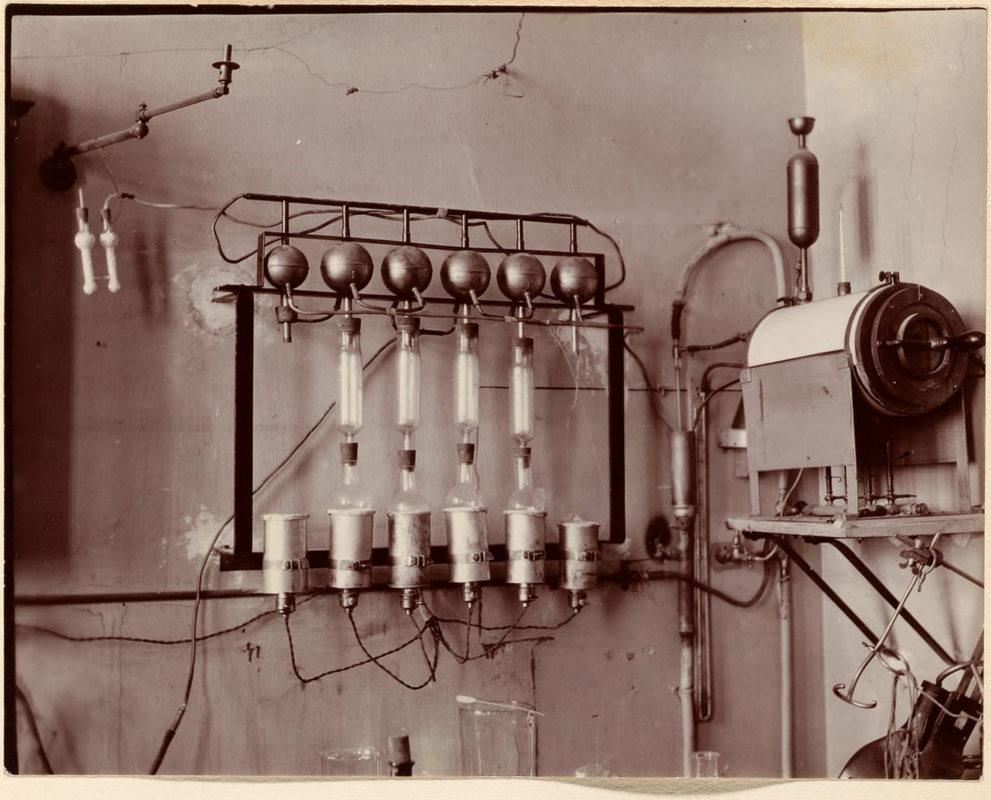


Fig. 39. Ether extraction apparatus and vacuum drying oven, Prof. Durig's laboratory, Vienna.

The ether extraction apparatus may be seen against the wall with the Soxhlet condensers at the top and the electrical heat at the bottom. The condensers are joined in one piece to which is attached, by means of a lead tube, the calcium chloride tube to prevent the absorption of moisture. Electric heating is provided by ordinary lamps in vessels lined with asbestos paper. This is very practical. The vacuum drying apparatus may be seen at the right, the vacuum being produced with a water suction pipe. Against the rear wall is the mercury manometer; at the right, the pump and the condenser for condensing the water in the water jacket is on top of the oven. The burners are perfectly shielded by the sheet of eternit.

has had his apparatus graduated in 1/100ths cc. and can read it to thousandths. In the expired air, the error is not more than 0.02 to 0.04 per cent carbonic acid. In air analyses the limits for nitrogen are 79.09 and 79.06. If the discrepancy is 0.04 per cent, it is too large. He averages a difference between duplicates of 0.01 and 0.02 per cent.

Capillary rubber tubes.--Unlike the other forms of the Zuntz apparatus, Durig has used capillary rubber tubing for all of his connections. This is important as it minimizes the dead air space and cuts down the error.

Pointed glass connections.--Instead of cutting off square all the glass capillary tubing which connects the different parts of the Zuntz gas analysis apparatus, Durig has had them pointed 45 degrees, thus again diminishing the dead air space and improving the accuracy.

Capillary Y fused to absorption pipette.--One other connection that is commonly found in the Zuntz apparatus, Durig has done away with by fusing the capillary Y direct to the arm of the absorption pipette.

Absorption of oxygen.--In a recent publication, Durig has pointed out the great value of a solution of sodium hydrosulphite ~~hydrogen sulphide~~ for the absorption of oxygen and he concludes that it is much better than either phosphorus or potassium pyrogallate. I have had an extended correspondence with Dr. Durig about this operation since I left Vienna and he has given me some very valuable information. He finds that the solution of sodium hydrosulphite ~~hydrogen sulphide~~ has a tendency to attack the glass of the pipette and he has sent me suggestions for coating the end of the pipette with a solution of caoutchouc.

Reservoir for water for the bomb calorimeter.--Instead of weighing the amount of water for each determination of the heat of combustion, Durig has a large pipette adjusted so as to deliver the exact amount of water required for the combustion.

Skill in using mouthpiece.--Durig has personally used the mouthpiece a great deal and is convinced that he can breathe normally with it. He does not agree with Jaquet that it is so very difficult for people to use it normally but still admits that it is not easy. He is inclined to think that for patients, it is also abnormal. (?)

Nose clamps.--Nearly every man in his laboratory uses his own specially constructed nose clamp. There is no regular form. Most of them are constructed with a chamois skin covering.

Respiration apparatus for use in mountain experiments.--This apparatus Durig said he found very trying when he first undertook to use it with Prof. Zuntz. He told Prof. Zuntz that it was a terrible experience and it would never become normal with any man. I put the apparatus on my shoulders and although it is a dry gas meter, I found it a great load for a man to carry. Prof. Durig gave me the accompanying photograph of himself wearing this apparatus. See Fig. 40.

Durig is from the Tyrol, is used to the mountains, is never mountain sick, and weighs 58 kilos. He is long-legged and built for an ideal mountain climber, so considers his experiments made on a normal man under normal conditions.

Pipette for urine.--Durig attaches a capillary rubber tube to an ordinary pipette and draws the liquid up to the mark. By pressure he can depress the level of the liquid to the capillary mark. He says this hastens the adjusting of the pipette greatly.

Fig. 40. Subject wearing the Zuntz-Durig respiration apparatus for mountain climbing.

One valve is shown thrown over the right shoulder, the gas meter on the back.

Personal impressions of Durig's laboratory and work.--Prof. Durig is perhaps the keenest and most intelligent worker in metabolism of the younger men that I ran across on my trip. I was extremely impressed with the amount of work that he was doing and with the methods he was using in his work. He expressed great interest in the Nutrition Laboratory and I feel sure that it would be possible to arrange with him to come to America for a part of the year. His presence here would be of very great assistance to all of us as he has innumerable technical manipulations that would require long experience for us to obtain.

BUDAPEST, HUNGARY.

Laboratory of the Agricultural Experiment Station

Professor Franz Tangl.

This laboratory has been constructed about five years, is very perfectly appointed and all the arrangements are very lavishly carried out. In common with many other of the European agricultural institutions, large sums can be obtained from the government for agricultural research and hence one finds many agricultural experiment station laboratories in many instances more expensively and better equipped than the university laboratories. A local photographer had made a very fine series of photographs of this laboratory and the different details of construction and arrangements were made whereby a series of photographs were procured. They are now on file at the Nutrition Laboratory. Reduced copies of some of them are included in this report.

Tops of tables of enamelled lava.--A French product consisting of lava enamelled is used extensively in this laboratory for the tops of tables. Its use is shown in several of the photographs taken in this laboratory. See Figs. 41 and 43. The material is made in France by sawing slabs of lava out of the natural deposit and they are then coated with enamel which is baked into the lava which is somewhat porous, the enamel thus becoming part of the stone itself. It does not chip off, is perfectly white, and is rather expensive. Many fine hair-like cracks appear in the enamel immediately after it comes out of the oven but they do not extend any further, neither does the enamel chip. It had been installed in Tangl's laboratory five years (see note regarding Arloing's laboratory in Lyons). There is no evidence of any wear in the lava in Tangl's laboratory and not a single slab had been broken or any enamel chipped off. The breakage for glassware on this hard enamel is not considered any greater than with ordinary wood tables. The assistants soon learn to accustom themselves to it and while it may be of doubtful value for elementary students, with trained assistants, its use should not be objected to on account of hardness.

Analytical laboratory.--A typical room, showing the construction, is shown in Fig. 41. On the central table the Kjeldahl distillations are carried out and in the hood at the left the Kjeldahl digestions. The lava top of the table is especially worthy of note and the linoleum which is glued to the floor. The cement or tile floor the assistants find more tiresome to stand upon than linoleum and a strip of linoleum 66 cm. wide is glued to the floor with ordinary glue. Through the door is seen the room for the drying apparatus and combustion room. At the left of the door a large stone crock holds the distilled water which is prepared in the small still above. The hoods are of iron and well glazed.

Drying oven.--A drying oven which allows the door to be let down in front and form a small shelf is much recommended by Prof. Tangl. This is made by Gustav Christ & Co. in Berlin.

Combustion room.--The muffle furnaces for ash analyses, and organic combustions, digesters and sterilizers are all placed in one room which is shown in Fig. 42. At the left in the hood is seen the Bredig apparatus for carbon combustions in duplicate which Tahgl recommends very strongly. ~~This~~ Use is made of asbestos coated with copper, ~~and has~~ in a form devised by Pregl and sold by Merck in Darmstadt.

Fig. 41. General view analytical room of Prof. Tangl's laboratory.

The Kjeldahl digestion apparatus is in the hood at the left; the Kjeldahl distillation apparatus on the central table with lava top. In the rear room is a large brown crocker container for distilled water, with still at the top. Linoleum is glued to the floor around the tables.

Fig. 42. Combustion and drying room.

In the immediate foreground may be seen the large vacuum drying apparatus. In the hood at the left is the Bredig combustion apparatus. In the small hood at the right are two muffle furnaces for ash determinations; at the extreme right, two digesters.

Prof. Tangl uses so-called "Murmer" boats of porcelain for containing material for combustions. These boats have small partitions across them and thus the material is burned in several small portions rather than in one large mass. Prof. Tangl says that he finds it easier to control the combustions in this way. A steam boiler heated by gas is shown in Fig. 42 at the left of the combustion hood. This is used in summer for the digesters and sterilizers. Two muffle furnaces for the ash determinations are shown at the rear of the room at the right, while at the extreme right in the foreground are two digesters or autoclaves.

The tops of the laboratory tables are 95 cm. from the floor and the table in the centre of Fig. 41 is 1 meter wide.

Apparatus for measuring standard solutions.--For measuring accurately 5, 10, or 15 cc. of standard acid solution, Prof. Tangl uses a series of three self-adjusting pipettes clamped to the retort stand in the manner shown in Fig. 43. This figure also shows very well the lava topped table. The supply of acid is on the shelf above and by opening the glass stop-cock, the acid rises in the burette to the fine capillary taper in the enlargement. It there overflows and accumulates in the bottom of the enlargement. By opening the pinchcock on the rubber tubes attached to the enlargement, the excess of acid can be drawn off if it accumulates too largely.

This method is very accurate and possibly of advantage for us to adopt. I found in Berlin in the workshop of Bleckmann and Burger an apparatus which I am having them modify for me which will, I think, be better than this. If not, this method can always be resorted to with advantage.

Electrical combustion furnaces.--In connection with the large

Fig. 43. Group of self-adjusting pipettes for measuring standard acid.

The top of the table is of enamelled lava.

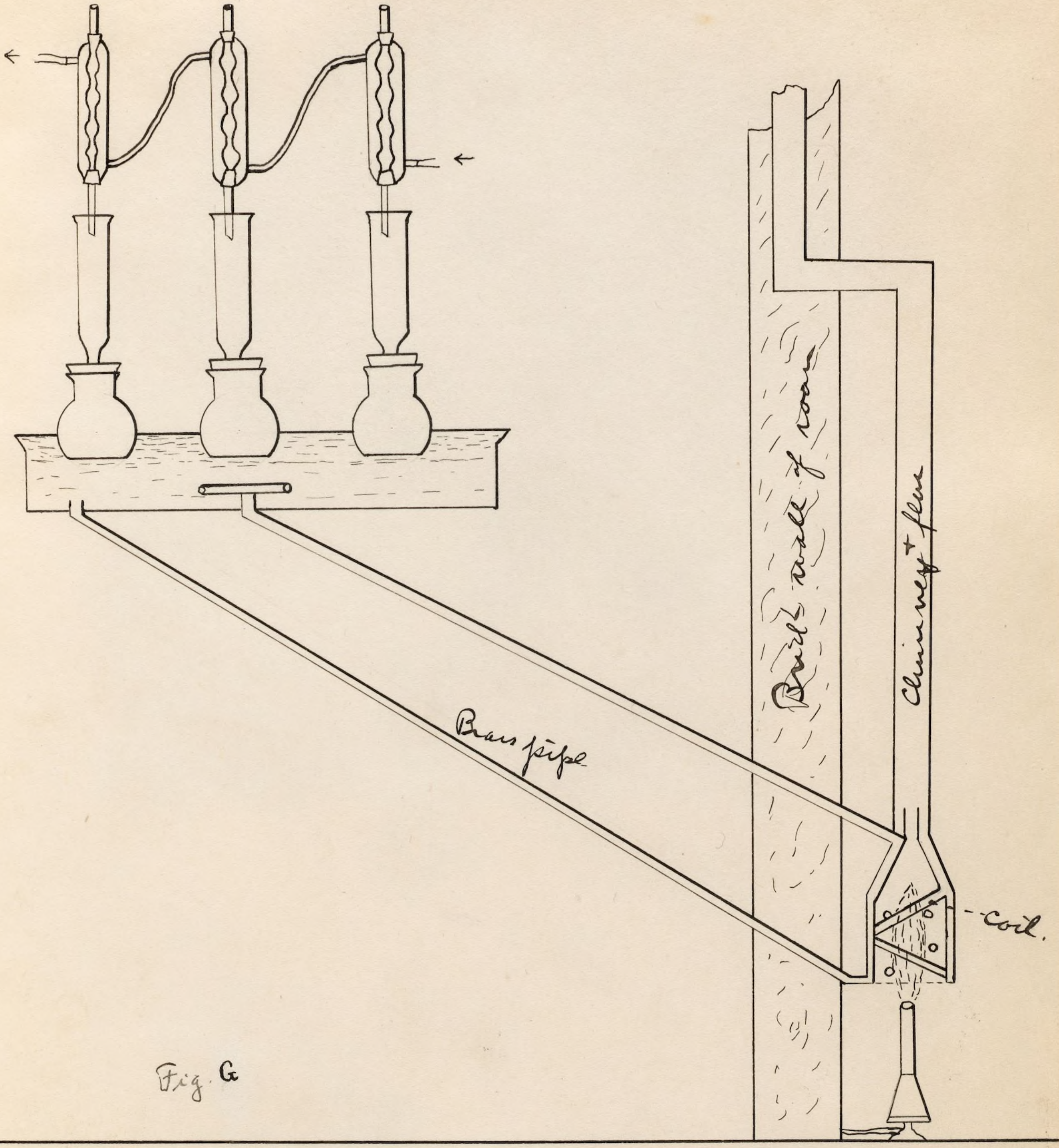


Fig. G

Fig. G. Scheme for heating water for ether extractions in Prof. Tangl's laboratory, Budapest.

The gas burner is in the next room and there is no possibility of fire. The heating coil causes a brisk circulation of water.

respiration apparatus for animals, Prof. Tangl has the problem of determining accurately the amount of marsh gas given off. This must be done by the use of electrical combustion furnaces to avoid the introduction of unburned gases into the air of the room.

The furnaces are somewhat similar in construction to those used by Hagemann (see Fig. 10) but are not so large. A series of seamless block tin pipes brings the sample of gases to the furnaces and takes it away. The apparatus is shown in detail in Fig. 44.

Metabolism experiments with fowls.--In connection with his agricultural experiment station work, Prof. Tangl has made many experiments regarding the metabolism of fowls and has constructed a very neat cage for them. This cage, which is made of galvanized iron, is shown in Fig. 45.

Respiration calorimeter laboratory.--One of the most elaborately installed laboratories that I found on my trip was this respiration calorimeter laboratory of Prof. Tangl. A general view is shown in Fig. 46. In this room he has a large respiration chamber, not calorimeter, for use with horses or oxen, provided in the floor with a rolling treadmill which can be inclined for experiments in walking up or down grades. In this room are also placed an ammonia refrigerating machine for depriving the air of moisture and mercury meter pump on the Blakeslee plan, constructed by Hart of Poughkeepsie, a set of meters and barium hydroxide pipettes for use with the Rubner-Voit method of measuring the sample of the air current, and finally, a small respiration chamber, not calorimeter, for swine, with the absorption of carbonic acid and water as developed at Middletown. Unfortunately, all of this apparatus is not in thorough working order. For example, the meter pump has given much trouble and the respiration chamber has

Fig. 44. Electrical combustion furnaces for large respiration apparatus.

Block tin pipes attached to the rear wall conduct gases to and from these furnaces.

Fig. 45. Special metabolism cage for experiments with fowls.

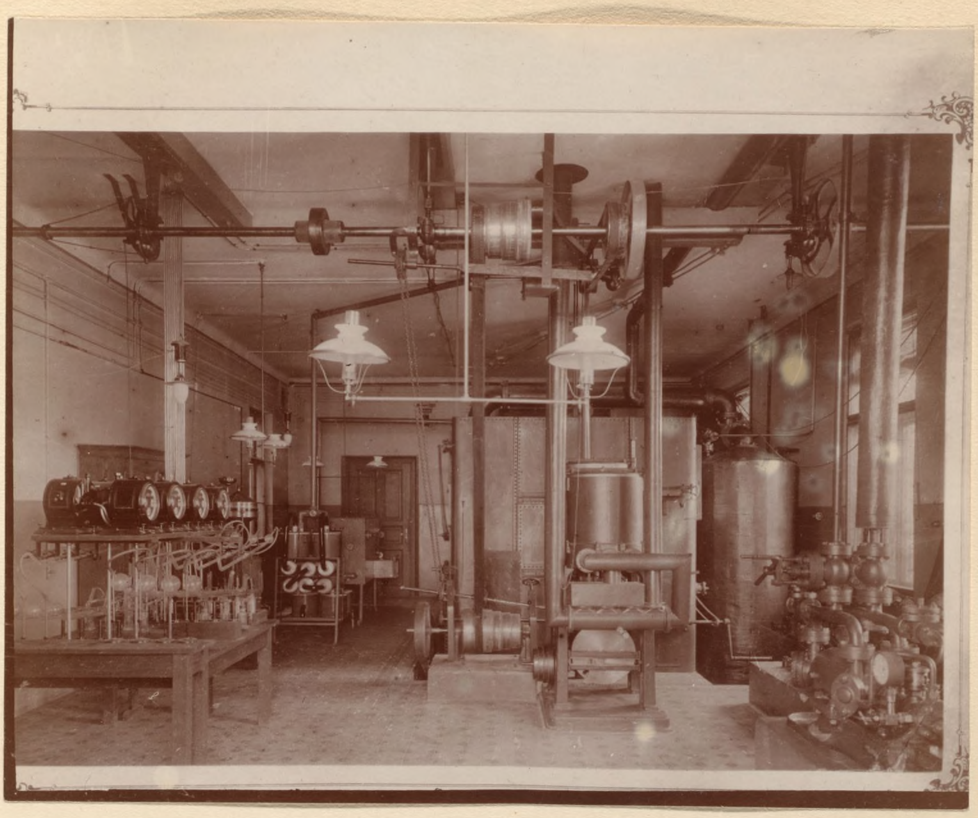


Fig. 46. General view respiration laboratory.

At the extreme right is the ammonia machine. In the middle foreground may be seen the Blakeslee meter pump. Back of this is the large steel box for the calorimeter chamber. At the extreme left is the series of meters and barium hydroxide tubes for the analysis of gases. At the left in the rear is the respiration apparatus for swine. In the rear at the right is the cooling tank for cooling the special current of air from the respiration chamber.

not been satisfactorily tested as yet so far as its usefulness for determining carbonic acid is concerned. The apparatus for swine was also giving much trouble at the time I was in Buda Pesth.

Apparatus for analysis of sample of air current.--This apparatus, which is shown in Fig. 47, is the Voit-Rubner method for using barium hydroxide. The apparatus was ordered complete from the mechanician in Rubner's laboratory and represents the highest grade of workmanship. A replica of this apparatus is also to be found in Tangl's laboratory in connection with the Medical School on the other side of the Danube. A photograph was also taken in Rubner's laboratory of his apparatus. (See Figs 102 and 106 ---.)

Interior of respiration chamber.---The large respiration chamber is devised to promote experiments on an ox or an horse. The interior is shown in Fig. 48. The feed box is shown at the rear of the photograph, the rolling platform at the bottom, and the arrangement for supplying grain is at the upper right hand corner of the rear of the chamber. This latter arrangement is an endless chain with a series of buckets which delivers a certain amount of grain in the funnel-like opening which conducts it to the bin where the horse can eat. Hay or other fodder is placed in the box at the upper left hand part of the chamber. The door is secured in place with levers against a rubber gasket. This method of closure has been criticised in connection with Prof. Hagemann's apparatus (see page -7-). It is planned to use the ammonia machine for cooling the air and depriving it of moisture and Prof. Tangl plans to have a ventilating fan carry air out of the respiration chamber in a special circuit, carry it over cold brine, and then carry it in at the bottom, this circuit to be entirely independent of the main ventilation circuit.

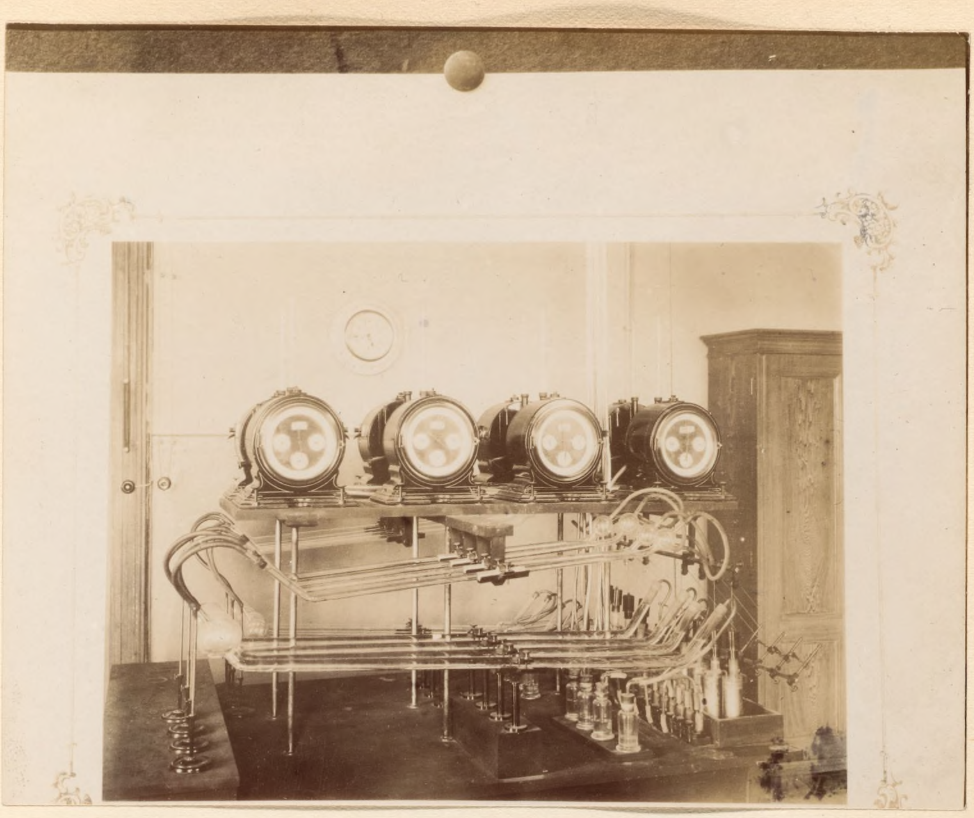


Fig. 47. Details of gas meters and barium hydroxide tubes for Voit-Rubner gas analysis apparatus.

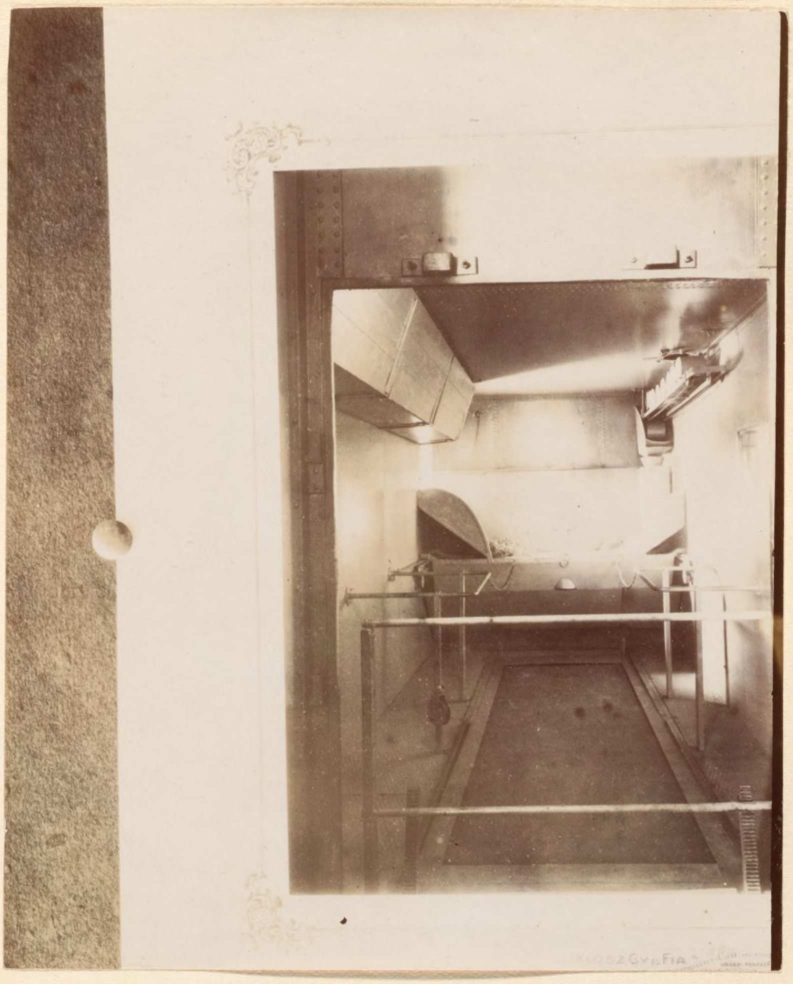


Fig. 48. Interior of animal respiration chamber.

The treadmill may be seen on the floor, the automatic feed box on the upper right-hand side and the hay duct on the upper left-hand side.

Respiration apparatus for swine.--This is shown at the rear of the room in Fig. 46 at the left. It consists of a galvanized iron box with a window at the rear, closed with a rubber gasket, and the air is caused to pass through silver-plated copper cans of the same dimensions as those at Middletown and likewise vessels made of galvanized iron. Tho whole apparatus is as yet in the experimental stage.

Bomb pellet press.--Prof. Tangl has the advantage of having a very ingenious mechanician who not only constructs apparatus for experimental purposes but has a shop where he constructs apparatus for sale to others. An especially well built press for preparing pellets for use inside of the calorimeteric bomb has been ordered for the new nutrition laboratory.

Medical School Laboratory.

Prof. Tangl.

In addition to being director of the Experiment Station, Prof. Tangl is professor of physiology in the Medical School of the University and has the charge of the very fine laboratory on the other side of the Danube. In this laboratory, experiments are being conducted upon respiration and heat production in animals and consequently the laboratory is being fitted with that care and excellence that characterizes Prof. Tangl's laboratory in the Experiment Station.

Operating room.--Of special significance in the operating room is an arrangement which is an improvement over the scheme in Exner's laboratory in Vienna (see page 136---) whereby the water taps are hung from the ceiling. In Prof. Tangl's laboratory they are so adjusted that by a mixing valve, water of any desired temperature can be obtained or a stream of hot and a stream of cold water can be secured at the same time.

Pedal faucets are used in the operating room so that the faucets may be opened and shut without touching them with the hands.

Heat evolution by bacteria.--Following the experiments of Rubner, Prof. Tangl has instituted a series of researches on the development of heat by bacteria, using a ~~dual belt~~ Dewar bulb and measuring the temperature rise by very delicate electrical thermometers. (Rubner uses mercurial thermometers.) The ~~dual~~ Dewar flasks are placed in a constant temperature bath and the rise in temperature noted and from the weight of the liquid and the specific heat, the amount of heat developed can be computed.

Electrical instruments.--Prof. Tangl believes that we can measure the heat used in our electrical experiments best by using a potentiometer and standard cell. He uses an instrument made by Land. u. Seekabelwerk A. G., Coln-Nippes. The potentiometer was numbered 3694 and the exact resistance used in connection with it was No. 3183.

Polariscope.--Having considerable work regarding rotation, Prof. Tangl has installed a very fine Schmidt and Haensch polariscope of the Liebig-Landolt three-field half-shadow type. Its number was 6632.

Treadmill.--Prof. Tangl's mechanician had constructed a treadmill of very ingenious type which was practically noiseless in running and in place of slats with wheels, a heavy fold of canvas curtain was used which slides over a sheet of plate glass. While this treadmill was primarily designed for work with dogs, it was possible for a man to walk upon it, as both Prof. Tangl and myself tested it. The curtain was driven by an electric motor and the weight of the man soon raised the heat of the glass so that it would have broken if long continued in use.

This device I found in Prof. Lehmann's laboratory in Berlin, although Prof. Lehmann used an aluminum plate instead of glass. I think that a treadmill of this type would be of very great value to us in our laboratory.

By means of a graduate~~d~~ arc and lever, the treadmill could be inclined in either direction and through a known arc.

Method of illuminating the Zuntz analytical apparatus.--A complete Zuntz repiration apparatus for use with man and dogs is installed in this laboratory. The laboratory is located in a rather crowded street and the light is deficient, so Tangl has illuminated the analytical apparatus very ingeniously by placing a large sheet of ground glass behind the water tank. There are four bunghole electric lamps placed end to end behind this, ~~which~~ thus illuminating the whole apparatus perfectly. By means of a ratchet wheel, the whole illuminating device, including the electric lights, may be raised or lowered with great ease.

Experiments with hibernating animals.---A series of experiments have been made with hibernating bats with some very interesting results. The work was along the line of that carried out by Weinland in Munich and gives results not wholly in accord with his. The animals were placed in a desiccator with an opening in the top. By allowing paraffin oil to run in, a sample of the air could be driven out from time to time and analyses made. The respiratory quotient found was, in many instances, below 0.7. The results should appear shortly.

General impression of Prof. Tangl's work and his laboratories.

Without doubt, the equipment possessed by Prof. Tangl is the finest of any that was observed in my whole tour of inspection. No apparatus that would seem to be necessary for experimenting on the metabolism of animals and men appears to have escaped his attention and had not been secured for his laboratory. Prof. Tangl seems to be obliged to divide his time between two institutions and this, together with the great amount of administrative work, unquestionably diminishes the available amount of time for actual experimental work to a minimum. One is very much disappointed at observing the small amount of new, telling, and original experimental work from laboratories possessing such wonderful equipments.

ST. PETERSBURG, RUSSIA.

Institute for Experimental Medicine.

Prof. Pawlow.

The marked advances in surgery of the alimentary tract that have been made by Prof. Pawlow have an unusually interesting bearing upon the physiology of digestion and therefore on the question of nutrition. By means of numerous fistulae from the various salivary glands, from the throat, and from the stomach, Prof. Pawlow has been able to study the mechanism of digestion and the secretion of the digestive juices. The experiments have been made almost wholly on dogs although instances have been recorded where studies have been made upon individuals. Dr. Bickel of Berlin has a young girl who has had such a fistula for some time.

In the St. Petersburg laboratory, the equipment was almost exclusively for septic operations on dogs and the greatest precautions were taken for cleanliness and hygienic conditions. The floors were all of concrete or of some similar material, the walls could be washed with water by means of pipes running around near the ceiling, provided with numerous openings, and every person entering either operating room or clinic rooms was required to wear rubber overshoes. At present, Prof. Pawlow is especially interested in the psychical stimuli and bemoans the fact that his Institute is not so constructed that he can carry on his experiments to advantage.

A few years ago his students presented him with a gift volume, which contains a very fine series of photographs of his laboratory and equipment and I made arrangements with Prof. Janicke to secure a series of these photographs. They are expected in Boston shortly.

Prof. Pawlow very kindly had a large number of experiments prepared to show some of his work. The secretion of saliva through stimulation by the sight of meat, for example, or by the smell of meat, was very interestingly shown, the quantity collected per minute or for a definite fraction of time varying with the nature of the stimulation.

An experiment was arranged to show the effect of a certain tone upon the stimulation of saliva, the dog being placed upon the table in quiet surroundings and at the proper time, a sound was produced by means of an organ pipe. At present, Prof. Pawlow's energies are all directed toward the study of problems of a similar nature.

Magensaftfabrik.--Perhaps the most spectacular feature of this laboratory is his so-called Magensaftfabrik. A large number of dogs were provided with both tracheal and stomach fistulae and by taking food through the mouth, it passes through the gullet and out of the tracheal fistula without coming in contact with the stomach in any way. Under these conditions there is an active secretion of juice which passes out through the fistula and is collected in a bottle.

The dogs begin their false feeding every morning at seven o'clock and eat evidently with considerable gusto until ten o'clock, after which time there is a falling off of the appetite, although the secretion of the juices continues. The dogs are large-sized Russian wolf hounds, are evidently very well cared for and enjoy the whole operation. From each dog about one liter of juice is collected. When first collected, this juice has a distinct odor of the dog but one of Prof. Pawlow's assistants found that by aspirating air through it, the smell is readily removed. This juice is made use of in cases of faulty digestion and has become quite a source of revenue to the Institute.

Imperial Medical Academy.

(Prof. Albitzsky), Dr. Kartaschefsky, and Dr. Awrorow.

In addition to his work at the Institute of Experimental Medicine, Prof. Pawlow holds an appointment in the Imperial Medical Academy. His equipment in this academy is essentially that of the Institute and the investigations carried on there were apparently along the same lines. There was little of especial interest, therefore, in the duplicate equipment.

Laboratory of Pathology.

In this laboratory I was greatly impressed by the large amount of research on nutrition which had been carried out. Although Prof. Albitzsky was not there at the time I was in the laboratory, there were two experiments going on which had been running for several days. In these experiments, the respiratory exchange was being studied by means of the Pashutin respiration apparatus for small animals. Unfortunately, the assistant spoke only Russian and understood very few words of German so our intercourse was mostly by sign manual.

Pashutin respiration apparatus for man.--This apparatus which has been used for a number of experiments with man has been but recently installed in the laboratory of the Medical Academy. Since its new installation, it has not been used for experiments. It was absolutely impossible to secure a photograph of it as it was located in a very dark interior room and evidently artificial light was relied upon alone for its manipulation and use. The apparatus was described by Likhachev in his Dissertation of 1893. Perhaps the two most interesting pieces of work carried out with it are the study of fasting by Sadovyen and more recently in 1902, a very interesting study of the heat production of man during malarial fever, published by Likhachev and Awrorow. Since Prof. Likhachev holds an appointment in the Woman's Medical College in St. Petersburg, and Prof. Awrorow has been transferred to Tomsk, the probabilities of this apparatus being used for experiments with man in the immediate future are not very bright, although Drs. Likhachev and Awrorow told me that they hoped to make some studies during the summer vacations. I went inside of the apparatus and inspected it very carefully but there is very little not given in the diagrams appended to Likhachev's Dissertation. A complete English translation of this Dissertation, containing a description of the apparatus, was made by Dr. Fireman for the Department of Agriculture and a copy has been secured for this laboratory.

Pashutin respiration apparatus for dogs.--Prof. Pashutin devised a number of forms of respiration apparatus for small animals, that for dogs being shown in Fig. 49. This consists simply of a copper case with two glass windows in it, the lid being secured from the top and tight closure being effected by a rubber gasket. The air enters through one glass tube near the bottom and passes out through another near the top.

The two experiments mentioned above were with this form of apparatus and one of them was stopped for a moment while a photograph (Fig. 50) was taken. For the absorption of water vapor, sulphuric acid is used and for the absorption of carbonic acid, caustic soda or caustic potash.

The respiration chamber shown in Fig. 50 is essentially on the same principle as that in Fig. 49. having, however, but one glass window in the top. The air is drawn through the apparatus by means of a suction pump and before entering the chamber, is freed from water

Fig. 49. Pashutin respiration apparatus for dogs, St. Petersburg.

A copper vessel with two tight glass windows, the lid held in place by a series of clamps pressing against a rubber gasket. The two glass tubes are for the entrance and exit of air.

Fig. 50. Pashutin respiration apparatus for dogs(in actual use).

The respiration chamber at the right shows the glass window at the top. The table with bottles containing sulphuric acid and caustic soda solution is at the left. The meter shows the total ventilation of the respiration chamber.

and carbonic acid. The total quantity of air passing through the apparatus is measured by a gas meter on the table in the rear. There are a very large number of bottles, through all of which this gas must pass and consequently there is a very considerable decrease in pressure in this system. There is, however, not a very great decrease in the pressure in the respiration chamber itself, since the air entering the chamber is purified by passing through a fewer number of bottles having large glass tubes, and the layer of liquid is not so great.

In the experiment which was going on in the apparatus shown in Fig. 50, a dog had been confined in the apparatus for 20 consecutive days on a certain diet. In another experiment going on at the same time, a dog had been in the chamber for 25 days. The chamber is open for a certain period each day, during which the dog is fed and catheterized.

Pashutin respiration apparatus for small animals.--A very interesting respiration chamber for small animals,--rabbits, rats, or guinea pigs,--is shown in Fig. 51. It consists of a large bell jar, clamped by iron straps to an iron plate. The closure can be made tight by oil or wax. The air enters through the bottom and goes out through a tube on the interior. A wire gauze laid flat over a tapered floor allows the collection of urine.

Pashutin respiration apparatus for use with compressed or decreased air pressure.--A large amount of research has been carried out in this laboratory in regard to the effect of compressed air on the respiratory exchange of animals. This apparatus was also devised by Prof. Pashutin and is shown in Fig. 52. It is characterized by having unusually strong walls and being provided with two gauges for decreased pressure or vacuum. Stout walled rubber tubing is used for making the connection.

Fig. 51. Pashutin respiration apparatus for small animals.

The large bell jar is clamped to a special iron plate with iron straps. The seal can be made with either wax or oil.

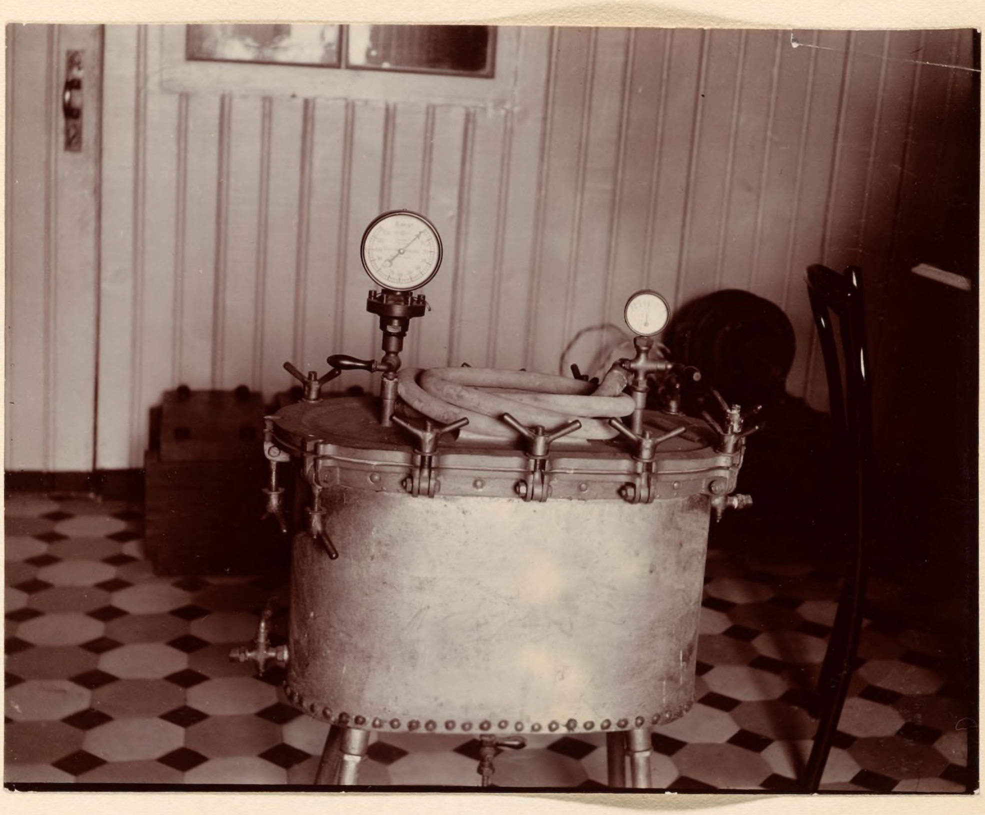


Fig. 52. Pashutin respiration apparatus for use with small animals in compressed or highly rarefied atmospheres.

A stout-walled copper chamber fitted with pressure and vacuum gauges.

Pashutin respiration calorimeter for small animals.--Not content with measuring the respiratory exchange during metabolism experiments, Prof. Pashutin devised a respiration calorimeter for use with small animals, a photograph of which is given in Fig. 53. Unfortunately, the description of this apparatus and of the experiments are given in Russian and I have not as yet been able to secure details regarding the construction of the apparatus. The apparatus is apparently of the same type as that of Rubner and Rosenthal, allowing the heat to radiate into a double-walled chamber containing water. This apparatus has been used for a great many experiments and especially for a series of experiments on fasting dogs.

Experiments with fasting dogs.--By means of the Pashutin respiration calorimeter for small animals, Prof. Likhachev and Dr. Awrorow, who is now professor at Tomsk, ~~has~~ have made a very remarkable series of experiments on fasting dogs. These dogs were placed in a respiration chamber(and were given neither food nor water)and their metabolism measured until they died. The experiments continued 44, 60, and 66 days respectively. The results are marvels of accuracy and have been plotted in a series of curves. Prof. Awrorow kindly gave me two of these curves which he took from the lecture room. They are to be mounted and placed in the Nutrition Laboratory.

Experiments with various atmospheres.--By using large gasometers in the laboratory, Dr. Kartaschefsky made a series of experiments with dogs, using various atmospheres, especially those low in oxygen. The Pashutin respiration apparatus for dogs was used and the gas from these large gasometers taken into the chamber. The gasometers each held not far from 500 to 600 liters.

Fig. 53. Pashutin respiration calorimeter for use with dogs.

The apparatus is made of copper, contains several walls and is installed in an insulated box. The double lid is necessary for heat measurements.

Ventilation of the various forms of Pashutin respiration apparatus.--With the large chamber for man, the ventilation was from 80 to 100 liters; in the small apparatus for dogs, it was from 6 to 10 liters; in that for rabbits, about 2 liters per minute.

Discussion with Prof. Likhachev.--Prof. Likhachev of the Woman's Medical College has had an active part in the use of the Pashutin respiration apparatus and is proposing to carry on experiments in his laboratory in the Woman's Medical College. Unfortunately, at present he is very active in politics and his friends believe that his scientific activities are being considerably impaired. He is a very brilliant man, speaks English quite fluently and was of very great assistance to me in securing some description of the St. Petersburg work. He has in mind the construction of another form of calorimeter for use with small animals, the details of which are not yet ready for publication. He very kindly translated many of the table headings in several of the reprints given me by Prof. Awrorow and Dr. Kartaschefsky.

Provision for the translation of Russian material.-- The very large amount of research in metabolism which has been carried out in the Russian laboratories must be made available to American and English readers. Unfortunately, being carried out as they are under subsidies from the Government, they are published in great detail in Russian and in Russian only, the barest abstracts only being published in the Comptes Rendus de Société Biologique. These publications give very detailed accounts of the investigation and are of the greatest value for our work. I have already succeeded in having two of the papers translated in part and am trying at the present time to make arrangements to have a regular Russian translator connected with our staff.

Prof. Pashutin's book on fasting.--A few days ago Prof. Likhachev very kindly sent to the laboratory a copy of Prof. Pashutin's book on fasting. This book, published in Russian in 1902, has so far as I am aware, not been even noted by German or English writers. It is of octavo size, covering 1700 odd pages and deals almost exclusively with the pathological conditions resulting from under-feeding and the experimental evidence resulting from the effects of fasting. It is of interest to note that although the existence of this book was entirely unknown at the time of writing Publication No. 77, the two volumes in no wise overlap, as the results given in Publication No. 77 were almost wholly original and were treated from the standpoint of metabolism during inanition of man. Certain parts of this book of Prof. Pashutin will be translated for use in the Nutrition Laboratory.

HELSINGFORS, FINLAND.

Physiological Institute.

Prof. Tigerstedt.

Prof. Tigerstedt's connection with the researches in the Physiological Institute at Stockholm, his most interesting book on physiology, his most appreciat~~ive~~ed article on the Physiology of Metabolism in Nagel's Handbuch, and the construction of the new respiration chamber at Helsingfors, made a visit to this institution of special interest.

The laboratory is in a new Institute, thoroughly well equipped and possessing every facility for instruction. Much use is made of linoleum on the floors, this being fastened to the floor with a special linoleum cement. The table tops have a three-ply veneer, oak, soft pine, and oak, the top layer being finished with aniline black, according to the well known method.

The respiration chamber is one of the rooms in the Institute and is approximately of the size of the original chamber at Stockholm, i.e., contains 100 cubic meters. The room is made by simply sheathing the interior of an ordinary laboratory room with zinc, making all connections absolutely tight. A general view of the interior, with special reference to the entrance door, is given in Fig. 54, showing the soldered straps in the zinc wall and the door. The door was closed by a small iron lock lever against a rubber gasket and did not seem to me especially tight.

The room is entered directly from the corridor of the laboratory and has no double lock device and no method of insuring absolute closure other than the pressure against the rubber ring.

Fig. 54. Interior view of Tigerstedt-Sonden respiration chamber at Helsingfors.

This shows the door, zinc walls, box for defecation and the foot of the bed.

Furniture.--In the chamber are a bed, one or two chairs, a stool, a Johansson ergostat, and a steam radiator for keeping the room comfortable during cold weather. The ergostat and radiator are shown in Fig. 57.

The door opening into the chamber and the window immediately above the food aperture are shown in Fig. 55. Looking through the door, one may see the figures of Prof. Tigerstedt and his son and immediately in front of them, the stool near the ergostat. The food is passed in or out of the food opening by raising the lid of the box, which can be sealed with oil. A similar arrangement is made for the feces.

An interior view of the chamber, showing the bed, chair, food opening and electric fan for stirring the air is given in Fig. 56. The wire frame over the electric fan was put on to prevent a small boy who was the subject of an experiment from coming in contact with the fan.

Ergometer.--The Johansson ergostat is shown in Fig. 57. This is inside of the chamber and the kymograph arrangement for tracing is used for recording some of the results of the experiments made with the apparatus. Another view of the Johansson ergostat is given in Fig. 67.

Gas analysis room.--The ventilation current through the chamber is maintained by a large Elster meter shown in Figs, 58 and 59. This is placed underneath the table on the floor of the small room adjoining the respiration chamber. A large zinc box containing pumice stone or other absorbent material drenched with water is used to saturate the air before it enters the meter. A drum of the meter is used as a means of propelling the air. The electric motor driving this machine was removed before this photograph was taken. It usually

Fig. 55. Tigerstedt-Sonden respiration apparatus, Helsingfors.

This gives a view through the open door into the chamber from the corridor. The food aperture is at the left. Inside the chamber are Prof. Tigerstedt and his son and the instrument for graphically recording work on the Johannsen ergostat.

Fig. 56. Interior of respiration apparatus, Helsingfors.

The bed, food aperture, chair, and electric fan for stirring the air are seen in this view. In the corner near the bottom is an air thermometer connecting with a fine lead pipe to the opening near the chair. Bent tubes in the wall for electric connections are filled with oil and are thoroughly tight.

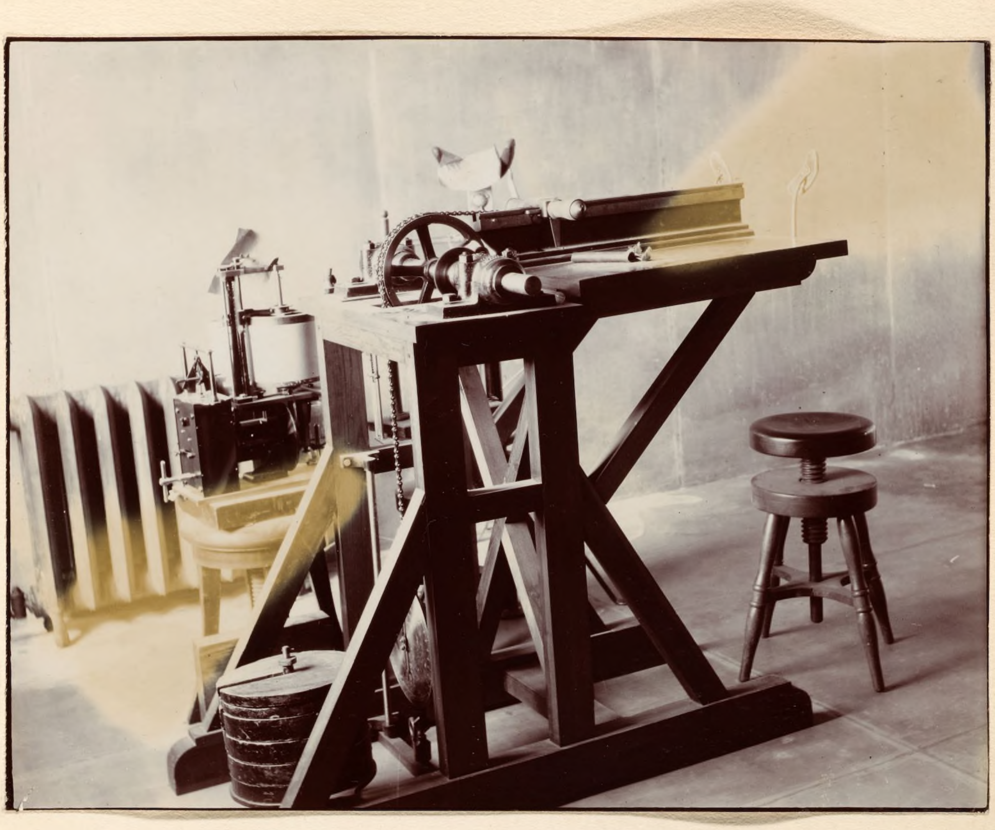


Fig. 57. The Johannsen ergostat and kymograph inside the respiration chamber, Helsingfors.

Steam radiator for warming the chamber at the rear. The seams where the zinc is soldered are plainly noticeable in the photograph.

stood on the table immediately above the meter. The wheel connecting the axle of the drum with the meter is shown in Fig. 58.

Gas analysis apparatus.--The Tigerstedt-Sondén respiration apparatus is possible only by virtue of the extremely accurate method of Pettersson for determining carbon dioxide in air. This analytical apparatus is supplemented ~~with~~ by the sample-taking device of Johansson. The accurate determination of carbon dioxide in the large chamber is thus made possible. At the further end of the table beneath which is the Elster meter (see Fig. 59) is the sample collecting device of Johansson, shown more in detail in Figs. 60 and 61. This consists of a series of pipettes, each holding approximately one liter, filled with mercury, and which can be used to collect sample of the gas out of the respiration chamber at any given moment. One of these pipettes is filled with mercury and then the mercury reservoir is lowered and a vacuum produced. By opening the stopcock, air rushes in from the main air pipe, filling the sample pipette. It takes about ~~20~~ 3 1/2 seconds to collect this sample. The samples can then be preserved and analyzed at leisure as provision is made for 10 pipettes.

The Pettersson apparatus for determining carbonic acid is shown, but unfortunately not with great clearness, in Fig. 62. As in all laboratories, the gas analysis apparatus stands immediately in front of a window and it was extremely difficult to secure satisfactory photographs. It should be stated here, however, that a replica of this apparatus has been ordered and will be in use in the Nutrition Laboratory. The apparatus is very similar in principle to that already discussed and shown in Figs. 19 and 20. It is also very similar to the hygrometer of Sondén shown in Fig. 71.

One essential feature of this apparatus is the ability to adjust

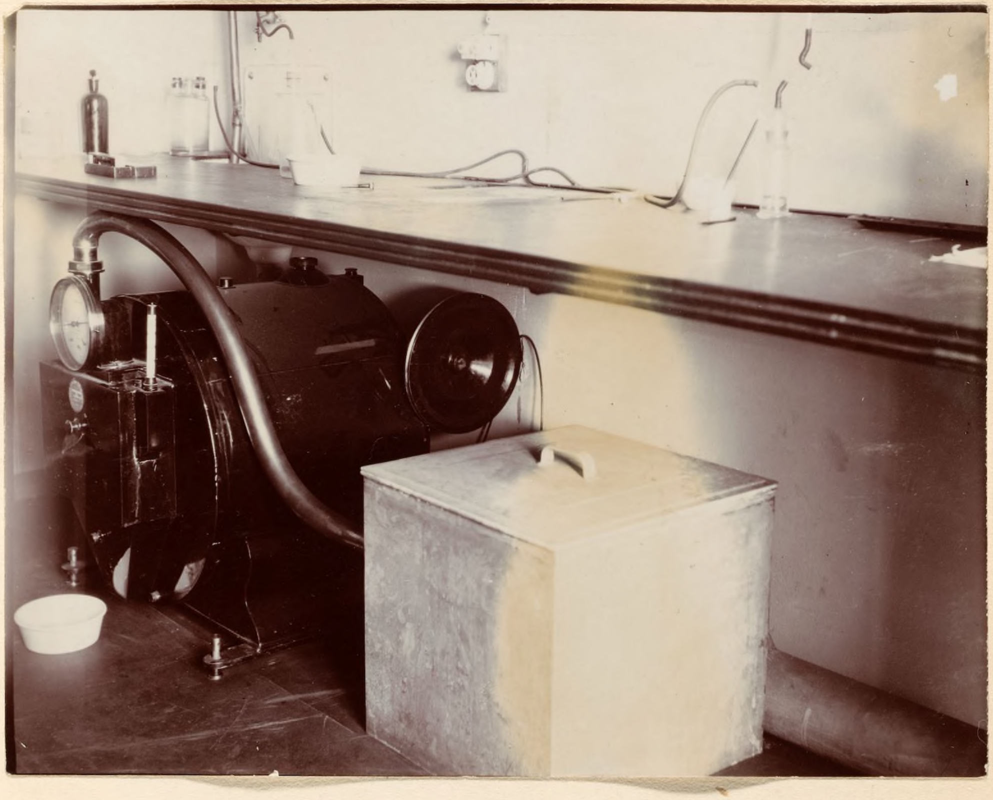


Fig. 58. Elster meter and air moistening apparatus for respiration chamber, Helsingfors.

A large Elster meter placed on the floor driven by an electric motor which was not in place when the photograph was taken. The large box is used for moistening the air before it enters the meter to prevent evaporation from the meter.

Fig. 59. Elster meter, air moistening box and Johanssen sample pipette, Helsingfors.

As the air is drawn into the air moistening box by means of the motor, a sample is withdrawn through a small tube immediately back of the sample pipette.

Fig. 60. <u>Johansson sample pipette</u>.

Ten pipettes filled with mercury by means of the reservoir at the left and fitted with exceptionally well-closed glass stoppers; can be used for collecting samples every two hours if necessary, the analyses being made subsequntly.

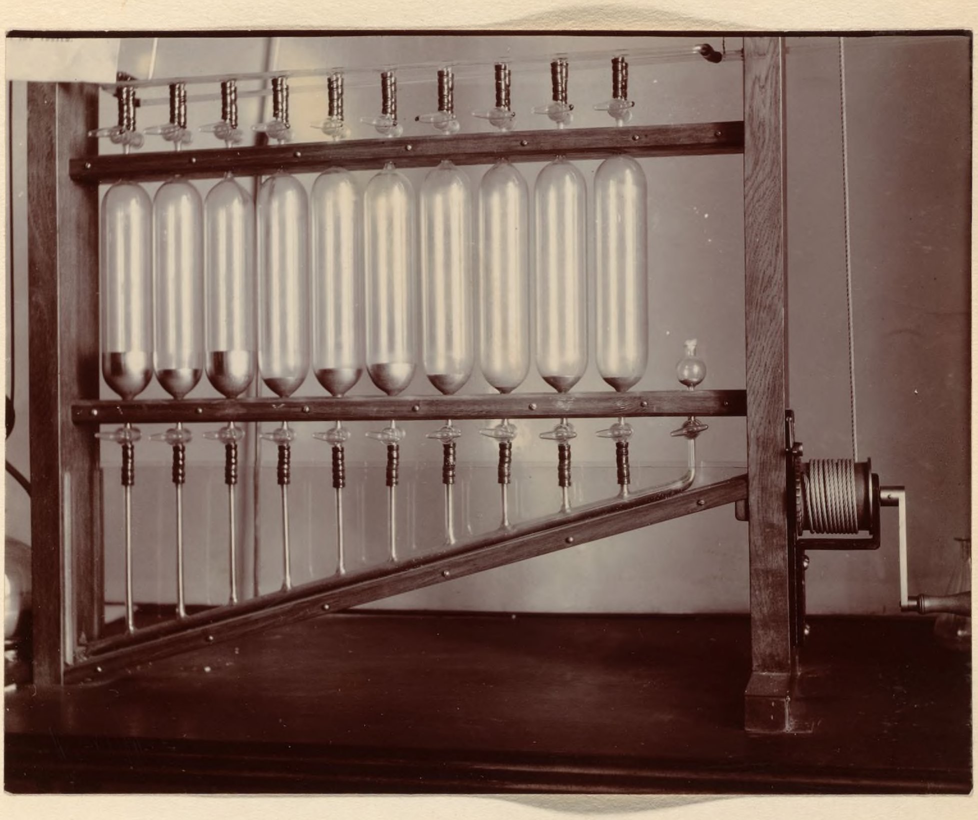


Fig. 61. Another view of the Johansson sample pipettes.

Fig. 62. Pettersson gas analysis apparatus for carbonic acid.

Fig. 63. Adjusting valves at base of Pettersson gas analysis apparatus.

a capillary column of mercury to an exact height. This is accomplished by means of the steel screws at the base of the apparatus, details of which are shown in Fig. 63. The mercury is lowered to a point below where the level is desired. The stopcock shown at the extreme base of the apparatus is then closed and by means of the screw cock, the screw is pushed in and thereby the mercury above it is caused to rise. In the photograph, the stopcock at the left is shown closed, that at the right is open. This feature is also on the new apparatus which will shortly be received for the Nutrition Laboratory.

The use of the Pettersson apparatus for determining carbonic acid is attended with considerable difficulty and until experience has been acquired, much time is lost and unsatisfactory results are obtained. In addition to the precautions noted in the laboratory at Basel (see Basel, this report) Prof. Tigerstedt offered many suggestions regarding minor manipulations.

For lubricating the stopcock, he obtains a special wax from the constructer of the apparatus (Grave in ~~St. Petersburg~~ Stockholm).

The paraffin oil index should be very thin; 1 mm. in width is sufficient.

It is important to have a drop of water above the mercury but great care must be taken not to get water between the globules of mercury and the capillary. The mercury is so adjusted at first that the mercury m~~i~~eniscus thus measures air plus water vapor plus a little water. Then the compensation vessel (which always accompanies this type of apparatus) is so adjusted that the pressure as measured by the oil index is the same in both vessels.

\- The greatest care must be taken to avoid sucking potassium hydroxide into the apparatus. In every instance, it will be necessary to have positive pressure in the measuring pipette before the air is driven into the potassium hydroxide. Tigerstedt usually drives the air into the potassium hydroxide twice; when there is a large amount of carbonic acid present, he does it three times.

When lowering the mercury, it is necessary to start slowly so as to make sure to remove the water completely for if the mercury is suddenly lowered, the water may be retained in the capillary and although the rush of gas from the potassium hydroxide pipette may apparently sweep all the water before it, as a matter of fact, it may simply blow the bubble apart and the water may then reunite and seal some of the gas, thus making it difficult to adjust the meniscus exactly.

Tigerstedt's apparatus is so adjusted that the other burette will give graduations from 1 to 4 or from 1 to 4 parts per mille of carbonic acid. The compensation vessel is likewise similarly adjusted so it is possible to obtain carbonic acid as high as 8 parts per mille.

Purification of mercury.--A funnel has been devised by Grave to separate mercury into fine bubbles when passing it through dilute hydrochloric acid. One of these has been ordered for the Nutrition Laboratory. Tigerstedt has three funnels with these fine holes in them. One is placed over a tube containing water, the second in a tube containing 20 per cent nitric acid and the third 96 per cent alcohol. The mercury is finally passed through water. The usual arrangement of the long tube with a capillary siphon in the lower end accompanies each of these purifying devices.

In connection with the respiration chamber, Tigerstedt uses a wet and dry bulb thermometer and air thermometers depending upon the expansion of a certain volume of air are used for determining the temperature in different parts of the chamber.

A very sensitive manometer, devised by Sondén, is used for measuring the pressure. The manometer and air thermometers are shown in Fig. 64. They pass through into the wall of the respiration chamber through pipes bent in U-form set in the wall and partly filled with oil to secure tight closure. Sondén's manometer has also been ordered for this laboratory.

Nitrogen in feces.--Commenting upon the regularity in the amount of fecal nitrogen per day in health, Prof. Tigerstedt mentioned some experiments by some investigator (I do not recall the name) who, when working on cocoa, found a large amount of nitrogen in the feces. He also said that Falta found considerable amounts in experiments with somatose.

Criticism of Loewy's method of computing the work of the heart.--Loewy has computed from analyses of blood gases the amount of blood flowing through the heart and from the blood pressure has computed the work of the heart. Tigerstedt criticises this on the ground that Loewy assumes that no carbonic acid is formed in the lungs themselves. Furthermore, Tigerstedt has shown that there may be a greater flow of blood through the heart accompanied by a much less pressure and thus the total amount of work would be the same or possibly even less.

Experiment to show the amount of blood flowing through the heart.--Tigerstedt has devised a special apparatus with a ball in a vessel of glass that can be attached to an artery and the ball is pushed by the blood from one end to the other of the glass tube. In its passage through the tube, 10.4 cc. of blood are necessary to force it from one end to the other. This glass tube is attached to the artery in such a manner that all the blood flowing out of one side of the heart is caused to pass through the apparatus. At the end of each 10.4 cc., the valve is turned about and the blood is pushed out and back into the

Fig. 64. Wet and dry bulb thermometer, Sonden manometer, and air thermometers in gas analysis room adjoining the respiration chamber, Helsingfors.

circulation. He marks the time on a kymograph and the number of times the valve is turned, also. By this method alone, it is possible to tell how much blood passes out of the heart. Simultaneously, the pressure can be determined and consequently the amount of work done. He uses hirudin to prevent coagulation of the blood and has made many studies of the effect of an increase in the volume by adding salt solution, etc.

Work of digestion.--In accounting for the increased heat evolution after eating, Tigerstedt thinks that it may be simply an increased muscular tonus resulting from the ingestion of food,--a better feeling all over the body. When a man is tired and hungry, he feels relaxed but after the first few mouthfuls, he feels better,--all braced up. This is very suggestive.

Reference to Smith's work on respiration.--Tigerstedt pointed out that Edward Smith in a paper "Researches into the phenomena of respiration", published in the Philosophical Transactions, 1859, and abstracted in the British Medical Journal of the same year, has made some remarks on hunger and the work of digestion.

If I remember rightly, in these experiments Smith used a mouthpiece for breathing 18 consecutive hours. Durig in Vienna told me that he had used it for 6 consecutive hours and this is the longest I ever heard of.

Experiments on mineral metabolism during pregnancy.--An assistant in Tigerstedt's laboratory has just completed a very complicated study of the mineral balance during the last 24 weeks of pregnancy. The subject, his wife, was a very intelligent, normal, powerfully built woman, who went the normal term. One-tenth of the daily food was dried and the samples of a week mixed and analyzed so that there was one sample for each week. An attempt was made to separate the feces weekly, but without very good success, as enemas were necessary and separations were very difficult. He used 2 grams of carbon in gelatin capsules but there was great uncertainty owing to constipation. He did, however, obtain separation at the beginning and end of the experiment. The ash analyses were made according to the method of Hoppe-Seyler by extracting the ash with water twice during the process of incineration. The ash was then treated with hydrochloric acid, and the water and ash solution were then combined and made up to a definite volume. Silica was determined in the residue and sulphur was determined according to Folin. In the urine, there was determined the total and unoxidized sulphur but not the neutral. Chlorine was determined in the dry substance according to Schlossing.

During the experiment, particular pains were taken to have the same amount of exercise per day. The subject did not exercise very much, walking about one kilometer per day. Analyses were made of the after-birth, the composition of the child being assumed from many analyses made elsewhere.

In the last 24 weeks, making due allowance for the child, after-birth, etc., the subject stored 500 grams of nitrogen or 2 to 3 grams per day. The body weight at the beginning was 62 kilos; at the end, just before delivery, 69 kilos. The weight of the child was 7 kilos, so the body was the same at the beginning as at the end. 2300 calories were eaten per day. During this period there were stored 200 grams of sulphur, 40 grams of phosphorus, and 195 grams of chlorine but there was a complete balance of calcium, magnesium, potassium, and sodium, and no alkali stored. It is possible that the sulphur and phosphorus were stored by the protein but there was no method for accounting for the chlorine,--certainly, a very perplexing point.

<u>Personal impressions of the Helsingfors laboratory</u>.--The laboratory

is most admirably equipped and Prof. Tigerstedt and his son are to be congratulated on having such excellent facilities for instruction. Prof. Tigerstedt has a most wonderful command of literature, has a very fine private library and is evidently in close touch with all physiologists the world over. His criticisms were very keen and helpful. He is very anxious that his son should come to America and do some work in the Nutrition Laboratory. The younger Tigerstedt seems to be a very bright fellow who is evidently planning to follow in the footsteps of his father.

In this laboratory I found a most typical situation which seems to prevail in most European laboratories, namely, that when an investigator has devised a method for studying any particular problem in physiology, he seems to possess an insane desire to utilize this method for studying problems which lie outside of the field for which the method or apparatus is designed. This is well illustrated in this laboratory. The Tigerstedt-Sondén apparatus was devised primarily for the purpose of studying the carbon dioxide output of a large number of people simultaneously and thus eliminate the personal equation. I find in Helsingfors that this large apparatus, containing 100 cubic meters, had last been used by an assistant of Prof. Tigerstedt's to study the carbon dioxide production of a resting, five-year-old boy.

STOCKHOLM, SWEDEN.

Laboratory of Physiology, Karolinska Institute.

Prof. J. E. Johansson and Dr. Ernst Landergren.

This laboratory is especially noteworthy as being the source of a large number of experiments with the original Sondén-Tigerstedt respiration apparatus. Since Prof. Tigerstedt removed to Helsingfors, Prof. Johansson has had charge of the laboratory and although his interests are in a large measure sociological and statistical, yet experiments have been in more or less continuous progress ever since Prof. Tigerstedt left.

Sondén-Tigerstedt respiration apparatus.--This apparatus, devised by Prof. Tigerstedt in company with the engineer Sondén, was first constructed in this laboratory. Since that time the chamber in Helsingfors was built. The chamber contains 100 cubic meters and is a small laboratory room lined with sheet zinc. Aside from some minor details, it is essentially the same apparatus as that in Helsingfors.

Ventilation.--The ventilation of this apparatus depends wholly upon the nature of the experiment. Originally designed for studying the carbon dioxide output of a large number of individuals at the same time, it has been used for the most part for experiments with only one individual. Apparently, as far as I could judge, very little thought was given to the ratio of the ventilating air current to the carbon dioxide content.

At the time I visited the laboratory, experiments were being made with a single subject at absolute rest with a ventilation of 16 cubic meters per hour. Two very large gas meters, furnished by the Gas Meter

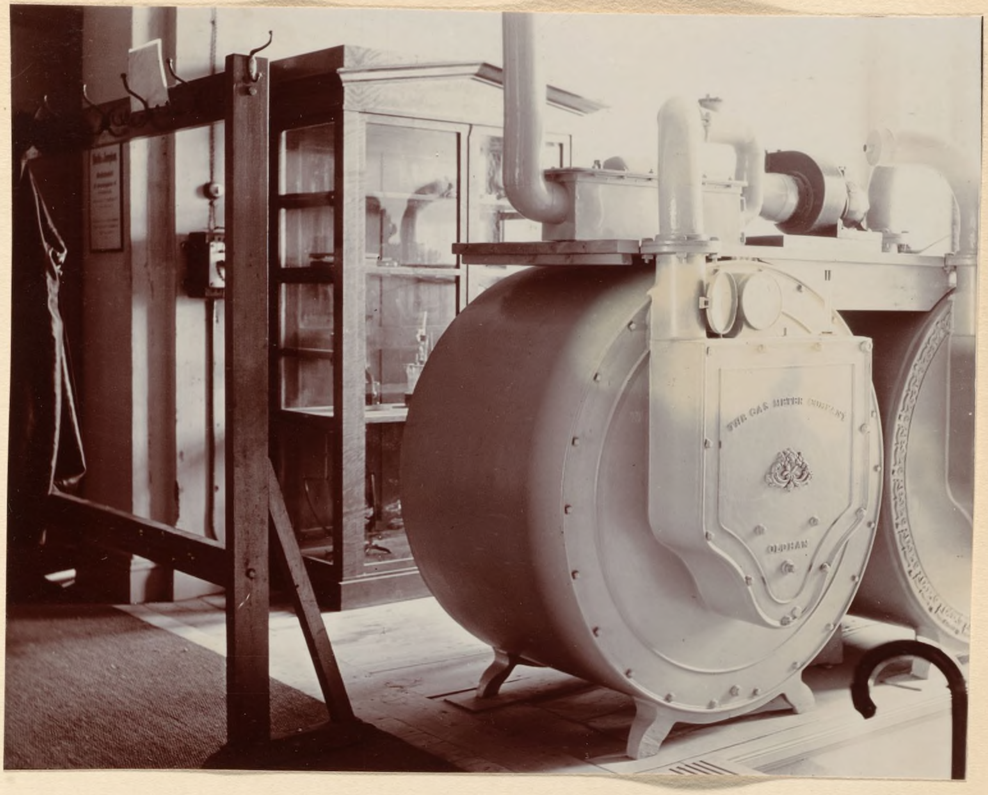


Fig. 65. Gas meters and electric ventilator, respiration apparatus, Stockholm.

The electric ventilator is over the two meters; the long rectangular box at the left is for moistening the air current before it enters the meter.

Co., Oldham, England, were connected with the apparatus. Only one is used at a time. The gas meters are shown in Fig. 65. These meters have been in the laboratory many years. They have possibly been calibrated some time but Prof. Johansson said that the absolute amount of ventilation ~~[illegible]~~ need not be known exactly and he did not know what their calibration was. This appears to be rather an oversight when the intricate nature of some of the experiments made with the apparatus is taken into consideration. There was an electric ventilator attached directly to the fan blower immediately after the meter. This can be seen in Fig. 65 on the shelf above the two meters and directly over the space between them. The rate of ventilation can be altered either by changing the rate of speed of the motor or by moving the check valve or damper in the pipe between the electric fan and the meter. As this is throttled, less air is pulled through. An attempt is made to moisten the air before it enters the meter in the longitudinal box immediately ~~before~~ above the meter.

Apparently very little attention is given to the exact measurement of the volume of air passing through the respiration chamber. This surprised me not a little.

Plan of experiments.--Prof. Johansson has attempted to secure complete muscular rest as the basis for his experiments. In other words, the respiratory exchange, particularly the carbon dioxide output of the subject when lying quietly at complete muscular rest, is taken as the basis. Prof. Johansson can personally obtain this complete muscular rest for several hours. Medical students can also do it but most others find it very difficult. Four hours at a time is all that any one can do, so the experiments are so adjusted that the subjects can move about in intermediate periods. Thus, in one day he gets results for the first, third and fifth hours of the experiments, and on the second, fourth, and sixth, etc., the subject moves at will. On the next day, he moves on the first, third, and fifth hours and the results are taken on the second, fourth, and sixth,--not necessarily on the next calendar day but the next experiment is made to fill in the gap.

Prof. Johansson has found it very difficult to keep diabetic patients quiet for it is very hard for them to keep still for two hours. With the present arrangement of experiments, all subjects are allowed to move the legs once an hour at the signal of a bell, that is, in an experiment with a 4-hour period of rest. Prof. Johansson says that many of his men come in early in the morning, say, seven o'clock, and are sleepy and take to the complete muscular rest very easily. They lie in a reclining chair, usually with the hands folded across the abdomen, the head resting on a pillow. Prof. Johansson was good enough to allow me to take a photograph of himself in this position in which he obtains complete muscular rest. This is shown in Fig. 66.

The apparatus is in the respiration chamber and immediately in front of the subject are the steps with oil sealed door for entering. At the right is the box for the food. With some of his medical subjects, Prof. Johansson is not sure but that they go to sleep at times but he thinks there is no difference in the carbon dioxide output. He thinks he has some experiments during sleep and he finds that he can actually get a lower carbon dioxide output with complete rest during waking than bed rest with sleep.

Bed rest vs. sitting rest as basis.--The Middletown experiments have been made in large measure with the degree of muscular activity attendant upon sitting in a comfortable arm chair, quietly reading, as

Fig. 66. Interior of Sonden-Tigerstedt respiration chamber, Stockholm.

Prof. Johansson is shown in the position of "complete muscular rest".The steps lead to an oil sealed opening through which the subject enters and leaves the chamber. The food aperture at the right, with telephone above it, is of similar construction to that at Helsingfors.

the basis. We have found that subjects experienced no difficulty in maintaining this muscular activity for 10 or 12 hours at a time. I discussed the matter very carefully with Prof. Johansson and I am firmly convinced that his so-called muscular rest involved a distinct strain upon a man to maintain this condition. It requires a trained man as does the respiratory mouthpiece and it would certainly appear that the subjects were not under normal conditions. Certainly, the American temperament would not lend itself to such experiments as readily as does the Swedish, according to his statements. As a matter of fact, the actual basis is immaterial so long as it remains constant from experiment to experiment. Prof. Johansson assured me that he would unquestionaly test the method used in America.

Experiments with carbohydrates.--- At the present time, Prof. Johansson is especially occupied in studying the effect of ingesting the carbohydrates. These experiments are made with single individuals and obviously with this form of apparatus only the carbonic acid output can be studied. As the basis, he uses the "nuchternwert" under conditions of complete muscular rest. On subsequent days, the particular carbohydrate to be studied, mixed with a little water, is given. A little water is allowed to rinse out the mouth. The evening before the experiment, the subject eats lightly, say, between nine and ten o'clock, taking a cup of tea with bread and butter, evidently not a determined amount. He goes to the laboratory at 7.30 a.m., and enters the respiration chamber at eight o'clock. As he enters, he takes, say, 50 grams of the carbohydrate with 150 cc. of water, part of which is used to wash out the mouth. The carbon dioxide output is measured for either 1, 3, or 5 hours, or for 2, 4, or 6 hours, etc. If he is a good subject, four consecutive hours can be measured. In some experiments the carbohydrates were given in small portions every 15 minutes for five hours. He always used medical students as subjects. Four movements of the arm per hour are allowed when taking the augar. In some experiments, one hour is spent inside the apparatus and the next hour outside of the apparatus doing laboratory work, but still taking sugar every fifteen minutes. He controls the movements of the legs by telling the man that he must not move them for he believes if they were allowed to move them at all, they would use no judgment and if told to move them a little, they would over-step this limit. Each movement is made at the signal of a bell. It frequently happens that after a holiday, the respiration chamber may become cold as the steam heat is not on. On one of the mornings that I was there, the temperature of the chamber was 16° C., and the subject said he felt cold. This certainly might influence the experiments and vitiate the results, producing an increase of carbon dioxide.

To make the subject glycogen-free.--In order to deprive the body of as much glycogen as possible, the subjects fast about 48 hours, walk a long distance and work as hard as they can. Many of them row on the Sound. When the body is glycogen-free, Prof. Johansson always finds a lower carbon dioxide value for hunger and complete rest.

The most remarkable result of his experiments when viewed from the standpoint of Middletown work is that when the subject is glycogen-free, there is no increase in the carbon dioxide output after the ingestion of as much as 150 grams of carbohydrate, even if this is all given at once. On the other hand, when the subject was not glycogen-free, there was a noticeable increase in the carbon dioxide output after the ingestion of sugar and, indeed, the increase is nearly, if not quite, proportional to the amount ingested up to about 150 grams.

Prof. Johansson's conception of the use and supply of body material.-

He considers the body has several deposits of material, protein, fat, and carbohydrate. These are supplied from the food. When work is done, these deposits are drawn upon but the process of drawing upon them is entirely independent of the process of supplying them. Only when the storage of glycogen is very low is there are influence of the food ingested upon the kind of material burned during work. It is an interesting assumption but rather difficult to believe wholly, since this would assume that the protein of food must be converted into a deposit before it can be burned and this idea is not in accord with Folin, if I am right. The general idea as expressed above has been incorporated in an article by Prof. Johansson in a Festschrift to Hammersten.

Measurements of development of men and women.--Johansson in studying the size and shape of the mother in influencing the size and shape of the child took measurements of the circumference of the thigh and upper right arm with a steel or brass strap about 20 mm. wide. The thigh measurement should be taken as high as possible in the groin but the nature of the measuring band will make the measurement adjust itself to about vertical to the axis of the thigh. The arm should be bent at right angles but not tense. This is a valuable measurement to show development, so he found it, and recommends it where but few measurements are to be taken. The circumference of the thigh, plus the circumference of the arm is, in the average woman, exactly one-half the height.

Johansson's ergometer.--The ergometer devised by Prof. Johansson for studying both static and muscular work was shown in some of the figures describing the Tigerstedt laboratory, Prof. Johansson's mechanician gave me a photograph of himself seated at the form of ergometer

Fig. 67. Subject working on the Johansson ergostat in the interior of the Stockholm respiration chamber.

132 in the respiration chamber at Stockholm. This photograph is shown here as Fig. 67. The apparatus was constructed by this mechanician inside of the respiration apparatus as the door was not large enough for the machine to be taken into it when fully mounted.

Method of entering the respiration apparatus at Stockholm.--The closure of the opening in the respiration chamber in Stockholm was much more satisfactory than that in use at Helsingfors. A projection is built out from the wall in such a manner that the large zinc or copper cover can be set down into a groove filled with oil. From this cover a short series of steps leads down into the chamber. The cover is removed, the subject walks over the stile, so to speak, and then the cover is put into place with no possibility of a leak.

Johansson's criticism of Zuntz.--Zuntz has used his method of studying the respiratory exchange to study the work of walking and climbing. In certain of his experiments, he finds by calculation the amount of carbon dioxide produced per kilogrammeter and the amount of oxygen absorbed per kilogrammeter, both for horizontal movement and for ascent. From these figures, Johansson computes the respiratory quotient and finds a different quotient for horizontal from that for the work of ascent. Thus ~~he~~ one must assume~~s~~ that the muscles act differently in two kinds of work. (See article by Tigerstedt in Nagel's Handbuch, page 452.) In one instance, for example, there is .18103 liters of carbon dioxide per kilogrammeter of work and .25049 lietrs of oxygen per kilogrammeter. This corresponds to a respiratory quotient of .7222. In another instance, there are 1.3178 liters of carbon dioxide and 1.585 liters of oxygen, corresponding to a respiratory quotient of .831, thus, as Johansson points out, indicating a difference of muscular action.

Zuntz misquotes Johansson.--A pupil of Zuntz, studying muscular work, finds results quite different from those of Johansson. (See Skand. Archiv, vol. 13, p. 293) Zuntz, in writing a note to the article, which was published in Pflüger's Archiv, vol. 95, p. 149, states positively that Johansson agrees with him. Johansson is at a loss to understand why he was quoted in this way as the results do not agree in any way.

Minor apparatus in the laboratory of Dr. Landergren.--Dr. Landergren has made a special study of metabolism in diabetes, has a growing clinic, and is a very serious student. He is working in a laboratory in the same building with Prof. Johansson, but is devoting his time exclusively to urine analysis.

The Kjeldahl room presents two novelties. One of these is an electric motor which is fastened directly to a fan to produce a slight positive ventilation in the room and thus force the draft up the chimney; in other words, the hood is so adjusted that a slight positive draft forces the hot gases through the flues.

An ordinary luminous Argand burner, with a fire clay or pottery burner, is used for heating the Kjeldahl flasks during digestion.

Use of bits of zinc.--For distilling acetone, small squares of zinc, like the tacks used for fastening glass into frames, are used. In the Kjeldahl distillation, three or four bits of this zinc are used in place of the zinc test or lumps of zinc.

Apparatus for ether extraction of liquids.--For determining the B-oxybutyric acid, the apparatus for the extraction of liquids by ether, devised by Magnus-Levy, is here used. This apparatus, together with a fire-proof water bath devised by Landergren, is shown in Fig. 68. The glass extraction apparatus is shown at the left, leaning against a gas bracket. The ether extraction apparatus has a flame enclosed

Fig. 68. Fire-proof water bath for ether extractions, Landergren's laboratory, Stockholm.

Porcelain pitcher, with gradations on the inside, at the left; glass extraction tube of Magnus-Levy leaning against the gas burner; Kjeldahl and Soxhlet coolers clamped above the water bath, the large black pipe going up against the wall is the chimney of the water bath. The Bunsen burner is enclosed in a metal house with an opening through a 2-inch pipe extending nearby to the floor. A mica cap permits the examination of the burner.

in an iron tube which heats the water bath. Air is drawn into the bottom through a 2-foot length of $1\frac{1}{2}$ inch pipe. m It passes out through a chimney 2 meters high of 1 inch pipe. A mica window permits the examination of the Bunsen burner. A condenser keeps the water in the water bath at constant level. The extraction apparatus is that of Magnus-Levy. For the condensation of ether, either a Soxhlet or a Kjeldahl cooler can be used. Considerable use is made of pitchers with graduations on the inside for measuring large volumes of liquid. See Fig. 68 at the left.

Acetone determination.--For determining acetone, Landergren takes 25 cc. of urine, 100 cc. of concentrated sulphuric acid. He adds two pieces of zinc, a small portion of beeswax (important), and distills off 110 cc. of distallate. The distillation lasts one-half hour. It is distilled into a bottle with a side outlet into a test tube containing water somewhat similar to the distilling apparatus discussed in the description of vonNoorden's laboratory in Vienna. He uses one-tenth normal iodine solution and sodium thiosulphate and titrates according to the Messinger-Hueppe method. This is very accurate; two different determinations give to one-tenth of 1 cc. of iodine solution.

Landergren makes considerable use of qualitative tests, the intensity of the reaction giving some idea of the quantitative amounts and thus suggesting subsequent analytical treatment. The reaction of B-oxybutyric acid with sodium nito-prussid is of value, the so-called Legal's test. Fresh sodium nitro-prussid solution plus urine, plus sodium hydroxide, plus concentrated acetic acid, if colorless, there is no acetone or di-acetic acid; if red, there is a little but if it becomes purple, it is a maximum amount which must be over 2 grams per day.

Ether coolers.--Landergren prefers the Soxhlet cooler but the Kjeldahl is much better than the usual ~~gas~~ glass condenser. For determining B-oxybutyric acid, the ether extraction method of Magnus-Levy described in the Archiv Experimentelle Pathologie u. Physiologie. He uses 200--300 cc. of urine with 10 per cent of crystals of ammonium sulphate in saturation. The mixture is evaporated to a volume of 60 cc., filtered and a measured quantity taken for extraction.

Determination of sugar.--Landergren is much disturbed over the problem of determining sugar in urine. He has determined it according to Allin, by the polariscope, and by fermentation. What he really wants is fermentable sugar and he is inclined to think that after all, the fermentation test may be the best. The pentosans also present difficulties since they themselves reduce.

Suggestion. How about the idea of fermenting and then determining the alcohol? Is this problem not worth taking up?

Dextrose: nitrogen ratio.--Landergren has done a great deal of work on the dextrose-nitrogen ratio with diabetes and has found some very high figures. Instead of 3.28, he finds something over 6. The details of his investigation I am not familiar with but he is thoroughly convinced that the dextrose-nitrogen ratio is much larger than is commonly believed.

Further points regarding the Pettersson apparatus for the determination of carbon dioxide.--Practically all of the analyses with the Pettersson apparatus for determining carbon dioxide in the Stockholm laboratory are made by Fraulein Rosenberg who has had a long experience in the laboratory and has become unusually skilful. In talking with her regarding the manipulation of this apparatus, she offered a number of suggestions.

She reads the mercury levels several times until the meniscus remains absolutely constant.

The gas is run into the potassium hydroxide vessel twice slowly and then it is drawn back into the gas measuring pipette until the potassium hydroxide stands with the meniscus tangential to the mark.

In transferring a sample from the Johansson sample pipette to the gas analysis apparatus, it is important not to have the large reservoir of the Johansson apparatus too high and thus have too great a pressure. The sample should be taken with a slight increased pressure, the mercury level adjusted at 0 and then the cock opened to the air for a moment. It is then connected with a compensation tube and again adjusted at 0, then the compensation tube is adjusted so that the manometer is at 0. A small telescope is used in reading the meniscus on the compensating manometer.

A sheet of paraffin paper is placed behind the Pettersson apparatus and Fraulein Rosenberg finds that she can work at night with a Welsbach light very satisfactorily. Often she can work better at night.

If the carbon dioxide content of the air is greater than 3 or 4 parts per mille, it is necessary to drive the air into the potassium hydroxide more than twice. This is not very often necessary, however.

In lowering the mercury to draw the sample into the pipette and especially at the end when adjusting the mercury level, the mercury reservoir is raised and lowered several times so as to insure that all the water is collected on top of the mercury. It will be remembered that a drop of water is always on top of the mercury so as to insure saturation of the air with water vapor. If the reading on the burette is 14.7, the error in duplicates can be either 14.8 or 14.6. These figures are multiplied by four to get parts per mille, thus, 0.147 x 4 equals .588 per mille. Ordinary air is 0.032.

The smaller the oil index, the better. The oil is drawn into the manometer from the left-hand cock and after filling the measuring pipette from the right-hand cock, lower the mercury reservoir and draw the oil into the manometer.

Water is also drawn into the system by this method but care must be taken not to leave water in the tube in the capillary.

When there is an interval of over an hour between the analyses, one must always re-adjust the level of the potassium hydroxide.

The Johanssen sample pipettes are left with a vacuum at the end of each experiment and before the experiment they are always evacuated twice so as to clear out all of the air. No especial reason is given for leaving a vacuum.

In Stockholm the mercury is always purified by distillation, since they think it is better than when purified by nitric acid.

The oil used in the manometer smells like ~~resin~~ Kerosene and has a slight yellowish color. The right-hand burette is filled with mercury one-half, then the left stop-cock is taken out and one drop of oil on the end of a match is placed in the opening at the end of the manometer. The other end of the manometer is so connected with the right pipette that when the cock is opened at the bottom carefully, the oil drop will be drawn into the manometer. After the oil has once got into the centre of the manometer, it can be reduced in size as much as desired by absorbing the oil on a long, thin strip of filter paper introduced with pinchers through the hole in the stop-cock along the caliber of the manometer. Care must be taken to absorb all excess of oil.

The wax used for lubrication is a mixture of beeswax and mutton tallow.

By having a vacuum in the collecting pipette, the sample is taken instantly. The sample is taken with a rush at the end of the exact hour. Perhaps five seconds are required to take the sample. One can hear the gas rushing in. After the vessel is filled with the sample, the cocks are shut and the mercury raised to get a slight positive pressure in the chamber.

Laboratory of the Department of Health.

Engineer Sondén.

One of the most active cooperators in the development of the respiration apparatus at Stockholm is Engineer Sondén, a man of remarkable technical skill and the greatest ingenuity. His relations with the University are not direct and he has a special laboratory in what corresponds to our Board of Health. He has been especially interested in the Pettersson gas analysis apparatus and is at present working upon a modification of this apparatus with a view to determining the amount of oxygen in normal air with great exactness. This was done primarily with the idea of studying the differences of oxygen content in air under varying hygienic conditions. Recognizing the great accuracy and sensitiveness of the Pettersson apparatus for determining carbon dioxide, Sondén believes that the same principle may be adapted for the determination of oxygen. His attempts to secure this accuracy have, as yet, however, been unsuccessful. The apparatus upon which he has been working is extremely complicated and is shown in Figs. 69 and 70. He is attempting to determine oxygen by admitting to the air a definite volume of pure hydrogen (electrically prepared), passing this through a quartz tube containing platinum which is heated to incandescence and then determining the diminution in volume.

Sondén objects to the usual method of determining oxygen by absorption in a solution of either potassium pyrogallate or sodium hydrosulphite, on the ground that there is a variation in the partial pressure of nitrogen at the beginning and end of the experiment. The ground is well taken theoretically but the difficulties of determining

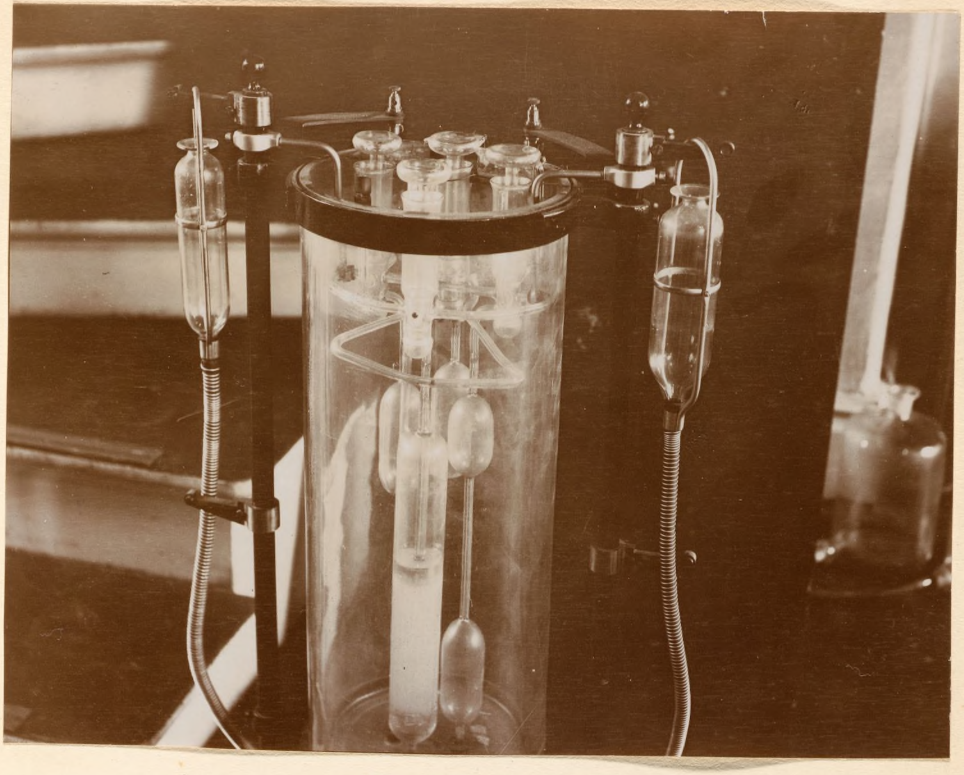


Fig. 69. Sondén apparatus for the determination of oxygen.

The apparatus is extremely complex; all stopcocks are mercury sealed. A quartz glass tube containing a platinum spiral is used for the combustion of the air and hydrogen but the apparatus is not yet out of the experimental stage.

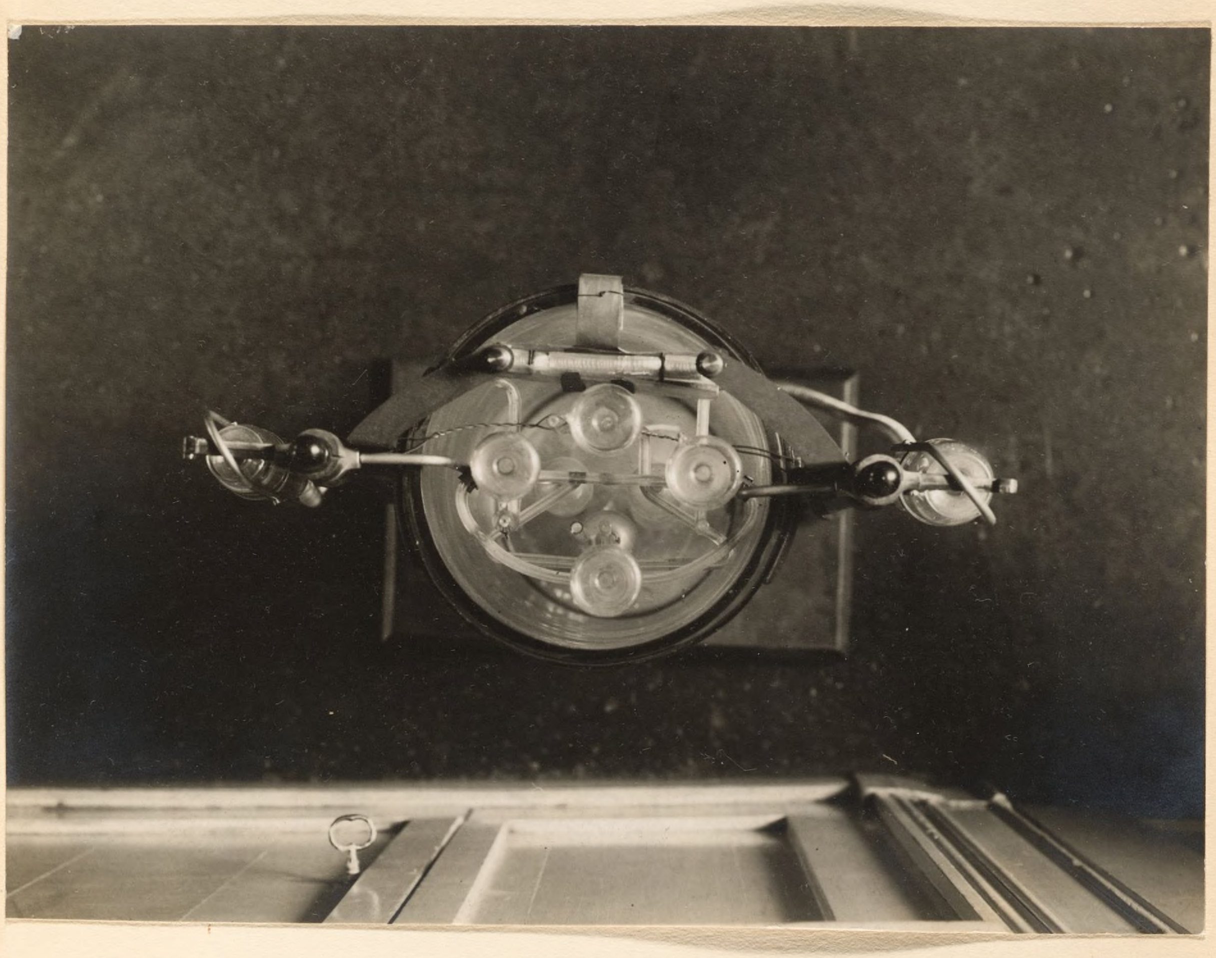


Fig. 70. Top view of the Sondén gas analysis apparatus.

The platinum spiral in the quartz tube can be seen near the upper part of the photograph.

oxygen by the method that he proposes seem to me insuperable, although since my visit to his laboratory, I have had the pleasure of seeing the apparatus of Chauveau and Tissot which promises the highest degree of accuracy for this method of determination. In Sondén's apparatus, all glass cocks are made with mercury seals. In the view taken from above, the platinum spiral for igniting the moisture of air and hydrogen is plainly seen. With the help of his assistant, Mr. Sondén is proposing to continue the investigation in the hope of elaborating this apparatus sufficiently to secure the degree of accuracy he so much desires.

Hygrometer of Sondén.--There are a large number of methods for determining the amount of carbon dioxide in air involving the use of small samples of air but prior to my visit to Stockholm, I was unaware of any method of determining accurately the amount of moisture in air without the use of a considerable volume of sample. Engineer Sondén has devised an apparatus on the Pettersson principle, using a compensation vessel and manometer for determining the tension of dry air and that of air with varying degrees of moisture. From this tension, the absolute water content is accurately calculated. The apparatus is shown in Fig. 71.

A sample of air is drawn into one of the pipettes, measured accurately, and then compensated against air of absolute dryness in a vessel containing phosphorus pentoxide. This vessel is the rear one of the three pipettes shown in the apparatus.

A duplicate of this hygrometer has been ordered and is now on the way to the Nutrition Laboratory. In the manipulation of this apparatus, it is important that the air after saturation should not be driven out of the same tube that it went in for the air entering is rarely saturated while at the end of the experiment, the air is completely

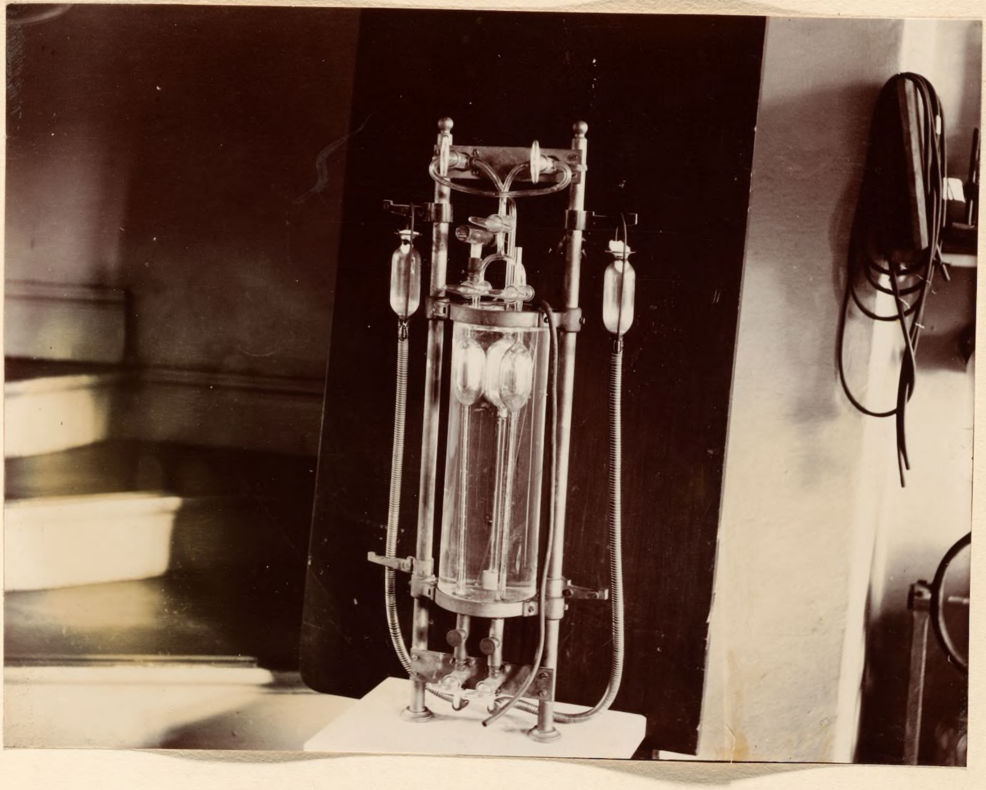


Fig. 71. Sondén hygrometer.

This consists of two measuring pipettes with a compensation vessel in a water bath connected with a manometer after the type of those used in the Pettersson gas analysis apparatus.

saturated and the tension measured as compared with the partially saturated air. If this wet air were driven out of the same tube, a certain amount of moisture might condense and the new sample, when entering, take up a portion of this moisture.

Of the greatest importance to the satisfactory use of this hygrometer is the accurate reading of temperature fluctuations. These should be kept as low as possible by the water bath and by a constant temperature room.

The apparatus appears to me to be extremely well suited for many determinations in the Nutrition Laboratory and it will no doubt have considerable use.

Personal impressions of the laboratories and workers in Stockholm.

The serious purpose of all three investigators, Johansson, Landergren and Sondén, impressed me very much.

The Karolinska Institute is contemplating, if not, indeed, actually experiencing a considerable addition to their building. In this addition, definite provision is to be made for a calorimeter, probably after the type of that used in Middletown. Prof. Johansson is extremely anxious to come to America to familiarize himself with the methods of manipulation of a calorimeter of this type and it is in a high degree probable that he will come here shortly.

Dr. Landergren is a most serious student of diabetes, a pupil of Naunyn, and bent upon a most careful study of his subject. I have the feeling that in Stockholm he is perhaps too isolated from other clinicians to have a most extended view of this phase of metabolism in pathology.

Mr. Sondén is supplied with a very well equipped laboratory, has a most skilful assistant and will undoubtedly contribute considerably to the methods of gas analysis since Prof. Pettersson has practically lost his interest in this line of research. Sondén is certainly a worthy successor of Pettersson in this line of investigation.

COPENHAGEN, DENMARK.

Physiological Institute, University of Copenhagen.

Prof. Bohr and Dr. Krogh.

Prof. Bohr has been confining his attention almost exclusively to analyses of blood gases in recent years although at present he is working upon the ventilation of individual lungs and studying the effect upon the gaseous content of the blood.

Gas meters.--Several gas meters with glass faces constructed of copper and britannia metal by the Dansk Maalere Fabrik were in use in this laboratory. Two meters have been ordered for the Nutrition Laboratory. They are very useful in many ways and the glass face is of great practical value in noting the height of the level of the water and the general condition of the interior of the vessel.

Gas holders.--Considerable use is made of large gas holders for supplying artificial atmospheres of different kinds and the device for maintaining constant pressure in these holders with different heights of the drum is quite interesting. The chain running over the large main wheel for support is furnished with weights of varying size, thus compensating for the variation in the amount of metal submerged as the drum descends into the water.

Methods of gas analysis.--At present Haldane's methods of gas analysis are used exclusively and a strong potassium pyrogallate solution recommended by Haldane is found very satisfactory for analysis of blood gases.

Mercury pump.--Prof. Bohr has developed to a high degree the mercury pump which is, indeed, essential for his work. In most of the laboratories that I visited previous to going to Copenhagen, I always asked the question "Have you a mercury pump? If so, is it in commission?" In no laboratory up to this time had I found a mercury pump that was in commission but Prof. Bohr's laboratory contained seven or eight, all of them in regular use. Perhaps the one factor which contributed most to the successful use of these pumps was the very ingenious scheme for raising and lowering the mercury receptacle. Instead of using a windlass or pulley to raise the mercury reservoir, he has it connected with the city water pressure so that the water presses on the top of the mercury, forcing it up into the mercury vacuum bulb. By opening a cock, the ~~air~~ water is then allowed to flow out and the mercury descends from the vacuum bulb. At first sight, it would appear that by this use of water directly on top of the mercury, there would be a certain amount of moisture transmitted from the mercury vessel into the vacuum bulb but Prof. Bohr assured me that this was not the case and subsequently, in talking with Prof. Zuntz in Berlin, he said that he was fully convinced that no water passed through the mercury into the vacuum bulb. (See discussion of new gas analysis apparatus in Zuntz' laboratory, Berlin.)

Apparatus for studying the ~~question~~ excretion of gaseous nitrogen.--The apparatus of Dr. Krogh for studying the excretion of gaseous nitrogen was unfortunately dismantled, only parts of it being presentable. Evidently Dr. Krogh is a man of unusual technique, works with the utmost accuracy, and inspires one with confidence in the assurance with which he attacks all of his research problems. A very simple method for analyzing minute quantities of blood gases has been devised by him. Since then he has presented the material in a paper at the Physiological Congress.

Dr. Krogh is much interested in the study of diet and especially of the nitrogenous excretion in people of northern climates. He proposes to make a very careful study, covering some months, in Greenland. He plans to transfer a rather extensive chemical laboratory to Greenland some time in the near future and conduct investigations there along this line.

Laboratory of the Experiment Station.

Prof. Henriques and Dr. Hansen.

Prof. Henriques and Dr. Hansen have contributed a great deal to our knowledge of metabolism and their laboratory is very active.

Small respiration apparatus.--A small respiration apparatus for mice and rates was partially mounted. Its use had not been attended with the greatest success although it presented many interesting points. For example, the pump used was a series of vacuum boxes for aneroid barometers, soldered together in such a way that by ~~belting~~ stretching them, there could be a suction of air. By connecting this with mercury valves, built on the principle of the Drechsel gas washing bottle, a regular current of air could be maintained with great ease.

Large gasometers such as were installed in Prof. Bohr's laboratory, were likewise found here. The glass-faced gas meters were also used and Prof. Henriques had attached a small electric counter to record the number of revolutions of the drum.

Two experimental forms of calorimeters after the principle of d'Arsonval and Lefevre were in a partial state of demolition. Their use had not been thoroughly successful, as I understood it.

Kjeldahl method of determining nitrogen.--The Kjeldahl method of determining nitrogen was developed in a brewery in Copenhagen and the method as originally carried out by Kjeldahl himself is in use in the Experiment Station laboratory. To the acid solution after ammonia is distilled into is added 10 cc. of a 5 per cent solution of potassium iodide, and then 2 cc. of a 4 per cent solution of potassium iodate.

This produces of course iodine from the free acid and this is titrated with sodium thiosulphate until the color disappears. Starch is not considered necessary as an indicator. The acid used is sulphuric acid, 14th normal, and for each 25 cc. of acid used, 2 cc. of a 4 per cent solution of potassium iodate are required.

The whole description of the Kjeldahl method was given in a publication entitled Meddelelser fra Carlsberg Laboratoriet. In 1885, Kjeldahl there described his method for determining nitrogen. In 1891 the method for the moist combustion process for carbon was there given.

The Kjeldahl method is so closely adhered to in this laboratory that the original distilling tubes on top of the Kjeldahl flasks when distilling off the ammonia are used. I have ordered a set for our laboratory.

Experiments on feeding animals with hydrolized proteid.--Henriques and Hansen found that when the protein was split with sulphuric acid until there was no more biuret reaction, then the animals could not use it to build up protein. (Dr. Spence of Liverpool pointed out that this cleavage with acid was lower than that with ferment.) If they split with trypsin and erepsin until there was no more biuret reaction, (See abderhalden. Berlin) they found the animal could synthesize the protein. In their experiments they used rats but found that they could not feed them longer than three weeks as they then refused food. The animals must be kept warm.

Voit respiration apparatus.--A small apparatus for animals was formerly used by Messrs. Henriques and Hansen. Samples of the air were taken and collected over mercury according to the method of Bohr, but the analyses were not considered satisfactory and the researches were given up.

Personal impressions of Copenhagen investigators.

Dr. Krogh impressed me as being a very keen, able physiologist. His interest in problems of metabolism will unquestionably lead him to more researches in metabolism than it has thus far. Prof. Henriques and Dr. Hansen are carrying on their investigations on metabolism in small and large animals but as with the Stockholm investigators, I received the impression from their laboratory that they were too isolated and not sufficiently in touch with other active workers. This leads in many instances to polemical discussions and, indeed, some of their work has not been free from adverse criticism.

EDINBURGH, SCOTLAND.

Laboratory of Physiology, University of Edinburgh.

Prof. Schaefer and Dr. Watson.

Prof. Schaefer holds in some respects the foremost position in physiology in Great Britain. He is looking forward to new laboratories from the fund established by Mr. Carnegie for the benefit of Scottish universities.

The equipment of the lecture room and laboratories is very good and of special interest is the fine collection of old physiological apparatus of historic interest, all of which is carefully mounted, well labelled and displayed in glass cases.

Experiments with rats.--Dr. Watson has been carrying on a large number of experiments with rats to study the effect of high proteid diet on the changes in tissues. These results have been published at considerable length in the Journal of Physiology and apparently indicate that a high protein diet given to rats results in a marked alteration of the nature of certain tissues. He takes as a standard diet a bread milk and diet which he calls a standard diet inasmuch as it has been used in the laboratory for many years and is found to be a diet upon which the rats thrive well.

One of his colleagues has done a large amount of research on the transplanting of the ovary.

Quarters for animals.--An unusually well arranged house for keeping animals before and after experiments is found in this university. The animals are out of doors the greater portion of the time but the houses are so arranged that they can be heated and Prof. Schaefer assured me that they had very few cases of infection, so hygienic were the conditions under which the animals are kept.

Respiration chamber for man.--A very old respiration chamber , used by one of the earlier investigators whose name I cannot at present recall, is in this building. It is surrounded with hair felt but has not been used for many years.

Respiration experiments with animals.--Some of Dr. Schaefer's assistants were planning experiments with rats with the Haldane respiration apparatus. They propose to use wide-necked Erlenmeyer flasks as the respiration chamber. The apparatus had not been wholly installed and no experiments had been made with it.

Personal impressions.--While surrounded with a number of very active, intelligent young assistants, Prof. Schaefer is obviously too much occupied with administrative duties to carry on any extensive investigations of his own, at least, that was the general impression I obtained from his conversation and from his statements of his duties and cares. The assistants are evidently given free hand and are encouraged to carry out research in every way possible.

LIVERPOOL, ENGLAND.

Laboratory of the School of Tropical Medicine.

Major Ross.

Dr. Ross was much interested in our methods of determining body temperature and stated that he published a number of years ago in the Lancet a temperature curve for man. He thinks that a curve during malarial fever would be of great value and hopes to obtain it. He stated that the malarial parasite was found in one-third of the cases examined. If one looks long enough for it, it will be found in all cases but it may be very hard at times and there may be but one parasite to 25,000,000,000 blood corpuscles. In fever, there may be 25,000,000 parasites. He was inclined to think that Dr. Councilman's small pox protozoa may prove to be a part of a cell as Pringle's (?) bodies proved to be.

The laboratory presented nothing of unusual interest for our work, although admirably adapted for the special researches in which it was engaged.

The Thompson Yates and Johnston Laboratories.

Prof. Moore, Drs. Roak and Edie.

This laboratory is essentially a research laboratory and Prof. Moore has a number of very interesting ideas regarding the equipment of such a laboratory. He does not believe in individual rooms for research workers but believes in a community of interest and hence the laboratory is so arranged that all work in one large room. The floors are concrete and the table tops are a patent preparation something like the Xylolith found in Vienna but very easily attacked by acids and very strongly condemned by Prof. Moore.

Distilling apparatus.--For the preparation of distilled water, the still was so adjusted that the first run of water could be drawn off through a special valve and thus not enter the distilled water tank. This enables one to obtain especially pure distilled water.

Goose neck with filtering apparatus.--In the main laboratory, the goose-neck faucet was commonly used and to the upright of the goose-neck was fastened an iron clamp into which a funnel could be set and thus the contents of the funnel washed very easily. I am not sure that this has any practical value for us.

Researches on conductivity.--Dr. Roak is especially interested at present in determining the possible union of alcohol and protein. He is studying the depression of the freezing point of serum and water and thus serum plus alcohol, chloroform, etc. He is also studying the conductivity of serum plus water and serum plus alcohol, chloroform, etc.

Metabolism experiments on animals and fruit.--A small respiration apparatus of bell jar construction, something like that of Paschutin's, is used for studying the carbon dioxide output and, indeed, the oxygen consumption of rabbits, cats, and fruit. The apparatus is described in detail in a reprint given me by Dr. Roak. No check tests regarding its accuracy were made. The principle depends upon the absorption of carbon dioxide by dry soda lime, exposed inside the bell jar. As the carbon dioxide is absorbed, oxygen is admitted. The oxygen is prepared from potassium permanganate and as charged, is very pure (99 per cent) but after remaining in the gasometer for some time, it is less pure, containing but 96 per cent oxygen.

In determining the oxygen he uses phosphorus for the absorption of the gas and mixes it with a known volume of pure nitrogen before analyzing. He makes the pure nitrogen by passing air and ammonia over platinized asbestos.

Suggestion for determining oxygen.--I do not know that the method of converting oxygen in the air to water by mixing it with ammonia gas and passing it over platinized asbestos has ever been used for quantitative determinations. It may be worth while to try out this method.

SHEFFIELD, ENGLAND.

Laboratory of Physiology, University of Sheffield.

Prof. Macdonald.

As a result of some correspondence with Prof. Macdonald, I found much to my astonishment that he was having constructed in his laboratory a duplicate of the respiration chamber as it was constructed in Middletown. On the invitation of Dr. Macdonald, I paid a visit to Sheffield just before sailing on my return.

The construction of this apparatus has a somewhat interesting history. Prof. Macdonald was allotted a certain sum of money to fit up his laboratory and it must be used within a certain time. He found that there was a liability of his losing several hundred dollars by inability to apply it at the time and therefore gave an order to an English concern, W. & J. George, to construct a respiration chamber similar to the Middletown one at a cost, I believe, of 100 pounds. This firm wrote for a copy of the Department of Agriculture publications and also for Publication No. 42 of the Carnegie Institution of Washington. With no further information, they proceeded to construct the apparatus and the series of photographs herewith show it in its present stage of development about the middle of July, 1907.

Prof. Macdonald has no idea of the use of the apparatus but has recently engaged a young assistant, Dr. DeSouza, whom he hopes he can arrange to send to America to become proficient in the use of this apparatus. Considering the fact that Publication No. 42 was not written with the idea of furnishing working specifications for the construction of a chamber of this type, the English instrument makers have certainly done remarkably well.

The apparatus is, however, far from being ready for practical use and I question whether Prof. Macdonald will be able to do any experimenting with it for many years. It certainly will need a good deal of reconstruction to put it in condition for use.

The apparatus is shown in Figs. 72, 73, and 74 and no special comments are required since it is an attempt to duplicate exactly the Middletown apparatus.

The laboratory at Sheffield is very well supplied with material and there are many interesting features in connection with it. Prof. Macdonald is especially pleased with a balance after the system of Curie of Paris, which has a large air-dampening device and also enables the milligrams and tenths of milligrams to be read with a microscope at the end of the beam. The balance is very expensive and evidently while much appreciated by those accustomed to its use is hardly worth the great expense for as much routine work as it would be given in the Nutrition Laboratory.

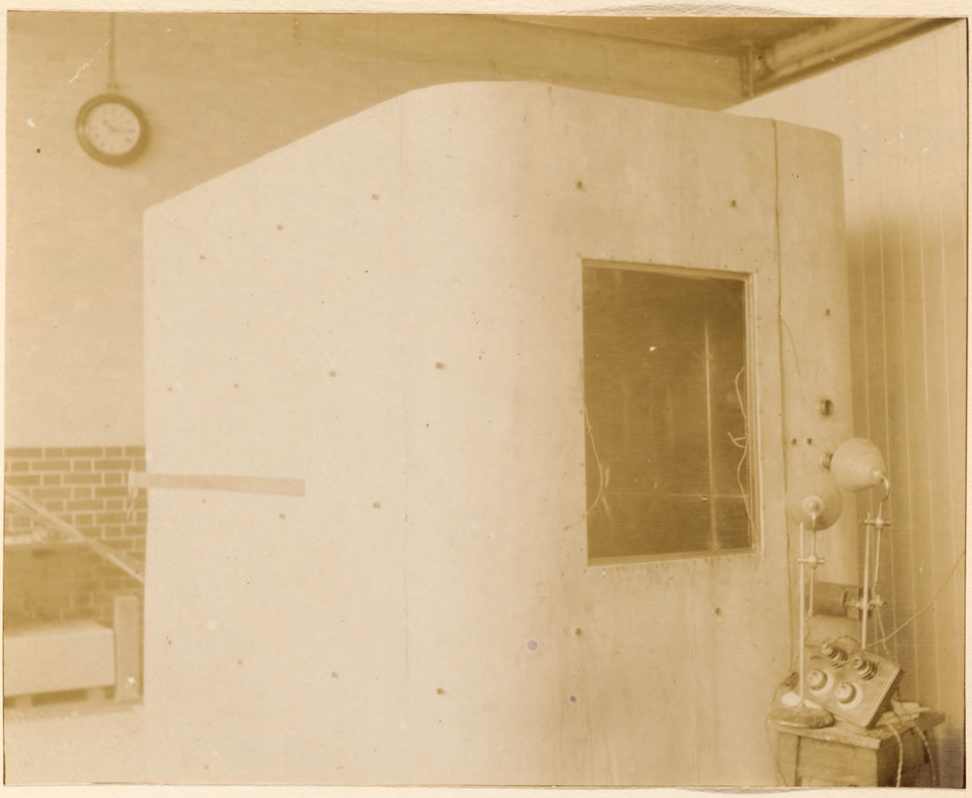


Fig. 72. View of the zinc wall of respiration apparatus in Sheffield laboratory of physiology.

The apparatus is constructed from the drawings and specifications given in the publications of the Department of Agriculture and in Publication No. 42. of the Carnegie Institution.

Fig. 73. Rear view of the respiration chamber at Sheffield, showing the food aperture.

Fig. 74. Front view of the respiration chamber at Sheffield.

This shows the zinc wall and wooden outer casing.

LONDON, ENGLAND.

Physiological Laboratory of the Guy's Hospital Medical School.

Dr. Pembrey.

At the time of my visit Prof. Haldane of Oxford was giving a series of lectures at this medical school and hence I was able to see him and discuss many points of common interest.

With regard to ventilation, Prof. Haldane maintains that if the wet bulb hygrometer is kept low, there is no trouble with ventilation. With a submarine, he has made experiments in which the carbonic acid was over 3 per cent for 24 hours. In 12 hours no lamp will burn but obviously in this experiment the moisture was condensed. Singularly enough, the sides of the vessel were painted with cork paint so there were no signs of moisture since the cork absorbs the moisture and does not sweat.

Prof. Haldane is not in sympathy with the Zuntz method. He thinks that the men should not be made to move the meter. The expirations are intermittent and as the last portion of the expiration is richer in carbonic acid, it is possible to get a higher carbonic acid content than really exists. The meter moves intermittently and especially at the last part of the respiration, there may be a very marked error in the sample.

Prof. Haldane himself has a motor to suck air through a long tube and he breathes through a T-tube inserted in this long tube. He says the motor ~~requires~~ draws only about twice as much as the expired air. Thus if it is 7 liters per minute, the motor is adjusted to draw 14 liters through the tube.

The arrangement of the Haldane respiration scheme is, then, a fan or electric blower connected directly with the meter and an intake pipe of some length with the sample taken between the mouthpiece and the meter.

He takes a sample regularly and gets but about 1 per cent of carbonic acid in the expired air instead of 4 per cent. After this discussion I asked Dr. Pembrey regarding the accuracy of these figures and he verified them. I do not see how it would be possible to have it less than 2 per cent as the ventilating air current is but double the ventilation of the lungs!!!

The carbonic acid in London air is about 6 parts per 10,000. A careful study of the air currents in the city showed that for the most part the air currents must be up and down rather than horizontal since in the greens and parks the carbonic acid is very much less.

Speaking of the strong pyrogallic acid solution for the absorption of oxygen, Prof. Haldane stated that it is very viscid and enclosed air and hence in his absorbing vessel, he uses glass rods instead of tubes. Rubber connections absorb oxygen but after leaving them for some time they get saturated with oxygen. At first, their absorption may prove a source of error. Prof. Haldane is not at all pleased with the large amount of dead air space on the Zuntz apparatus. This he calculates to be about 500 cc.

(In a later discussion with Zuntz, I brought up this point but Zuntz contends that the dead air space is more apparent than real so far as its influence upon the respiratory gases is concerned.)

Laboratory of Prof. Pembrey.--While very much occupied with teaching and administration duties, Prof. Pembrey has carried out a considerable number of experiments of interest in metabolism ~~work~~, although at the present time he is not very active in this line. His laboratory is

157 provided with a room in which all measurements over mercury are conducted. This room has a concrete floor which slopes toward one corner and there is a small gulley running all around the edge of the floor, thus allowing for the collection of the mercury. Straw mats are used to stand upon.

Haldane apparatus for determining moisture and carbon dioxide in the air.--Two sets of test tubes, fitted with well paraffined rubber stoppers, are filled with sulphuric acid and pumice. These tubes are weighed at one time and collect all the water. They are weighed to .2 of a milligram. A second set of tubes, one containing soda lime and the second containing sulphuric acid and pumice, are used to collect the carbon dioxide. The inlet tube to the soda lime test tube extends to the bottom of the tube and Prof. Pembrey says that they find it advantageous to put a cotton plug on the end of a wire, thrust it through the long inlet tube to the bottom and then fill the whole test tube with soda lime. When the tube is filled, the cotton plug can be withdrawn on a wire.

The Guy's Hospital Medical School is of interest since it is a development of the old South Sea bubble, the benefactor making his money during this phantasy. It is rather noted as being the home of the celebrated Dr. Bright and Dr. Addison, both of whom have had diseases named after them. A most wonderful collection of wax models made by a modeller who had been in the employ of the hospital for nearly 40 years is of great interest.

Experiments on marmots.--Prof. Pembrey, along with others who have been experimenting on hibernating animals, found an actual gain in weight (during hibernation) in the first decimal place but the marmots are very heavy. I should judge that they would weigh not less than

15 lbs. and the criticism has been raised that the gain in weight might be due to the difference in water in the fur but Prof. Pembrey says that the chamber was well ventilated and all the water was collected and allowed for. He weighs against a dummy in all instances.

Rise in temperature during fever.--Prof. Pembrey believes that the rise in temperature during fever is advantageous to the patient in that he gets the benefit of an increased metabolism. This also applies to the rise in temperature following muscular work.

Respiration Apparatus

In his experiments with marmots, Prof. Pembrey used a respiration chamber according to Haldane and the sulphuric acid and soda lime were contained in 3-necked Woulff bottles. A general view of the apparatus is shown in Fig. 75. The gas meter is at the right and the galvanized iron respiration chamber at the extreme left.

Practically all the forms of Prof. Haldane's gas analysis apparatus have been used to a greater or less extent in Prof. Pembrey's laboratory and Dr. Pembrey was kind enough to volunteer to superintend the construction of a complete set of Haldane apparatus for the Nutrition Laboratory. This apparatus has been ordered and is expected shortly.

The method of using this apparatus of Haldane's is described in a book entitled "The investigation of mine air" by Foster and Haldane, published by Griffin, 1905.

Fig. 75. View of Prof. Pembrey's laboratory, Guy's Hospital Medical School, showing the Haldane respiration apparatus for use with marmots.

Respiration chamber at the left, the 3-necked Woulff bottles containing soda lime and sulphuric acid and pumice stone in the middle and the gas meter at the right. The air current is maintained by means of a large water suction pump. At the extreme right, a portable Haldane gas analysis apparatus.

Lister Institute.

(Dr. Haldane) and Dr. Cathcart.

The Lister Institute is very well equipped but as in all English laboratories, teak is used for table tops in preference to anything else.

A minor point of interest in the laboratory was the use of copper gauze 3 mm. square during the digestion of the Kjeldahl process.

All iron material in the laboratory, such as retort stands, air baths, etc. ~~were~~ was painted with aluminum bronze. This is made by mixing powdered aluminium with turpentine to a thick fluid and adding 5 per cent of gold size.

The Institute was also supplied with a large number of different forms of Haldane gas analysis apparatus and Prof. Haldane was engaged in conducting some experiments on the effect of increased pressures on respiration the problem being closely allied to the work ~~on~~ of divers and the caisson disease. A large boiler of sufficient size to hold two or three men was used for a respiration chamber. At the time of my visit, a number of goats were inside of the chamber and the pressure had been raised to 75 lbs. There seems to be no difficulty in suddenly increasing the pressure, although if this pressure is ~~continued~~ attained, in six minutes the goats do not like it as the rush of air into the chamber is unpleasant,-- a strong wind. If the decompression takes place in a half hour, all the animals die; if in three hours, some have bad symptoms.

Experiments have also been made with decreased pressure. With half an atmosphere, the men noticed that there was a great tendency to arithmetical errors and if certain experiments were planned for before entering the apparatus, they were entirely forgotten on coming out of the chamber, thus indicating distinct cerebral disturbances.

Life saving apparatus.--Prof. Haldane had also made a large number of experiments on a method of saving life in fires and under similar conditions. He had used oxygen from sodium peroxide and had also used compressed oxygen. I found that Dr. Tissot in Chauveau's laboratory worked on an exactly similar problem.

Dr. Cathcart.--Dr. Cathcart in connection with Dr. Leathes at the St. Thomas Medical School was making a series of experiments to study the excretion of uric acid under various conditions, especially fever. His work was being carried out in the Lister Institute.

St. Thomas's Hospital Medical School.

Dr. Leathes.

Although conducting experiments at the Lister Institute, Dr. Leathes makes his headquarters at the St. Thomas's Medical School where I visited him. He is much interested in metabolism during fever and is working in conjunction with Dr. Cathcart on the uric acid excretion. His results are certainly of great interest regarding the question of exogenous uric acid excretion. Dr. Leathes produces artificial febrile conditions by anti-typhoid toxine. This he takes himself, securing a rise in temperature to 104°. He states that this toxin is used in Africa very extensively by the soldiers, since they are required to take it by the military regulations. There is no danger in using it.

London Hospital Medical College.

Drs. Hill and Greenwood.

Dr. Hill has been especially engaged in the investigation of problems similar to those studied by Dr. Haldane, with special reference to the effect of compression and depression, with its bearing on caisson disease. For this purpose he had a large cylinder, furnished by a local company, which is capable of standing several hundred pounds pressure, one end of the cylinder being supplied with a heavy plate glass cover which can be bolted into place. A large cat was placed in this cylinder and from a tank compressed air admitted until the pressure registered 100 lbs. The apparatus is shown in Fig. 76. The animal was then left for one hour under these conditions, during which time the blood becomes saturated with gases at high pressure. At the end of the hour, connections were broken so that the pressure could be reduced to atmospheric, this requiring but three and one-half seconds. During the process of depression, the animal appeared to be perfectly normal and undisturbed. This condition continued for six minutes when convulsions appeared and the cat almost immediately died. An immediate autopsy showed that the blood vessels were filled with air bubbles, the blood from the lungs frothed as did that from the kidneys. Microscopic sections of the kidneys also showed air bubbles.

Hill and Haldane do not quite agree regarding the best method of depression. One of them recommends that the depression in caissons should be made suddenly from 100 to 25 pounds but that the last 25 pounds should be very slowly decreased, the idea being that the expansion of the gases

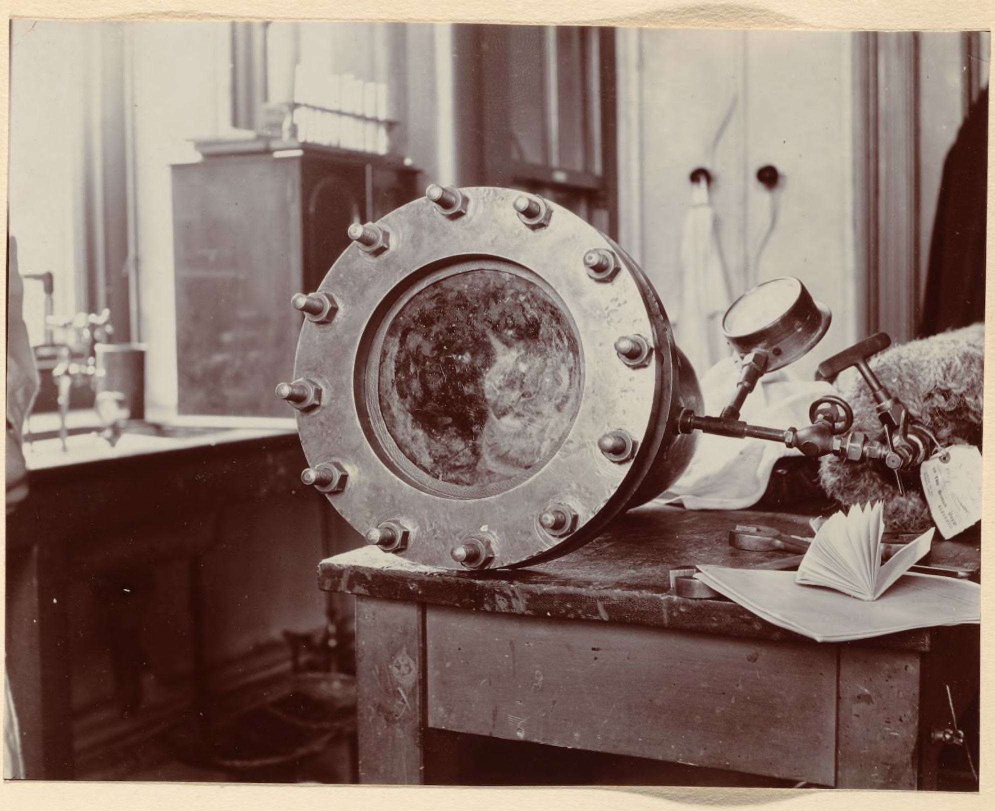


Fig. 76. Apparatus for studying the effect of high pressures on respiration devised by Dr. Hill of the St. Thomas's Medical School.

A steel chamber with glass cap in which an animal is placed and the pressure increased to 100 pounds. The pressure is increased by compressed air in a matting covered cylinder at the right.

in the blood from 100 to 25 pounds would be very small as compared with the expansion from 25 pounds to 0.

Minor apparatus.--Of interest to teachers is the projection of pictures, commonly taken on a kymograph, on a mica sheet. The apparatus has just been completed and certainly gave excellent results.

A vest pocket blood pressure apparatus of Hill's was of interest, especially when the possibilities of its being used by a clinician ~~was~~ were taken into consideration.

A small blood pump, very simple in construction, was also of interest.

Dr. Hill's interest in diving apparatus and depression has led him to make a number of models of diving apparatus which he has used in public lectures.

Gases in urine.--Water ordinarily has 0.9 per cent of nitrogen. Hill finds that with practically all men, urine has 1.1 per cent of nitrogen. This, however, increases as the pressure increases. In studying the question of gases in body fluids, such as urine and blood, he has found that when urine containing a small amount of albumen ~~when~~ is shaken with air ~~and~~ the colloid keeps the air in solution and the froth remains. This was the common observation ~~of~~ on urine ~~[illegible]~~ many years ago but Hill finds that one part of albuminous urine to 125,000 parts of water apparently shows a delayed disappearance of the froth. He thinks it may possibly be a good test for albumen in urine. He finds that blood which has been subjected to 6 atmospheres of pressure has 6 per cent of nitrogen.

Alveolar air.--Two methods of studying alveolar air content were shown me. In one instance the subject breathed into and out of a rubber bag, thereby increasing the carbonic acid content until he was forced to stop and get fresh air. The carbonic acid content of this air at the end of such an experiment varied from 6.8 to 8.0 per cent. If the bag was filled with oxygen beforehand, there was no apparent influence upon the carbonic acid content at the end. If, after filling the lungs with pure oxygen, the breath is held until it is necessary to let go, he finds that the carbonic acid content of the alveolar air is about the same.

Haldane's method of obtaining a sample of alveolar air was also used. This consists of breathing through a large pipe after holding the breath and taking a sample in a vacuum sample pipette at the very end of the reservoir. In other words, the subject holds the breath as long as possible and exhales into a tube about 1 inch in diameter and the side tube about one inch from the mouth is connected with a vacuum pipette. When this is opened, it instantly fills with gas. The analysis of this gas shows the carbonic acid content to be about 7 or 8 per cent. This is found to be the same for almost all men. One man, however, actually held the breath for two and one-half minutes. Under these conditions it would be expected that the carbonic acid produced would be higher than 8 per cent. Such was not the case, however.

LYONS, FRANCE.

Physiological Laboratory of the University of Lyons.

Prof. Dubois

Prof. Dubois' large treatise on the physiology of the marmot led me to believe that I should obtain material of considerable interest by visiting his laboratory but unfortunately for a number of years Prof. Dubois has taken no active interest in metabolism and I saw nothing in progress. The laboratory has been built a good many years and presents no especially interesting features. The genial personality of the director, however, and his interesting reminiscences are a stimulus to any one who visits this laboratory, which has been a source of so much interesting work.

Laboratory of the Ecole Nationale Vétérinaire de Lyon.

Prof. Arloing and Prof. Maignon.

I visited this laboratory under the impression that M. Tissot was conducting his researches here and although I found to my surprise that Tissot was in Paris, I was greatly pleased by the visit to this laboratory since I saw much of interest. A large Pettenkofer respiration apparatus for use with animals was constructed in this laboratory many years ago but has never been used for the purpose designed. I believe that Tissot did carry out some experiments here a number of years ago, using this chamber to study the carbon dioxide output under varying conditions. This led to my belief that he was in Lyons now. The opening into the respiration chamber, together with a partial interior view, are given in Fig. 77. At present the apparatus is not in use.

In the same room with the Pettenkofer respiration chamber, M. Maignon was having constructed an apparatus for studying the respiratory exchange of small animals after the principle of Chauveau, i.e., with a closed chamber. This apparatus is shown in Fig. 78 and consists of an animal cage over which a large galvanized iron box can be lowered, the bottom being sealed in water or oil. The carbon dioxide accumulates in this chamber during a given period and then samples are withdrawn for analysis.

These investigators have found that the carbon dioxide may accumulate to 6 per cent without having any influence upon the respiratory exchange. This is in complete harmony with the results obtained by Durig and Zuntz, although the latter investigators found the danger point much higher.

Fig. 77. Pettenkofer respiration apparatus for horses in the laboratory of the Ecole Nationale Vétérinaire, Lyons, France.

The view shows the interior of the chamber, with the feed box at the further end. As a matter of fact, the apparatus has never been used for animals and has not been used for any purpose for many years.

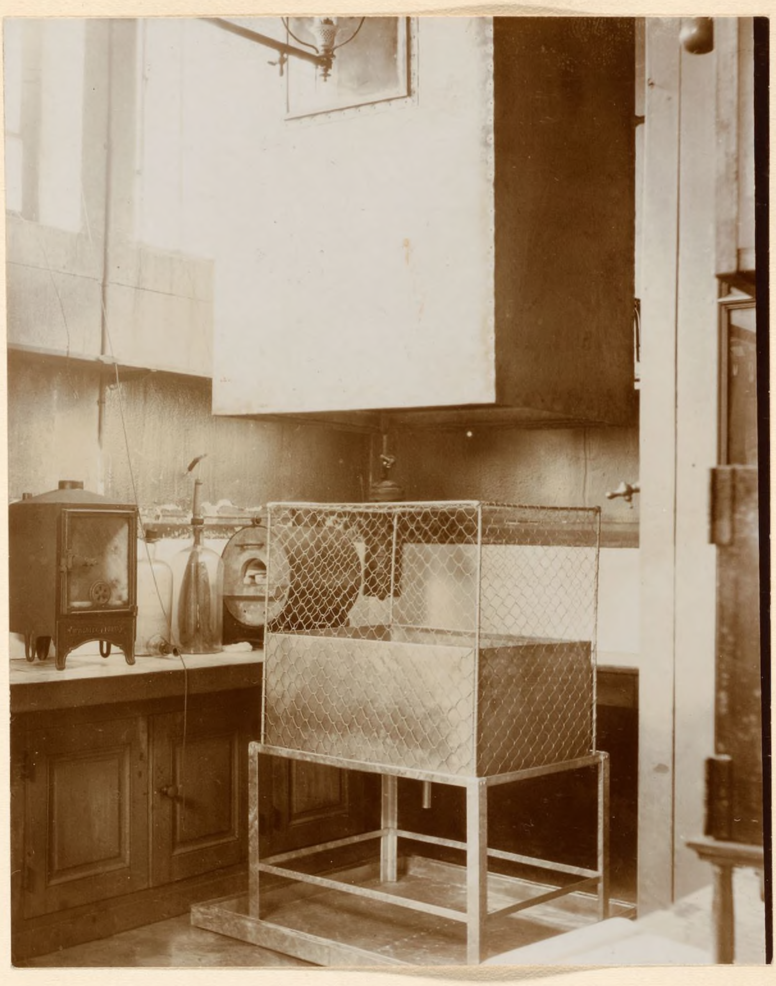


Fig. 78. New respiration chamber for small animals in the laboratory of the Ecole Nationale Vétérinaire, Lyons, France.

The animal is placed in the wire cage and the large galvanized iron box lowered so as to fit in the grooved seal at the bottom. The urine is collected in the tube projecting from the bottom of the cage. When the cover is raised, it is suspended by pulleys and weights.

Investigations on the respiratory exchange with tuberculous patients.--Prof. Arloing and M. Maignon are interested in studying the respiratory exchange of tuberculous patients, using the method of Chauveau and Tissot. The apparatus is shown in Fig. 79. It consists of a large spirometer and a nosepiece, with the valves of Tissot. The nosepiece valves are clamped to a retort stand as shown in Fig. 79. In the background on the table is the air analysis apparatus of Laulanie, which is used in analyzing the contents of the spirometer. The expired air is delivered into this spirometer and a sample taken at the end. The investigators were simply getting the apparatus into condition and had made but a few preliminary observations on patients. Especially noticeable in this form of apparatus is the dead air space between the end of the glass nostril pieces and the T piece carrying the valves. This is not right and doubtless will cause trouble. Tissot, the originator of this form of apparatus, uses a very close connection between the nosepiece and the valves. The spirometer holds 60 liters which is considered sufficient to contain the total exhalation from three minutes respiration.

Researches on glycogen in animals.--This laboratory has been equipped for making researches on the glycogen content of livers of animals. In summer, no glycogen was found in the liver after 48 hours of fasting. In the winter, on the contrary, glycogen was found after 10 days of fasting. The maximum amount of glycogen was found in March or 8 grams of glycogen per kilogram of fresh muscle. In July, it was much lower, being but 3 grams of glycogen per kilogram of muscle. In April and May, there was only 1 gram of glycogen in the liver. In January, even after 14 days of fast, there was found 17 to 18 grams of glycogen

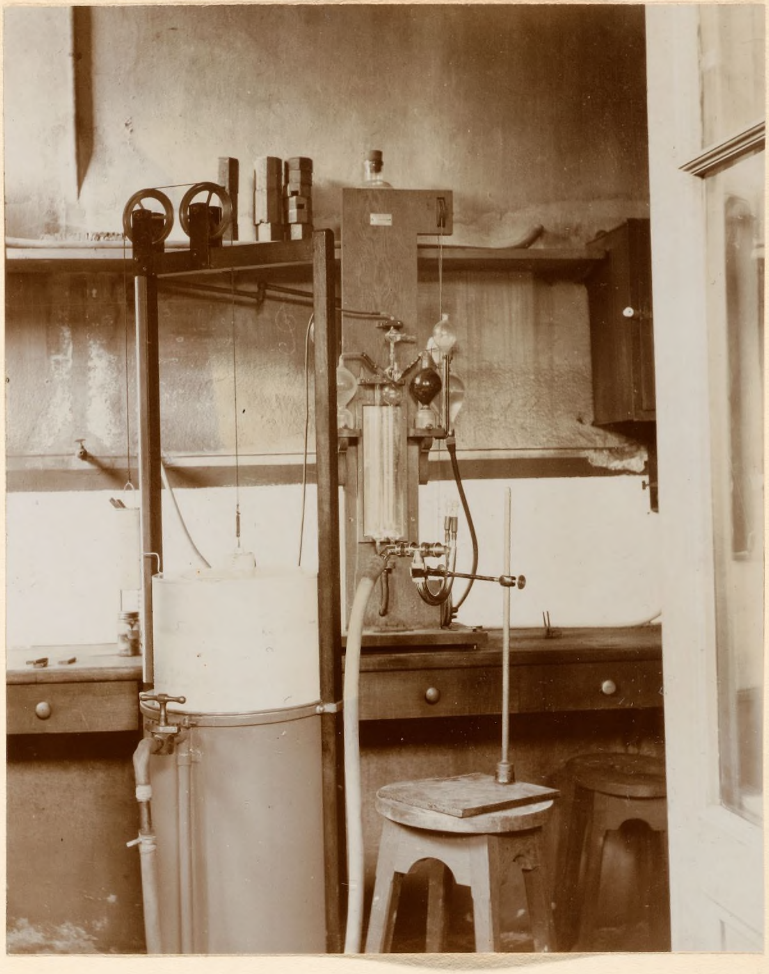


Fig. 79. Apparatus for studying respiratory exchange in tuberculosis cases, laboratory of the Ecole Nationale Vétérinaire, Lyons, France.

The spirometer in the centre is used to collect the exhaled air which is delivered through the glass nosepieces attached to the T with two Tissot valves which, in the picture, is clamped to the retort stand. In the rear of the room is a Laulanié gas analysis apparatus for determining carbon dioxide and oxygen in the expired air collected in the spirometer.

per kilogram.

Suggestion.--If this large glycogen content holds true for men as for dogs, a repetition of some of our fasting experiments at different times of the year should give most interesting results.

Alcohol in living tissues.--M. Maignon has made a study of the amount of alcohol present in the ordinary living tissue and finds alcohol present everywhere. The experiments were made so that fresh muscle was taken from the hind limb of a dog. It was living muscle and no anaesthetic was given. Even under these conditions, alcohol was found in demonstrable quantities. The idea in using unanaesthetized dogs was to preclude any possibility of ferment action after death or the possible effect of ether itself.

Graphic recording.--A very unusually complete set of kymographs which were formerly used by M. Chauveau is here installed.

Enamelled lava table tops.--This was probably one of the first laboratories to install the enamelled lava table tops. Prof. Arloing said that they had been in use for 34 years. I did not see a single table which was broken or any one in which the enamel was chipped off. In one case, where some retort stands had evidently been in use, the enamel had worn through and showed a little of the dark lava beneath. This I consider one of the best tests of the durability of this product.

LIEGE, BELGIUM.

Institute of Physiology, University of Liége.

(Prof. Fredericq) and Dr. Sainmont.

Prof. Fredericq's extensive researches into metabolism and especially gaseous exchange made a visit to this laboratory unusually interesting, although the director was unfortunately away. This laboratory has been constructed but a few years and is supplied throughout with the beautiful enamelled lava table tops, a type of which is shown in Fig. 80.

Museum.--Prof. Fredericq has collected many things of historic interest to physiologists and placed them in a museum which is very well labelled. Autograph letters from noted physiologists and original papers of classical importance may be seen here, as well as apparatus. Perhaps the most interesting to my mind is the old apparatus of Sch~~midt~~wann for life saving, in which the carbon dioxide is absorbed in alkali. The original mouthpiece (the precursor of the Zuntz mouthpiece) is here to be seen.

Minor apparatus and laboratory construction.--Referring to Fig. 80, it is seen that the cupboards at the bottom of the desks are supplied with doors having large panes of glass. The assistants assured me that while elementary students break these glass panes so easily that it was not considered advisable to install them in the main laboratory, in private research rooms, they were found very satisfactory.

A special glass adapter for connecting rubber tubes of different sizes was first seen in this laboratory. It is shown in the photograph connected to a piece of rubber tubing.

Fig. 80. General view of the research laboratory in the Physiological Institute of the University of Liége, Belgium.

The special features of this laboratory are the large sheet of enamelled lava for the table top and the glass doors in the cupboards beneath the table. The mechanician, Bouquette, has devised the simple method of suspending the reagent shelf above this lava without mutilating the table top itself. The glass adapter in the end of of the rubber tube is also unique.

A very ingenious mechanician, M. Bouquette has contributed a great deal to much of the minor apparatus found in this laboratory. Of special interest is, perhaps, the method of installing a reagent shelf above one of the lava topped tables. This is shown very well in the photograph.

Throughout the laboratory, wooden sinks with galvanized iron bands are used. These are similar to those used in I Chemical Institute in the laboratory of Prof. Emil Fischer.

PARIS, FRANCE.

Laboratory of the Museum of Natural History.

Prof. Chauveau, Dr. Tissot and M. Mansion.

For a great many years Prof. Chauveau has been most active in the study not only of the respiratory exchange but also of the heat elimination of both men and animals. Associated with him, Dr. Tissot has been in a position to elaborate and devise a large number of experimental details which have furthered the investigation markedly. Dr. Tissot is perhaps the foremost advocate of the nose breathing in studying respiratory exchange and it was particularly to obtain his opinions on this point that I went to Lyons, thinking that he was there.

The laboratory of the Museum of Natural History is located in the Jardin des Plantes, is very well equipped for studying problems regarding respiratory exchange and heat elimination but practically all the experiments have been made with animals.

Methods of air analysis.--Throughout this tour of European laboratories, I have been weeking the most refined methods for the analysis of air, with special reference to the determination of oxygen. Jaquet, with his form of the Pettersson apparatus, Durig with his form of the Zuntz apparatus, and Sondén with the possibilities of his modification of the Pettersson apparatus, all gave promise of securing a determination of oxygen to within 0.01 per cent. Thus, if the actual oxygen content of the air was 20.93 per cent, the results as obtained by these refined methods would approximate 20.94 or 20.92. If the open circuit ventilation system of the respiration apparatus is to be used (and for many purposes this system is very advantageous) in order to determine the oxygen consumed by man under these conditions, the determination of the oxygen in the outcoming air must be made with the greatest exactness. Rarely can the conditions of ventilation be so adjusted that the difference in oxygen content between the ingoing and outcoming air is greater than 0.80 per cent. An error of ~~0.1~~ 0.01 per cent, therefore, indicates that the method is accurate only to 1 part in 80. This degree of accuracy is not satisfactory for the best experimenting.

On the first day of my visit to the Chauveau laboratory, I was very much impressed by the very elaborate and costly gas analysis apparatus devised by Prof. Chauveau and Dr. Tissot. There are two forms of this apparatus, one for handling large amounts of air and the other for handling the minute quantities obtained in the analysis of blood gases. These two forms of apparatus have been described in great detail in an article by Dr. Tissot in the first volume of the Traité de Physique Biologique, page 709 et seq. In discussing the accuracy of these two forms of apparatus, Dr. Tissot maintained that with the small apparatus an accuracy of 0.002 per cent could be secured. In other words, duplicate analyses would give 20.942 and 20.940 per cent of oxygen. This claim for accuracy seems to me to be beyond belief and I append herewith a discussion and criticism and point out the possible errors of this apparatus.

Taking, first, the larger apparatus which lays claim to an accuracy only equal to that of the Pettersson type, namely, 0.01 per cent, the oxygen is absorbed either by phosphorus or by explosion with hydrogen, both methods being used with about the same degree of exactness. Of this larger type of apparatus, Dr.

Tissot has two forms. In one of them, provision is made only for explosion with hydrogen. In the other, there is a second pipette so connected that the determinations can be made either with phosphorus or by explosion with hydrogen. Of especial interest in the phosphorus pipette is the fact that the ends of the sticks of phosphorus are cut at angles of 45°. Tissot found that the continued absorption of oxygen resulted in the partial melting of the phosphorus which formed cavities with the occlusion of gases but when the sticks are cut in this form, the difficulties are removed. The air is passed into the phosphorus twice to be sure that all the oxygen is absorbed. Obviously, having to deal only with air analyses, the ~~amount~~ consumption of phosphorus is very small. As a matter of fact, the phosphorus pipette was filled nearly two years ago and had been in continuous use ever since. No special precautions were taken to protect the phosphorus from the action of light. Indeed, it seemed to be highly colored. Furthermore, no precautions were taken to keep the apparatus warm other than that it was placed in the laboratory room, which probably was always sufficiently heated.

The carbon dioxide is absorbed in an 8 to 10 per cent solution of potassium hydroxide.

Preparation of hydrogen.--For use both with the large and small apparatus, pure hydrogen is essential. This Dr. Tissot obtains by a very simple combination of two Woulff bottles connected by rubber tubing like a small gas generator. Distilled zinc is used in one and a few drops of chloride of gold are added to hasten electrolytic action. The other Woulff bottle contains a solution of two parts of concentrated pure hydrochloric acid and one part of distilled water. By raising the acid bottle, the acid flows in at the bottom of the bottle containing zinc. The gas evolved is purified by passing it through an

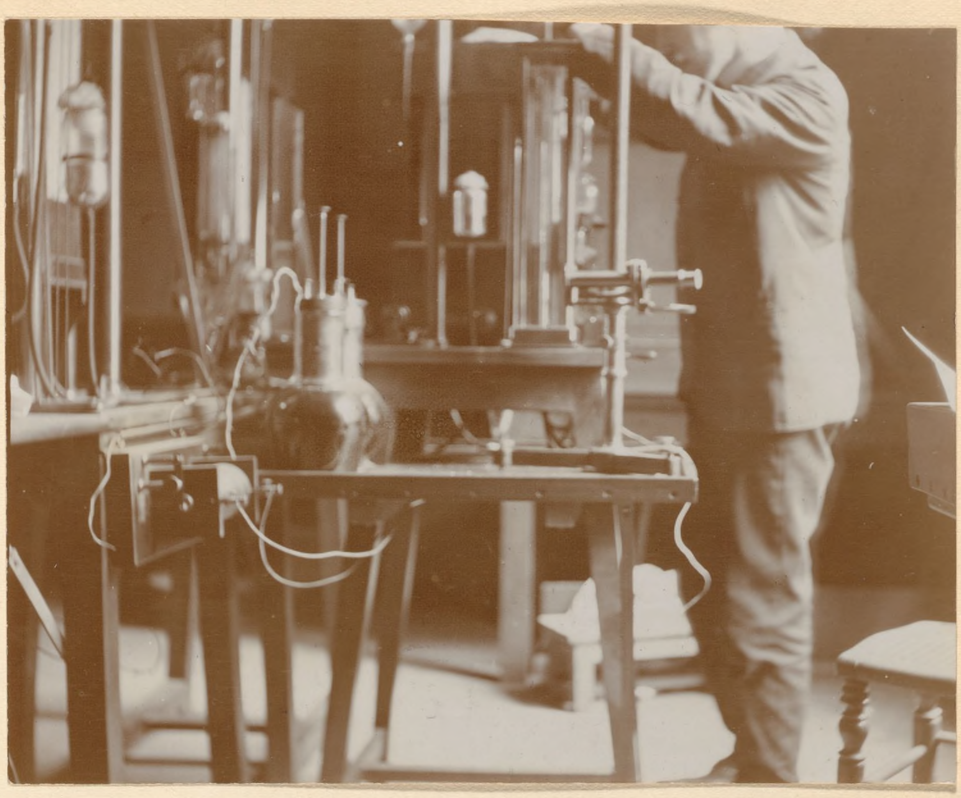


Fig. 81. General view of gas analysis apparatus, laboratory of the Museum of Natural History, Paris, France.

The apparatus directly before the assistant is for the very exact analysis of small quantities of gas. The two pieces at the left are for larger gas volumes. The induction coil and batteries for explosion are shown in the foreground and at their right is the telescope with micrometer adjustment used for reading the gas volumes in the smaller analysis apparatus.

8 to 10 per cent solution of potassium hydroxide.

The hydrogen is collected over mercury and kept sealed under mercury until desired for use. It was the belief of Tissot and Mansion that the hydrogen could thus be preserved for a considerable length of time without any contamination of air.

Laboratory for gas analysis.--A very imperfect photograph (Fig. 81) shows the general laboratory for gas analysis. This figure, although poorly focussed, shows all three of the gas analysis apparatus. The one directly in front of M. Mansion is that having the greatest accuracy while the two at the left are those for larger volumes of gas. The details of construction of the smaller apparatus may be found on page 709 of the article by M. Tissot above referred to and the description of the larger apparatus may be found on page 717 of the same article. The apparatus permitting the determination of oxygen both by absorption with phosphorus and explosion of hydrogen is figured and described on page 722 of Tissot's article.

Apparatus for exact gas analysis.--The smaller of the two forms of apparatus above mentioned can be used only for gas volumes of 15 cc., hence some considerations regarding its accuracy are of importance. The method employed in both forms of gas analysis apparatus is to measure the gas before and after absorption and correct for barometric~~al~~ and thermometric~~al~~ changes by reading the volume of a confined mass in a comparateur. This volume is definitely enclosed at the time the apparatus is adjusted and the tube is so graduated as to give directly the ~~fall of the~~ true gas volume when reduced to 0° and 760 mm. This volume is read in the case of the small gas analysis apparatus by a telescope with a micrometer adjustment. A rather complicated system of mirrors is used to illuminate the apparatus.

Several possible errors appear to be present in this apparatus

175 and to preclude the degree of accuracy claimed for it by M. Tissot. First, while the measuring tube and the comparateur are side by side and are immersed in a water bath, it frequently happens that the volume of gas in the comparateur is nearly twice as large as that in the measuring burette. As the water in the water jacket is not stirred, the temperature at the top of the water layer would, in all probability, be somewhat warmer than at the bottom and there would thus be a difference in the temperature change in both volumes of gas. M. Mansion said that he had many times put a thermometer in the water bath and held it at various levels but there were no observable differences in temperature. Still, if the thermometer was not very accurate and I do not believe it could be read closer than .1 of a degree, there might be an error on 15 cc. of gas or even on 7 cc. Usually there are 15 cc. of gas in the comparateur. If there was a change of but .01 of a degree, this corresponds to a change of $\frac{1}{273}$ x 100 equals $\frac{1}{27300}$ or approximately .0005 cc. in 15 cc. This corresponds to a temperature change of but 1/100 of a degree. If there were a change of 4/100, the error due to this alone would be 0.002 cc. or the limit of error claimed by Tissot and his assistants.

Suggestion.--The water bath should be stirred and the temperature read with a thermometer graduated to 1/100ths of a degree.

Second, when the air is mixed with hydrogen and exploded, there is considerable pressure formed by the explosion. This is in spite of the fact that before the explosion the mercury reservoir is always lowered so that there is a diminished pressure of 3 cm. of mercury inside of the explosion chamber. Immediately at the explosion, some gas, (nitrogen or excess of hydrogen,) is probably forced into the solution which may be but .5 of a cc. of potassium hydroxide on top of the mercury. Immediately after the explosion, when the pressure returns to normal, and indeed, the pressure is for the first few minutes less than normal because the mercury in the reservoir is low, it is assumed that all of the gas absorbed by the .5 cc. of the potassium hydroxide solution is immediately given up to the gas above it, even to the 0.001 cc.

With the larger gas analysis apparatus, I distinctly saw considerable bubbling of gas from the liquid immediately after the explosion and I also saw bubbles rising from the potassium hydroxide solution in the tube leading to the potassium hydroxide reservoir.

Is it correct to assume that the gas is given up to exactly the same amount after the explosion as it was dissolved by the pressure of the explosion?

M. Mansion thought that Dr. Tissot had tested this point by using ~~a~~ different amounts of pure oxygen and seeing what contraction he obtained.

Constancy vs. absolute accuracy.--A gas analysis apparatus might give duplicates which agree with the greatest exactness but still be far from the correct absolute values. For our purpose, if the ground or base error remained constant, the apparatus could still be used, even if it were not absolutely accurate. If, for example:

The incoming air was 20.942 plus a constant error
" outgoing " " 20.142 " " " "
The difference would be .800

and if this is exact to .002, the accuracy is all that could be desired.

Tests of the apparatus.--Believing that this apparatus, based upon the claims of M. Tissot, was especially adapted for our use, I devoted considerable time to an attempt to find its exact limitations, seeking to verify, if possible, the claims of M. Tissot. To this end, M. Mansion and myself made a number of experiments with the apparatus and after I left Paris, I commissioned M. Mansion to continue some of the experiments.

Our first attempt was to introduce a known volume of pure oxygen. This we attempted to prepare by the action of water on sodium peroxide. The results were not sufficiently satisfactory to justify any conclusions regarding the apparatus itself. In a report dated July 11, M. Mansion enclosed a note regarding these most interesting experiments with the apparatus.

The first point was to establish whether a definite volume of gas could be measured in the measuring tube, compared with the comparateur, transferred to the laboratory vessel, allowed to stand there for some little time, and then be returned to the measuring tube and read so as to indicate the same volume of gas. He made a series of three experiments, the first of which gave on successive days, 15.514; 15.508; and 15.517 cc., respectively, not an especially satisfactory agreement. The second experiment gave two results, 15.714 and 15.712. The third experiment gave 15.600 against 15.596, an agreement quite satisfactory when the long sojourn of the air in the laboratory vessel is taken into consideration. Obviously, in all of the experiments the air was carbon dioxide free when passed into the laboratory vessel.

The next series of experiments made by M. Mansion attempted the determination of oxygen when a known volume was introduced. Unfortunately ~~Obviously~~, he was not able to secure pure oxygen.

Perhaps the most remarkable series of experiments were three duplicate analyses of the same sample of ordinary air. 15 cc. of air were used, and the oxygen was determined to be 20.796, 20.795, and 20.794 per cent respectively. As a result of these experiments, it appeared clear that M. Tissot's claim that duplicate analyses of air could be made to within an error of 0.002 was correct but obviously the apparatus has not been proved regarding its ability to determine absolute percentages of oxygen.

M. Tissot assured me that he has certain modifications in contemplation which would not only facilitate manipulation but also increase the accuracy. He seemed loath to furnish me, however, with any information regarding these changes and acting on M. Mansion's advice, I did not secure the apparatus for our laboratory. It is very expensive, costing some $300 or $400.

For reading these small volumes of gas with the greatest accuracy, M. Tissot has devised a micrometer lunette or telescope which is described in the articles previously referred to. Two readings of this vernier are always taken independently to verify its exact position.

M. Mansion has evidently a very high technique in the use of this apparatus and in hands such as his, it should give most satisfactory results. It is extremely complex in structure, very friable and if results are as accurate as are claimed by M. Tissot, the apparatus is certainly a most valuable addition to any laboratory in which gas analyses are made.

Purification of mercury.--A simple method of purifying mercury in some of the larger troughs was used by skimming off the surface with a clean glass plate. The mercury was also purified by allowing it to flow out of a capillary funnel made of a large glass tube.

Minor laboratory apparatus.--For lighting the gas in the hoods, a long gas pipe with holes drilled at intervals of about an inch is fastened against the back wall of the hood. This is parallel to the pipe supplying the burner in the hood opening above. When the gas is turned on to the pipe full of holes and lighted, the flame travels the whole length of the pipe, lights the burner and then the stop-cock connecting the tube with the holes can be closed.

At all desks in front of the windows, there are no drawers, so one can sit at the table and work with the microscope. In the spaces between the windows, there is a column of drawers going from the table to the floor.

Smoked paper for kymograph.--A 2-necked Woulff bottle, filled with pumice stone and containing benzine, is connected with a gas supply and the gas saturated with benzine. This gas is connected with a fish-tail burner with holes in it. The kymograph is rotated in a horizontal position on a support and this flame held by the hand is caused to play over the surface of the paper until the desired smoking is accomplished. (See Fig. 83.)

Construction of laboratory tables.--The enamelled lava is here again used extensively in this laboratory as is seen from some of the tables shown in Figs. 82 and 83. Solid oak construction, with no top other than the lava, was the rule. The smaller tables were 71 x 81 cm. across the top and 82 cm. high. The wall table shown under the window in Fig. 83 was 60 x 181 cm. and 75 cm. high.

In the main laboratory, where chemical work is done, the tables were made of three slabs, each a meter wide, and 110, 72, and 110 cm. long respectively. In the central slab there was an opening 27 x 33 cm. for the sink. The table tops were 95 cm. from the floor. Rough sketches, with dimensions of wood work of these tables, are given in Note Book No. 2, page 64.

Fig. 82. General view of the Tissot spirometers in Chauveau's laboratory, Paris, France.

The two large spirometers at the right each contain 210.5 liters, and are so adjusted that they can be read to one-half liter. The small spirometer in the centre of the picture contains 65 liters which can be read to one-fifth of a liter. At the right of the small spirometer is the glass tube drawn out to a capillary for purifying mercury, mentioned on page 178. On the table are a large number of wine glasses containing mercury for the preservation of samples from the dog respiration apparatus. On the enamelled lava topped table at the left is an elaborate kymograph and between the two large gasometers can be seen the top of a compressed oxygen cylinder. On the skeleton above each of the spirometers is attached the recording device for graphically recording the height to which each spirometer rises after each expiration.

Fig. 83. General view of the Chauveau laboratory.

The three spirometers and the lava topped table with the gas samples preserved over mercury are easily recognized. On the lava topped table before the window can be seen the arrangement for smoking kymograph paper mentioned on page 179. Lying on the table near the hat is a muzzle for dogs.

Tissot's method for studying the respiratory exchange.--Using a spirometer and a nosepiece, M. Tissot has made a large number of experiments with both dogs and men to study the respiratory exchange. His spirometers are of special interest in that they are automatically counterpoised by a siphon arrangement. The apparatus has been described in detail in an article by M. Tissot in the Journal de Physiologie et de Pathologie générale, in July, 1904, page 693. Several forms of this spirometer are shown in Figs. 82 and 83. The siphon arrangement is especially well shown in Fig. 82 on the large gasometer in the immediate foreground. These bells are so sensitively adjusted that at each exhalation, the bell rises and can be made to write the height to which it has risen on a smoked paper. When these fluctuations in the height of respiration are compared with other factors, M. Tissot makes a very interesting study of the whole mechanics of respiration.

Believing that a great deal of experimental work must be done in order to demonstrate to all workers in metabolism the conditions under which nose breathing, mouthpiece breathing, mask breathing, and unhampered breathing may be normal or abnormal, I have ordered a complete set of M. Tissot's apparatus for the Nutrition Laboratory. I believe it will be of great value in throwing light on the best methods for studying the respiratory exchange.

The nosepiece is shown in Fig. 84 at the extreme right of the front. In the immediate foreground in the centre of the picture, the nosepiece is shown without the two glass nostril connections. This is clamped to the chin in the method described and figured in the article referred to above and Tissot maintains that the most regular, normal breathing can be obtained by this method.

Fig. 84. Tissot life-saving apparatus for furnishing oxygen and absorbing carbonic acid from the breath of miners and firemen.

The box at the left is strapped to the back of the subject. The nose and valve pieces are shown along the edge of the table. At the extreme right is a valve piece with glass nosepieces.

He is strongly opposed to the mouthpiece of Zuntz and Speck and maintains that his subjects have used his method of nose breathing for hours at a time with no inconvenience.

Life saving apparatus.--Working on problems similar to those studied by Haldane, namely the use of purifying apparatus for saving the lives of firemen and miners, M. Tissot is actively engaged in developing an apparatus. This is shown in Fig. 84. The carbonic acid is absorbed by caustic soda and a small cylinder of oxygen is used to furnish fresh air. M. Tissot has also used sodium peroxide for obtaining oxygen but considers it not as good as compressed oxygen.

In the picture, the valve system of the oxygen cylinder is shown at the right of the box and the rounding surface of the steel bomb can be seen resting on the table. The whole apparatus is carried on the back. In order to prevent kinking of the rubber tubes leading to the nosepiece, Prof. Tissot uses an aluminum reenforced tubing, a piece of which is shown leaning in an inclined position in Fig. 84.

Calorimeter for small animals.--A number of years ago, Prof. Chauveau devised a calorimeter for small animals. I could find very little regarding the construction or mechanism of this apparatus which is shown in Fig. 85. The outside is of wood and a glass door in front permits an examination of the animal. So far as I am aware, no experiments made with the apparatus have been published.

Tread-wheel for muscular work of man.--The old tread-wheel of Hirn has been employed in this laboratory for the study of the muscular work of man. Although located in a very dark corner of the laboratory, a photograph was taken of it, (Fig. 86). The man takes hold of the

Fig. 85. View of small calorimeter for animals in the Chauveau laboratory.

Fig. 86. Hirn wheel for muscular work of man.

two uprights with the hands and steps from step to step as the large wheel rotates. A brake can be adjusted to regulate the speed of rotation.

Emission calorimeter for dogs.--An emission calorimeter on the Chauveau principle for dogs, especially after active exercise, is shown in Fig. 87. A large wheel revolves as the dogs run on the inside and the ventilating air current passes through a tube in the axle. The drum is constructed of very thin copper and the heat is determined by the radiation constant.

Emission calorimeter for men.--In a very dark room in the basement of this laboratory is the very interesting emission calorimeter for man, constructed by Prof. Chauveau. This consists of a large, very thin-walled copper sheathed box, in which is placed, also, a large Hirn wheel. The opening is at the bottom and is on the porthole principle, closed with a rubber gasket. Many experiments have been made but the apparatus has not been used for some time. It is shown in Fig. 88.

The copper walls of this chamber are constructed of metal 1/10th of a millimeter thick. It is admittedly very hard to get it air tight but M. Mansion says that it has been tight to 10 mm. of water. The large opening can be closed with a bicycle tube inflation. Inside of this chamber, a man can work for two hours with no ventilation whatever, since the cubical contents is about 10 cubic meters. An electric fan is placed inside of the chamber which throws the expired air away from the face

The apparatus is calibrated by electric current and the rate of radiation determined. One is impressed by the very large area through which this radiation must be measured, the irregularity in

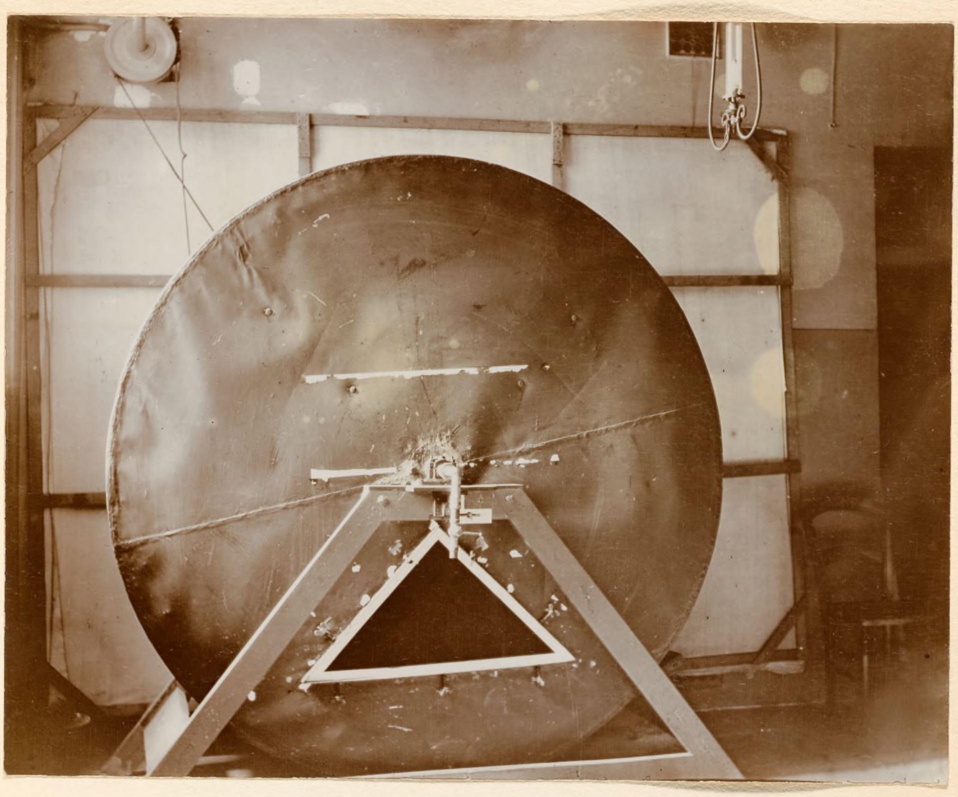


Fig. 87. Emission calorimeter for work with dogs.

The cover is clamped over the triangular opening; the wheel rotates and the ventilating air current passes through the axis.

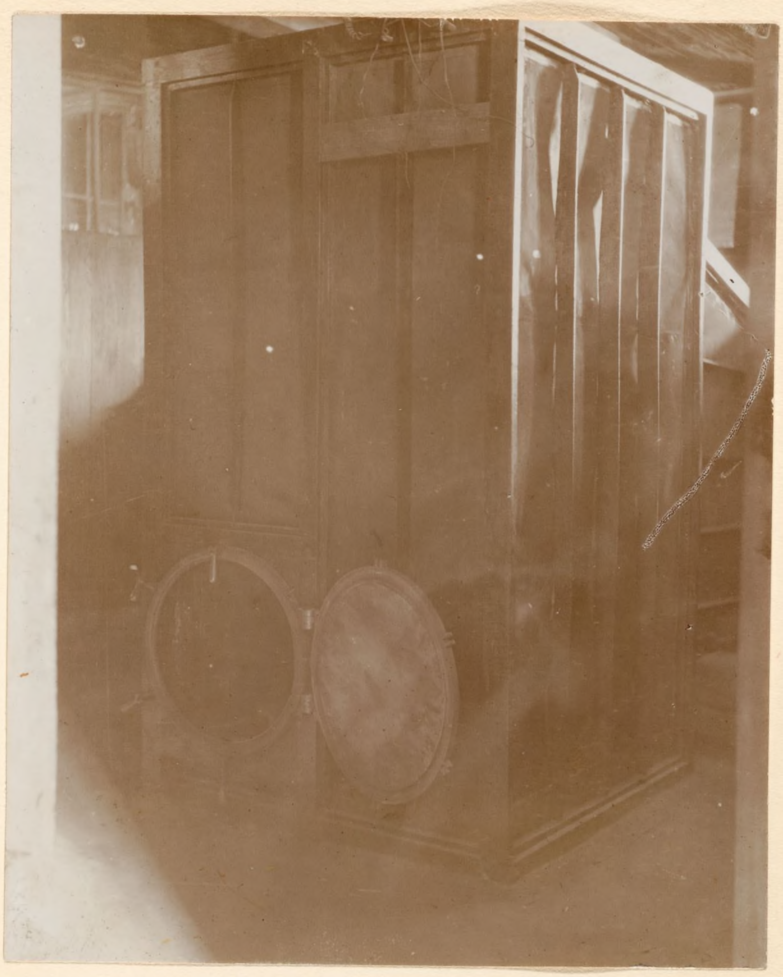


Fig. 88. Emission calorimeter for men, Chauveau's laboratory.

The round opening near the bottom serves as a door. It can be closed with rubber packing. The long extension at the right in the rear is for a Hirn wheel.

the shape of the box and the probable fluctuations of the temperature. It is hardly to be supposed that determinations made with this calorimeter can reasonably be more than approximate. M. Mansion, on the other hand, says that the calibration is very accurate. Prof. Chauveau has used it for many experiments on muscular work.

<u>Respiration experiments with dogs</u>.--Using the confined chamber method and allowing the carbonic acid to accumulate. Prof. Chauveau has made many experiments with dogs, especially on metabolism with the use of carbohydrates. The apparatus is shown in Fig. 89. The chamber consists of galvanized iron, with a top that can be lowered into an oil or mercury seal and clamped into position. A small electric fan is placed inside to insure thorough mixing of the air and a connection is made directly with a large bottle outside, whereby any fluctuation in the volume of the air in the chamber can be compensated so as to maintain the pressure inside always at the atmospheric pressure. A manometer shown on the box at the right of the window indicates the interior pressure. The dog stays in the apparatus about one and a half hours.

The particular experiment which I saw carried on several days was an experiment with a female dog which was placed in a small cage and this placed in the chamber. The cover is then put on and clamped down with two long clamps. An opening in the top of the lid allows the air to obtain constant pressure. A cork is inserted in the opening and the experiment has begun. An assistant remains with the apparatus and raises or lowers the bottle shown suspended on a ladder so that the manometer indicates constant pressure. The heat given off by the dog at first increases the volume of the air and consequently increases the pressure but by lowering the bottle, the air expansion is compensated.

At the end of the experimental period, the bottle is raised

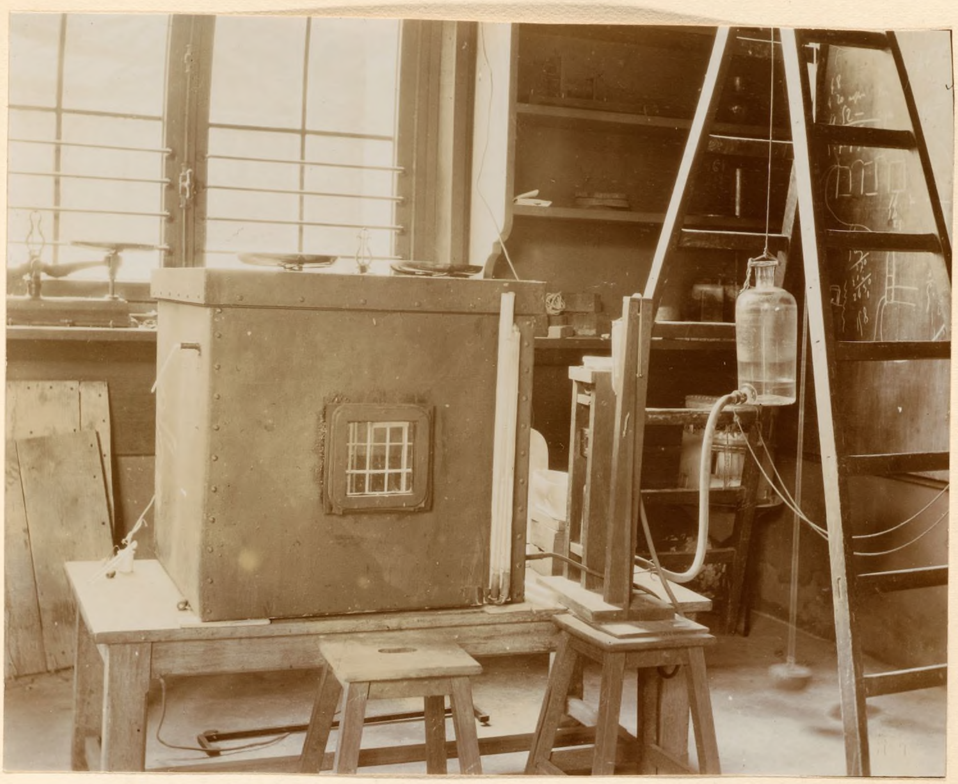


Fig. 89. Respiration chamber for dogs.

Suspended on a ladder at the right is a bottle which connects with a compensating bottle, only a fraction of which is shown at the right of the iron chamber. The apparatus for taking a sample stands at the right of the chamber but the details are not sufficiently clear here to be of any value.

and considerable increased pressure inside the chamber maintained, the ventilating fan started up, and then a sample of air drawn off over mercury by a special sample collecting device.

The pressure in the chamber is equal to about 8½ cm of water just before taking the sample. In the experiments, the dogs are placed in the box four times a day for about one and a half hours each time. The urine is removed by catheter every two hours. Prof. Chauveau was studying the effect of the ingestion of carbohydrates and also the fasting metabolism of these dogs. The box is about 70 cm. ~~cubic meters~~ square. Just before the end of the experiment, when the electric fan is started, there is a decreased pressure consequent upon the cooling of the chamber, consequently the compensating bottle must be raised. This is raised sufficiently high to drive an excess of air into the chamber and produce an increased ~~constant~~ pressure.

Weighing the animals.--The dog used in these experiments weighed 16 kilograms and a special balance, by means of which the weight could be recorded or printed on a card, was used. A similar balance for weighing horses or other large animals was found in Tangl's laboratory in Buda Pesth. Toward the end of the experiment, it is essential that no one approach the box and thus warm the air and introduce an error. The gas samples, which are collected over mercury, are preserved in wine glasses containing an excess of mercury. These samples are very clearly shown on the central table in Figs. 82 and 83. A diagram of the respiration chamber, showing the layer of paraffin oil on top of the bottle directly connected with the respiration chamber and not shown in Fig. 89 is given on page 52 of Note Book No. 2.

Minor points regarding the study of respiratory exchange.--When studying the effect of muscular work upon the respiratory exchange,

M. Tissot had the subject sit in an arm-chair with his feet on the floor. The work was done with a finger or arm ergometer.

The temperature of the air in the laboratory and the temperature of the water in the gasometer are recorded but the temperature of the air in the bell is assumed to be that of the water. The temperature is taken in tenths of a degree.

Personal impressions.--To say the least, I was profoundly impressed with the wonderful technique shown in the experiments conducted in the laboratory of Prof. Chauveau. No expense has been spared to secure the utmost accuracy in manipulation and in construction of apparatus. In spite of this exceeding refinement on the one hand, the general impression obtained was that in a large number of operations in the experiments, there was a great inequality in the accuracy of manipulation with different pieces of apparatus. Thus, while gas analysis might be made with most exceeding exactness, the taking of the sample, the method of conducting the experiment as a whole, and many of the minor details of the general conduct of the experiment, were possibly open to serious criticism. This neglect in regard to the accuracy of the manipulation I found in almost all of the laboratories that I visited. Going to the Paris laboratory with the preconceived idea that there was unusual carelessness and disregard of the highest scientific accuracy on the part of the French investigators as a whole, I left profoundly impressed with the general accuracy of their work. If there were inequalities, they are apparently no greater than those found in the laboratories of other institutions. They appear, however, all the greater in Prof. Chauveau's laboratory in that one finds here this most wonderful gas analysis apparatus which would seemingly justify the utmost accuracy in all the preliminaries of the experiment.

Certainly, the work of the French investigators should not be looked upon with the general distrust that is only too common among outsiders.

Respiration Laboratory, Boucicault Hospital.

Dr. Letulle and Mlle. Pompilian.

From a very brief statement accompanied by an undecipherable diagram which appeared in the Compt. Rendus about a year ago, it appeared that there was being constructed in the Boucicault Hospital, Paris, a respiration calorimeter for use with man. It was my great misfortune to find Dr. Letulle ~~Littulle~~ too busy with surgical operations to show me the calorimeter and to find that Mlle. Pompilian, owing to the serious illness of her father, was in Bucharest.

I made two attempts to obtain an appointment with Dr. ~~Littulle~~ but ineffectively. At the second attempt, a concierge was asked to show me the laboratory and the apparatus. The calorimeter itself is as inexplicable from a superficial observation as is the diagram originally describing it. It is located in a small room on the ground floor of a special building devoted to tubercular cases. I believe that the funds for constructing this calorimeter were procured upon the ground that they were to be used primarily for the study of the respiratory exchange in tuberculosis.

The calorimeter chamber is very dark, the window opening on to a narrow passageway, so that the subject sitting in this chamber cannot look out of doors. A number of electrical measuring instruments, such as ammeters and voltmeters, appear to be used in connection with the apparatus and the intricate piping system furnished the two most marked features of the exterior construction of the apparatus. It was a source of great disappointment to me that more of the details could not be learned. As near as I can make out from conversations with others in Paris, the apparatus is but imperfectly understood by Mlle. Pompilian and not at all understood by Dr. Letulle. Check tests made with it have, I have been told, not been satisfactory. I received a most courteous letter from Mlle. Pompilian, expressing her regret at not being able to describe the apparatus to me. I am endeavoring to make arrangements with some one in Paris to secure a very complete description of the apparatus and method of its use.

In the top of the building, Mlle. Pompilian has a laboratory in which, judging from the charts in the room, she was doing some special work on blood.

The assistant gave me a reprint of some metabolism experiments made by Mlle. Pompilian on chlorine.

From the general statements one hears in Paris and elsewhere regarding the work of Mlle. Pompilian, both with the respiration calorimeter and her other metabolism work, the standard of accuracy is not as high as it should be. Personally, I could form no opinion of this as I was unable to secure the desired information.

Marey Institute.

Dr. Carvello and Mr. Bull.

The development of the graphic recording of observations is of prime importance in connection with an apparatus as intricate as is the respiration calorimeter and hence a visit to the Marey Institute, where, following in the footsteps of Marey, especial stress has been laid upon the development of graphic recording, was particularly profitable.

Dr. Carvallo has been making skiagraph studies of the movements of the alimentary tract during digestion and his extremely interesting apparatus for automatically moving a sensitized film and taking a skiagraph at the end of definite periods has been developed.

Furthermore, the photographs showing the movements of the alimentary tract when suspended in a salt solution were projected upon a screen with wonderful reality.

A specimen of the Blix-Sandstrom kymograph, manufactured in Lund, Sweden, had been tested with the greatest accuracy in the Marey Institute. They told me that it was the finest kymograph in existence. One of these instruments has been ordered for the Nutrition Laboratory.

Dr. Bull has been making a study of the photographic registration of the flight of insects and his use of quartz lenses and a tuning fork adjusted motor may prove of considerable value to us. A copy of the publication of the Marey Institute giving excellent photographs of the movements of the alimentary tract during digestion and of the flight of insects was given to me.

This Institute should be visited by all who have any interest in graphic recording.

Chemical Laboratory of the Pasteur Institute.

Prof. Bertrand and Dr. Abt.

This chemical laboratory is remarkably well equipped, using lava tops for the tables. Especially noteworthy is the fact that the experimental tables do not extend clear to the floor, thus apparently giving more sanitary and hygienic conditions. A general view of the laboratory is given in Fig. 90. A system in use in this laboratory which is well worth copying is to keep standard stock pieces of apparatus, such as Kipp generators, water baths, drying ovens, distilling apparatus for vacuum, set up in working order on a special table in the laboratory. These can be used by individuals without the necessity of having each person setting up the whole outfit whenever it is desired for use. Throughout the laboratory, use is made of the Roux regulator for gas ovens. The drying was almost invariably done in dry hydrogen at 108°.

For Bunsen burners, especially for burners permanently located in apparatus, rubber tubing was disposed with and fine copper tubing, coiled so as to be quite flexible, was permanently connected with the gas main with male and female screws. This system was likewise very commonly used on many of the laboratory desks and tables. Thus, as can be seen in Fig. 90, the burner beneath the water bath is connected with the gas directly back of it in the photograph by a long bend of copper tube. The rubber tube at the left supplies water to the water bath and the idea in using the copper tubing is to insure against risk of fire when leaving the burners, as, for instance, during the noon hour. It is maintained that the copper coil is sufficiently flexible and the connections so rapidly made that it is of the greatest advantage to use this type of connection between burner and gas supply.

Fig. 90. General view of the chemical laboratory of the Pasteur Institute.

Of special importance are the lava topped tables and the arrangement of desks, so that the cupboards do not extend clear to the floor. As can be seen in the back of the room, the hood system is very elaborate, extending along almost all of the available wall space in the room.

Large apparatus.--A most wonderfully complete series of large vacuum drying ovens, filter presses, vacuum stills, Kossel cutting machines, and similar apparatus of especial importance in studying the chemistry of muscle juice is to be found in a special hall adjoining the chemical laboratory.

Minor apparatus.--In this laboratory I first saw two especially interesting pieces of minor apparatus. One was a Bunsen burner devised by Meker which was used in the dark room for polariscope work. This burner has a grating of sheet nickel at the top, thus breaking up the large Bunsen flame into a large number of small Bunsen flames. By laying a piece of fused sodium chloride on this grating, a very powerful sodium flame for polariscope work is obtained.

I also saw here an especially interesting cooler and I subsequently visited the factory of Leune where the coolers and burners were made. A supply of both of these interesting pieces of apparatus has been ordered for the new laboratory.

Personal impressions.--This very large chemical laboratory was being used at the time of my visit by a very few students and assistants. The work was generally associated with the biological investigations in the other department and had no direct bearing upon metabolism. One is surprised that such a wonderful equipment is apparently so little used.

Chemical Laboratory of the Sorbonne.

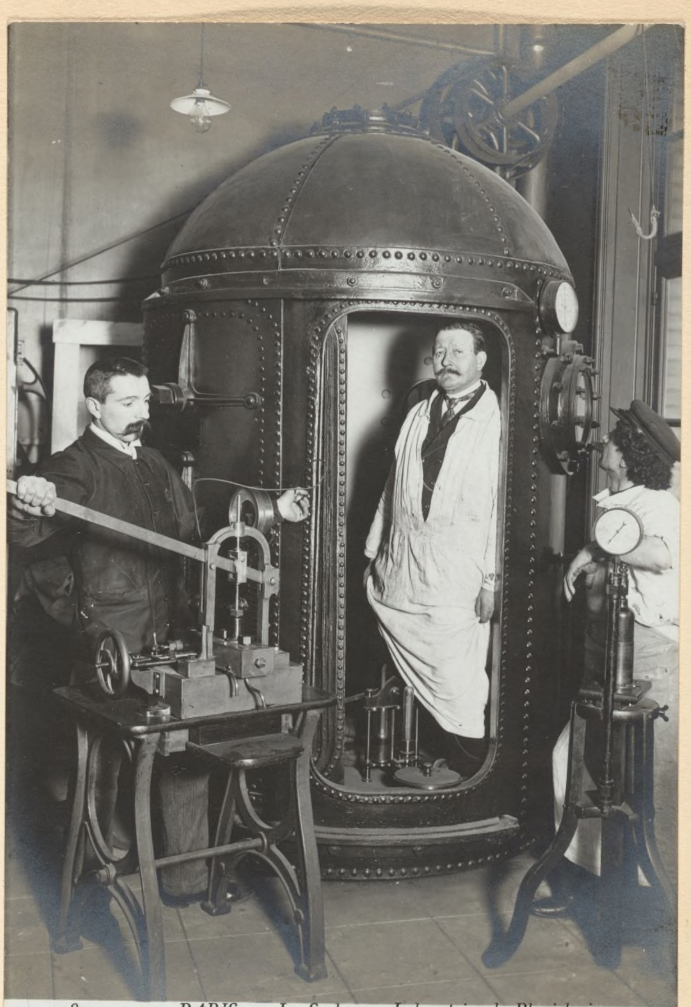
Prof. Dastre.

Unfortunately I was unable to make an appointment to visit the Sorbonne until the day before leaving Paris and hence my visit was too short for a complete and satisfactory inspection of this most interesting laboratory. Of great historic importance is the apparatus that Paul Bert used for studying the problems of decreased and increased air pressure. This is mounted as a historic exhibit although of no practical use at the present time. A postcard photograph showing this apparatus with great clearness is given in Fig. 91. In another part of the same room is the machinery and a general view is given in Fig. 92.

Experiments on metabolism.--Some of the assistants in the laboratory have been making metabolism experiments on animals that are designed to throw light upon some of the more perplexing problems in nutrition. Unfortunately, the assistants thus engaged in these investigations were not in the building at the time of my visit and from personal conversation I could learn but little of the details of these experiments. I shall hope at a subsequent time to visit this laboratory and examine it more in detail.

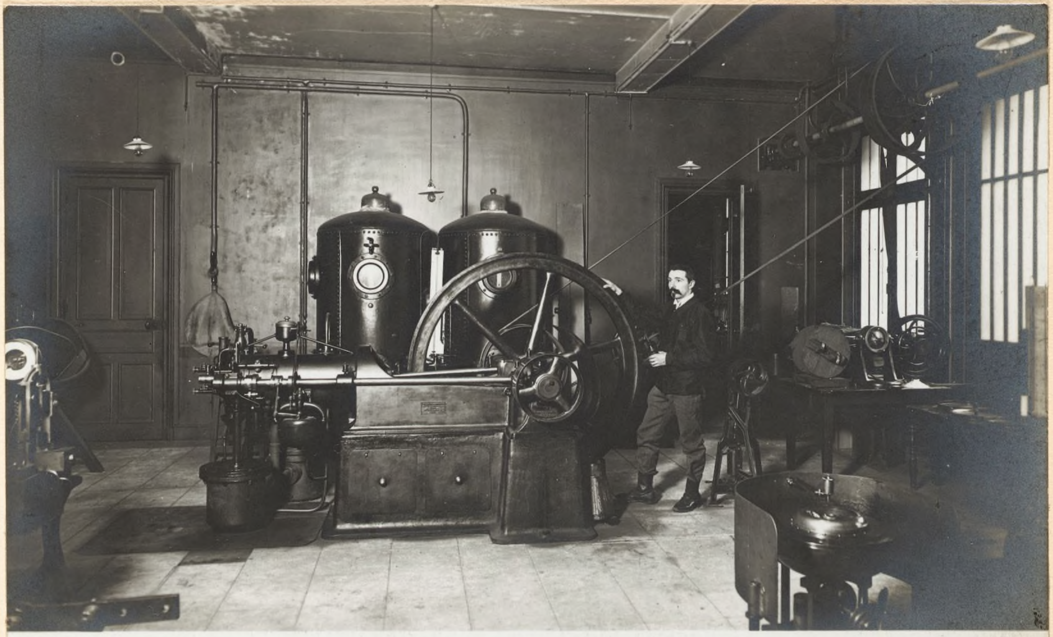
Prof. Dastre, a most genial investigator, has been active in some of the operations of Pawlow and has, I believe, modified one of his operations for fistulas in a very desirable manner. A photograph of Prof. Dastre at his desk is appended herewith as Fig. 93.

Animal quarters.--The investigations have almost wholly to do with animals and a most elaborate series of animal quarters are provided on the ground floor. Not only are the small animals used



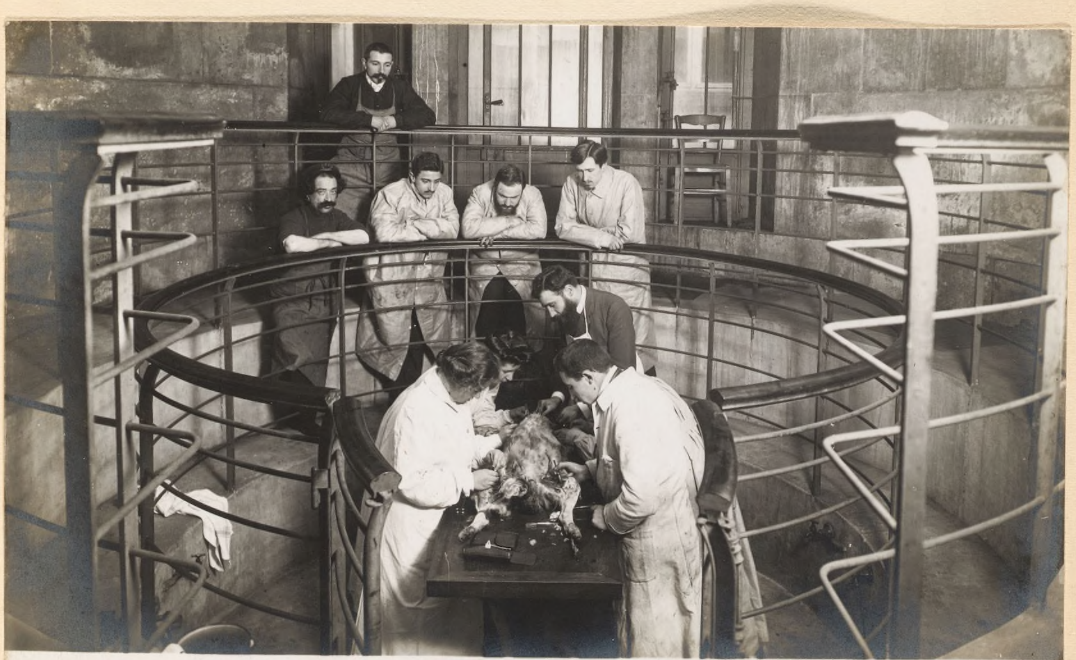
1389 PARIS. — *La Sorbonne, Laboratoire de Physiologie,*
Salle des Machines, la Cloche de Paul Bert
ND Phot

Fig. 91. Armored chamber used by Paul Bert in studying the effects of compressed air and decreased air pressure on respiration.



1435 PARIS. — La Sorbonne, laboratoire de physiologie. Salle des Machines ND. Phot.

Fig. 92. General view of the machinery and other air chambers in the laboratory of the Sorbonne.



1386 PARIS. — *La Sorbonne, Petit Amphithéâtre de Dissection, Laboratoire de Physiologie* ND Phot

Fig. 92 a. Dissecting ampitheatre, Laboratory of Physiology,
Sorbonne.

1545 PARIS. — *La Sorbonne, M. le Professeur Dastre, Membre de l'Institut (Physiologie)* ND Phot

Fig. 93. Prof. Dastre, director of the Laboratory of Physiology, in the Sorbonne.

but large dogs and even horses and cattle. Unfortunately, I could not possibly secure an adequate description of the nature of the work being carried on in this laboratory, and I must record my visit to this laboratory as the most unsatisfactory of any made in my trip, unsatisfactory solely because I was unable to get in touch with the various kinds of work in progress.

BERLIN, GERMANY.

Laboratory of the I Chemical Institute.

Prof. Emil Fischer, Drs. Abderhalden and Wrede.

Discussion with Prof. Fischer.--The laboratory is occupied almost exclusively in studying the chemistry of the proteins and their cleavage products. Prof. Fischer is much impressed with the idea of the possibilities of variations in the nature of the proteins being of value as signifying the usefulness of food materials. He is also very firm in his belief that mental activity is the resultant of a metabolism entirely different from that of ordinary muscular activity.

Discussion with Dr. Abderhalden.--Abderhalden criticises the experiments of Henriques and Hansen as they do not examine the food of their animals carefully enough, since long after the biuret reaction is gone, there are still long carbon ~~changes~~ chains. He has kept a dog three months on cleavage products of protein and succeeded in obtaining an increase in nitrogen and also an increase in weight.

He has found a short chain with four amino acids that gives albumose reaction and also long ones that do not give it. Tyrosine is a very important factor. Formerly, the series ran protein--albumose--peptone, but now we must cut out the albumose as it is not the size of the molecule but the character of the ~~change~~ chain that determines the albumose reaction.

Dr. Abderhalden is a very bright man, formerly of Basel, is an indefatigable worker, and the amount of work that he has accomplished in the last four or five years seems almost incredible. He is probably one of the brightest of the younger men in Germany.

Minor apparatus.--The sinks throughout the whole Institute are of wood with galvanized bands.

There is always a flask used as a water trap between the suction pump and the filtering vessel. This flask is anchored to the table by a heavy lead ring.

All conduits and pipes in the floor are covered by removable iron flooring.

A drying vacuum apparatus that is commonly used in the laboratory employs phosphorus pentoxide as the desiccating agent.

In the hoods there is a small three-quarters to one inch hole made in the wall opening into each flue so as to enable bad gases to be carried through a rubber tube into this hole.

A balance much in use in this laboratory is made by E. Mentz and was sold on contract price at 150 M.

The table tops were all of wood, save on tables that contained apparatus used in common by a number of students. These tables were all heavily leaded.

Bomb calorimeter.--Dr. Wrede has been working with Prof. Fischer for some time on the heat of combustion of the cleavage products of the proteins and as a result, they have developed an extremely accurate method for studying the heat of combustion of these products. Dr. Wrede devoted a considerable time to giving me a large number of points regarding their method of combustion. Unfortunately, the whole method has not as yet been published as they are awaiting further results before making their researches public.

The combustion is made with 50 atmospheres of oxygen instead of 20. They always seek to have as low a nitrogen content as possible.

The difficulty of combustion seems to depend not so much upon the nitrogen content of the substance burned as upon the method in which the nitrogen is bound. For example, glycocol burns well; alalin does not burn well; leucin burns much better; but glutaminic acid burns with very great difficulty.

The form of bomb used in all of these combustions is that of Berthelot, modified by Kroeker. It is made by Julius Peters of Berlin, is lined on the inside with enamel but has a platinum lining to the lid. The cubical contents are not far from that of the bombs in use in Middletown but the calorimeter and the cover are all in one piece and much lighter than those of the Berthelot-Atwater bomb calorimeter. Dr. Wrede told me that a Kroeker bomb had burst in Zurich. I believe that the iron had taken fire where the enamel had chipped off and the bomb had burned a hole inside and blown out. I did not understand that there had been an explosion and the whole apparatus destroyed. (Since my return to America, Mr. Carpenter tells me that he has seen an account of a bomb that burst in some European city.)

The hydrothermal equivalent of the bomb and water system as used by Fischer is 4,000 calories, neafly twice as large as that with the Berthelot-Atwater bomb calorimeter.

Filling with oxygen.--The bombs are filled with highly compressed oxygen obtained from one of the local factories in Berlin. A manometer which is very accurate and with exceedingly good valves enables the cylinder to be emptied to a very low pressure. The manometer arrangement is shown in Fig. 94, as is also shown the pellet press. This manometer arrangement and two steel cylinders have been ordered for the Nutrition Laboratory.

Temperature measurements.--The temperature measurements are made wholly with electrical methods. A resistance thermometer constructed by Heraeus of platinum encased in a fine copper tube is used. This thermometer is shown lying in an inclined position on the table in Fig. 95. The fine copper tube is coiled something like a hook and the

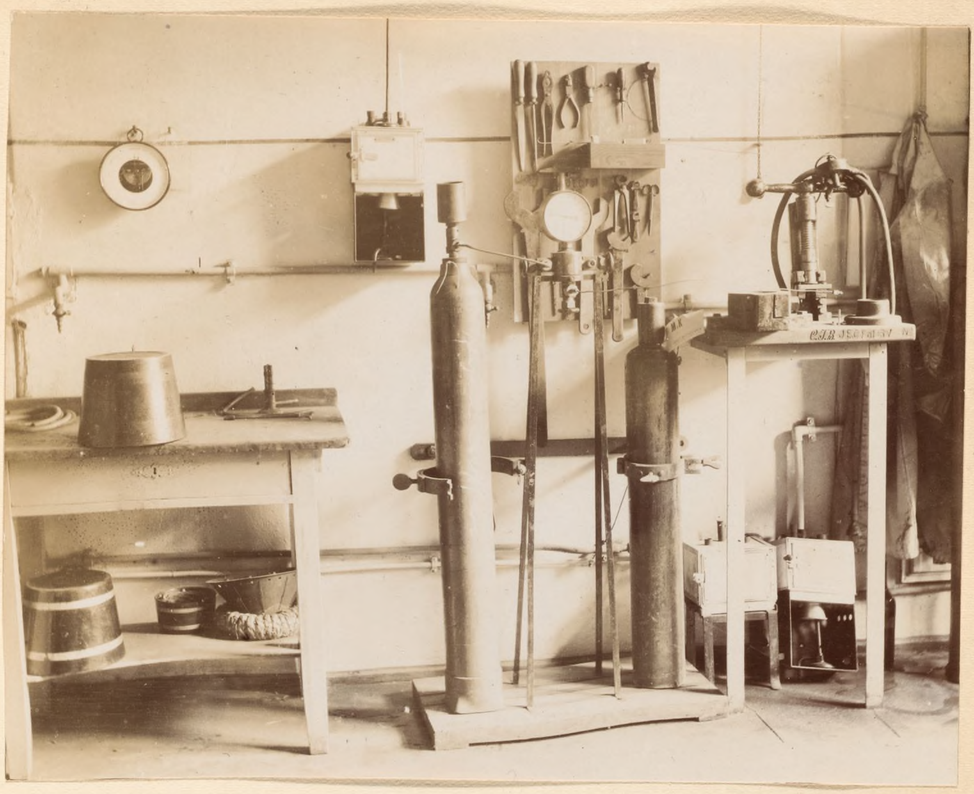


Fig. 94. Oxygen cylinders and manometer, bomb calorimeter laboratory of Prof. Fischer.

The bomb pellet press is at the right; beneath the press stand two drying ovens of the form used in this laboratory. The manometer has unusually well-fitting valves.

platinum wire is drawn through it. This system is immersed in water and the variations in the electrical resistances measured. In the figure are shown, also, the mercury switches imbedded in paraffin for making connections and the telescope and millimeter scale. The apparatus for temperature measurements is extremely complex, the whole outfit consisting of the following pieces of apparatus:--

Telescope and scale;
Galvanometer with special suspension;
Three resistances running from
    0.1 to 50 ohms
    0.1 to 5000 ohms
    0.1 to 10,000 ohms
A normal resistance of 10 ohms;
A complicated compensation apparatus;
A platinum thermometer.

Conferring with the officials of the Physikalisch~~e~~-Technische Reichsanstalt, Prof. Fischer has succeeded in assembling this apparatus for the electrical measurement of temperature, which gives most wonderfully satisfactory results. The rise is ~~given~~ measured with an accuracy of 1/5000 of a degree Centigrade. Consequently, the whole system is so adjusted as to give a rise of only one degree, thus eliminating in a marked manner any tendency for a cooling correction.

The general appearance of the bomb calorimeter room is shown in Fig. 96. In the further corner, surrounded by a cardboard or asbestos box, is the galvanometer. One side of the protecting sheath has a slit through for the beam of light to pass in and out. On the floor is a calorimeter vessel with a pulley system on a standard above, the system being actuated by an electric motor near the window. When in operation, the central part of the calorimeter chamber is closed. The water mantle is constructed of copper. On the table at the left are the three resistances and the compensation apparatus. This is covered and not shown in the photograph. The apparatus on the two tables at the right is used for another research and is of interest only in that the telescope

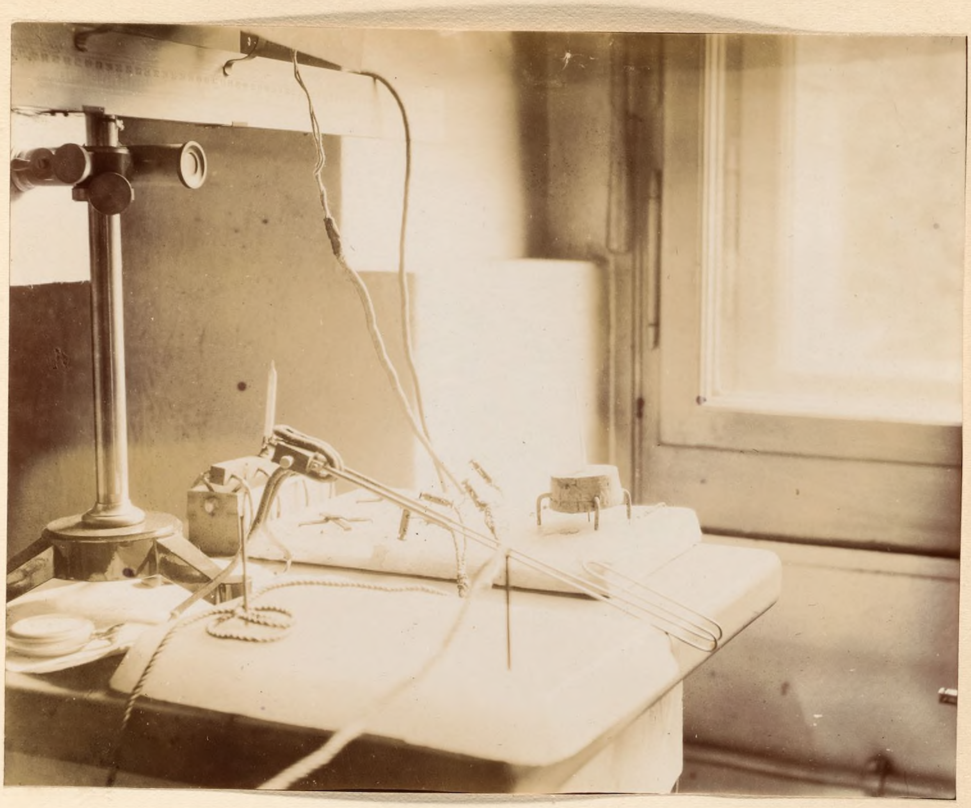


Fig. 95. Electrical resistance thermometer, paraffin sheets, with switch connections, telescope, and millimeter scale used in bomb calorimeter investigations of Fischer and Wrede.

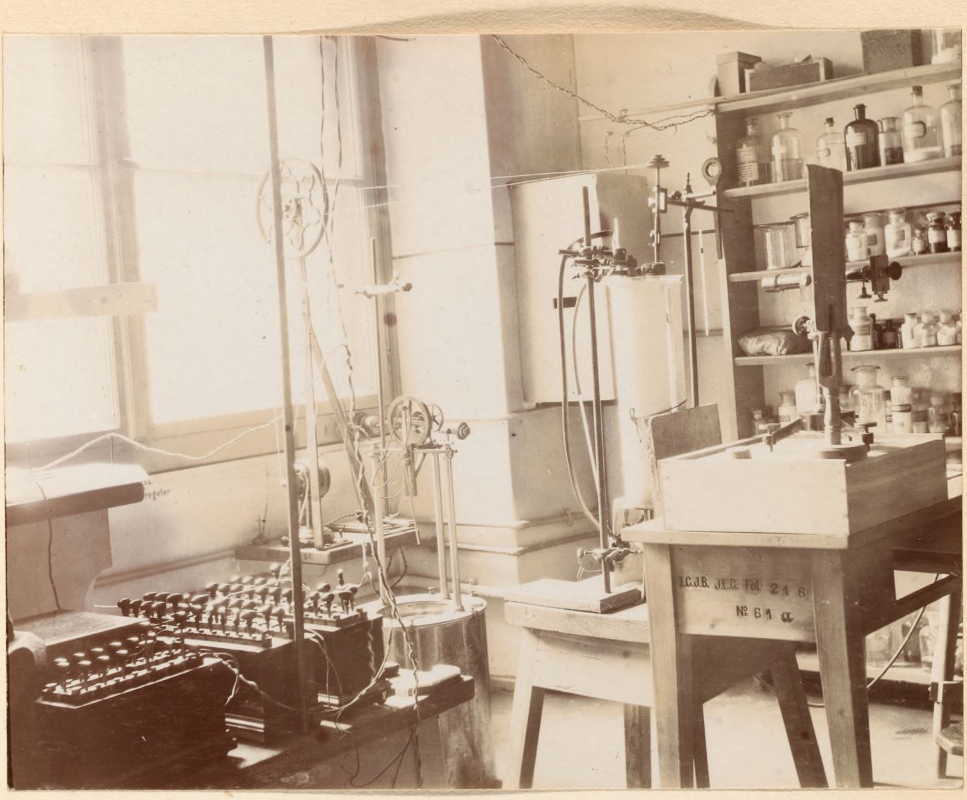


Fig. 96. General view of bomb calorimeter room, Fischer's laboratory.

The compensation apparatus with cover on it and three resistances on the table at the left. Paraffin plate shown in Fig. 95 immediately above it. On the floor in the centre, the copper double-walled water vessel of the calorimeter with stirring apparatus above. On the wall in the further corner is the galvanometer suspended with three wires and surrounded with cardboard with an opening. On the table at the right, placed on an inverted drawer, is a telescope with micrometer ocular for measuring the differences between gradations on the mercurial thermometer.

on the inverted drawer has an ocular that permits of micrometer measurements of the differences between two gradations on a thermometer, thus comparing with the micrometer lunette in Tissot's laboratory.

Another view of the electrical measuring apparatus is shown in Fig. 97, the three resistances in front of the compensation apparatus with the wooden cover being plainly seen. The stone pillar in the rear supports the telescope and ~~micrometer~~ millimeter scale as well as the plates of paraffin used with switches shown in Fig. 95. The normal resistance used in connection with the compensating apparatus is on the floor beneath the table in an oil bath.

Compensation apparatus.--The compensation apparatus was constructed by Wolff in Berlin and is recommended in the highest terms by the Physikalisch~~e~~-Technische Reichsanstalt. This apparatus has been purchased for the Nutrition Laboratory. It has obviously innumerable uses other than that of measuring the temperature rise in the bomb calorimeter.

Minor points regarding combustions.--The highest temperature of the calorimeter system is obtained in 25 seconds, with measurements with an electrical thermometer. The apparatus is stirred with a movement of 42 strokes per minute with the stirrer. With a mercury thermometer, the highest temperature is not reached for one and one-half minutes.

When it is remembered that in the combustions made with the Berthelot-Atwater calorimeter, with a mercury thermometer, the maximum temperature rise was not attained for three minutes or over, the fact that the maximum temperature is attained at the end of 25 seconds seems almost incredible. It is a fact, however, that the Kroeker bomb contains much less metal than does the Berthelot-Atwater bomb calorimeter and therefore must impart its heat much more readily to the water. Secondly, the resistance thermometer has practically no lag while the mercurial thermometer has

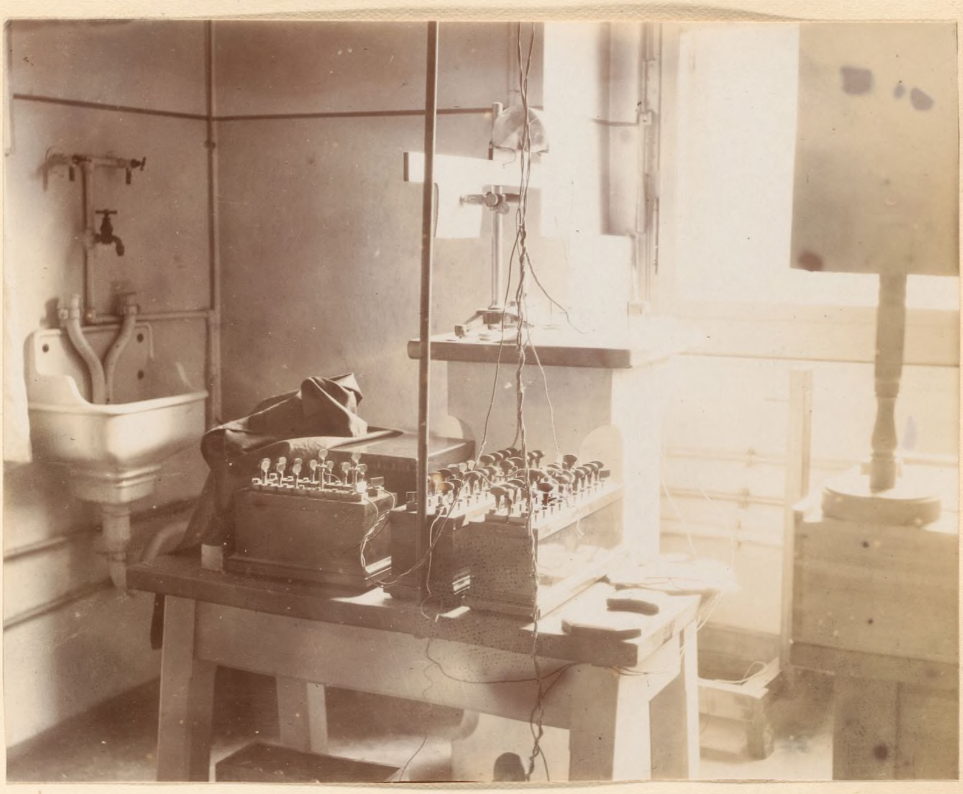


Fig. 97. General view of resistances and paraffin switches used in measuring temperature rise in the bomb calorimeter.

Note the arrangement in sink at the left for attaching suction pump with lead pipe outlet into the sink.

considerable lag. It will be interesting to study the rapidity of combustion of different materials as measured by an apparatus in which the maximum temperature is obtained by the electrical thermometer and compare the results with those obtained by Mr. Fletcher and myself in studying the pressures developed during combustion in the bomb.

Nitric acid in the bomb.--Nitric acid formed in the combustion is almost wholly derived from the nitrogen in the oxygen admitted to the bomb and is the same with the same amount of heat. If nitrogenous bodies are burned, there is not a great increase in the nitric acid formed. Generally, there is no increase but occasionally an increase is found and under those conditions, it is greatest with the bodies containing the largest amount of nitrogen.

Richards and Henderson of Harvard University have recently made some studies in the formation of nitric acid in the progress of combustion. These investigations have been substantiated for the greater part by the results obtained by Fischer and Wrede.

Other laboratory notes.--Bunsen burner. A Bunsen burner with pilot light in the centre of the burner tube is very much used.

The water, gas and heating connections are painted different colors as are also the valves connected with the different pipes.

At the end of the desks, where there are no sinks, there is a box with hooks on each side to protect the pipes.

Physikalisch-Technische Reichsanstalt.

Prof. Lindeck and (Dr. Jaeger).

The great aid furnished to Fischer and Wrede by the scientists at the Physikalisch-Technische Reichsanstalt made a visit to this laboratory of unusual interest and Prof. Lindeck devoted a great deal of time to suggestions regarding the equipment of a bomb calorimeter room.

Compensation apparatus.--The apparatus of Wolff was especially recommended as the Reichsanstalt had failed to find any discrepancies in calibrating this instrument. This apparatus was therefore ordered for the Nutrition Laboratory.

Galvanometer.--For a general all-round galvanometer, the instrument manufactured by Siemens & Halske, and designated a Spiegelgalvanometer nach Deprez-d'Arsonval, was recommended as being the most flexible and adaptable for general laboratory use. On this recommendation, two such galvanometers have been ordered.

Mercurial thermometers.--The Reichsanstalt also stated that the best thermometers made in Germany were manufactured by C. Richter in Berlin and accordingly, four thermometers of special construction were ordered from him for the Nutrition Laboratory.

Platinum resistance thermometers.--A new platinum resistance thermometer constructed by Heraeus was especially recommended. This thermometer is constructed by winding a coil of platinum wire about a quartz tube. Another thin quartz tube is drawn over the coil and then both tubes fused together, thus giving a coil of platinum wire imbedded in fused quartz. Double lead wires are connected with each end of the platinum coil and attached to four binding posts at the other end of the thermometer. By means of this apparatus, the variations in the [illegible] resistance of the leads may be entirely taken out of consideration by the method of measurement devised by Kohlrausch and designated <u>uebergreifende Nebenschluss</u>. With this instrument, it is maintained that the measurement of the temperature may even be more delicately made and more satisfactorily than with the platinum resistance thermometer used by Fischer and Wrede shown in Fig. 95.

Four of these thermometers have been ordered for the Nutrition Laboratory.

In discussing with Prof. Lindeck the different thermal couples best to use, he pointed out that copper-constantan gives 40 micro-volts for each degree; iron-constantan, 50; and iron-German silver, 25. For certain measurements, therefore, copper-constantan is by far the best junction to use. Since, however, a large number of iron-German silver junctions had already been made for the new apparatus in the Nutrition Laboratory, Prof. Lindeck did not think there would be enough advantage to have them reconstructed, since one would have only to use two junctions instead of one to get the equivalent of copper-constantan.

<u>Telescope with micrometer ocular</u>.--The telescope mentioned as being used in Fischer's laboratory for measuring temperatures was borrowed from the Reichsanstalt. It is manufactured by Schmidt & Haentsch. The eyepiece is so adjusted that by moving the micrometer scale, the divisions on the thermometer may be accurately read instead of as is usual, estimated. At the time of my visit, I was not decided regarding the purchase of the gas analysis apparatus of Tissot and hence did not order this micrometer eyepiece, but doubtless such an apparatus will be of great value in the Nutrition Laboratory.

Laboratory of the Imperial Health Bureau.

(Dr. Rost) and Dr. Franz.

Owing to the red tape surrounding the German imperial institutions, it was difficult for me to secure admission to this laboratory. I was especially interested in seeing it since Prof. Cohnheim in Heidelberg had told me that Dr. Rost had a very complete equipment for studying the respiration of man. Finally, on leaving my camera in the office, I was able to meet Dr. Franz, one of Dr. Rost's assistants. Unfortunately, Dr. Rost was away at the time and I had to leave Berlin without meeting him personally.

The laboratory is provided with a new Rubner respiration apparatus for man, an exact duplicate of that described in connection with Rubner's laboratory and shown in Figs. 104 and 105. Apparently Dr. Franz and his colleagues are trying to obtain results with this apparatus but as yet, they have had very little success, their alcohol checks proving very unsatisfactory. They recognize the difficulty of securing a water balance and are attempting to remove all wood from the interior of the chamber. Practically no results have been obtained as yet with this apparatus.

Two pieces of minor apparatus were of interest here, one, a tripod with a side rest for a Kjeldahl flask, devised by Dr. Sonntag, and the other a special self-adjusting burette. Both pieces of apparatus have been ordered for the Nutrition Laboratory.

Laboratory of the Physiological Institute.

Prof. Thierfelder and Dr. Mueller.

At the invitation of Prof. Zuntz, I was ~~invited to~~ present at a demonstration of the use of the Saitengalvanometer of Einthoven for the determination of the electricity developed by the heart beat. Unfortunately, I was too poorly versed in physiology to appreciate the significance of the experiments but it is an outcome of the investigations by Einthoven in the University of Leyden. By means of the Saitengalvanometer, some very interesting studies have been made of the heart action, and by photographic registration of the curve obtained, the method bids fair to be of great diagnostic value.

The subject sits in a chair, and places one hand in each of two tanks containing, I suppose, salt solution. Some distance away is the galvanometer which is extremely sensitive and brilliantly illuminated with an arc light. The impulses are photographically recorded and the curve studied minutely after development.

Chemical laboratory.--Prof. Thierfelder has a much smaller laboratory than Prof. Emil Fischer but is apparently working on similar lines. I found but little new material in this laboratory outside of an interesting form of balance constructed by Jos. Nemetz of Vienna, which permits of rapid weighing by use of a complicated system of riders.

Chemical Laboratory of the Charité.

(Prof. Salkowski) and Dr. Magnus-Levy.

After several unsuccessful attempts to meet Dr. Magnus-Levy at Prof. Zuntz's laboratory, I went to the Charité laboratory, there hoping, also, to see Prof. Bickel, who has charge of one of the departments. Prof. Bickel is the man who has been working with a girl with a Pawlow fistula but unfortunately I was unable to meet him. I saw Dr. Magnus-Levy for only a short time and could discuss matters with him but very briefly.

He is just getting out a large book on diabetes and is becoming more and more impressed with the importance of ash analyses in urine. He hopes that we will be able to complete and publish the ash analyses of the urines secured in the fasting experiments. He is most appreciative of American work and implied that he might at no great distant day visit America for the first time. I regret exceedingly that I did not have more time to discuss with him his experience with the Zuntz respiration apparatus.

Hygienisches Institut.

Prof. Rubner and Dr. Kisskalt.

Perhaps no one man in Europe has attained to so great a reputation in the line of investigations of the respiratory exchange and heat production of man as has Prof. Rubner.

Working in Munich in the laboratory of Voit, he developed his calorimeter for dogs and there made his classic experiments on the heat production of animals at 33°. (See Fig. 29, page 114.) In Berlin, he is the director of a very large institute devoted to hygiene. The building is new and the details of construction have been given in a publication, copy of which was presented to me by Prof. Rubner and apparently the greatest care and thought has been given to every detail.

Laboratory tables.--The floors and tops of tables in both the laboratory and lecture room are covered with linoleum which has, according to Prof. Rubner, proved very satisfactory. Since, however, the laboratory is nearly new, it is a fair question as to how long the linoleum will last. According to the assistants, the linoleum stands all reagents well except caustic soda. It is glued to the floor with ordinary glue and likewise glued to the table tops but it is tacked down at the edge with small headed nails. There is a small wooden beading between the edge of the linoleum and the edge of the table, thus making a good edge for the linoleum itself.

A general view of a laboratory table is shown in Fig. 98. Even here it is seen that the linoleum is considerably marked where bottles have been set down upon it. On either side of the pipette lying on the table round rings, showing where acids or alkalis have rested on the linoleum, are easily seen. The drawer and cupboard arrangement is extremely simple. The tables are 93 cm. high, 123 cm. wide, and

Fig. 98. General view of laboratory desk. Laboratory in the Hygienic Institute, Prof. Rubner.

The tables are covered with linoleum and and the special removable shelf supported for reagent bottles, devised by Prof. Rubner.

256 cm. long.

Running the length of the central table is a special iron bracket with shelves, devised by Dr. Rubner for reagents. A detailed sketch of this shelf, with measurements, is given in my notebook. The distribution of water at the sinks is shown in detail in Fig. 98, the central cock supplying the suction pump for use at both tables. Practically all of the burettes in the laboratory have the offset at the bottom as shown in the three burettes in Fig. 98. There is no water supply in the length of the table but four gas cocks are conveniently placed for supplying gas to each desk. Water is supplied only at the end. All brass work is nickel plated and buffed.

Doors.--The doors throughout the building are provided with handles instead of door-knobs, as Dr. Rubner maintains that less dirt accumulates on the handles than on door-knobs. There is also a hard rubber plate placed on the door to protect it at about the point where the hand touches it when passing through the door. The objection to these is the fact that they warp readily and those exposed to the light turn yellow, thus making the door look disfigured.

Hoods.--A typical hood in the large chemical room is shown in Fig. 99. The shelf is 83 cm. deep, liberally supplied with gas and water connections and, as the photograph shows, all cocks are at the forward part of the table. Special cocks are inserted for gas leading to the hood burners for increasing the draft. The cocks are so adjusted that the outside edge of the thumbpiece is in a line perpendicular with the edge of the shelf; thus it is rather difficult for one to open or close these cocks by the body.

Combustion room.--The combustion room is provided with a very large hood, with a damper at the top, and illumined by electricity. The

Fig. 99. General view of hood, chemical laboratory of Hygienic Institute.

The control of all gas and water supplies is at the front end of the shelf. Burners lead to opening in the hood at the top for increasing the draft.

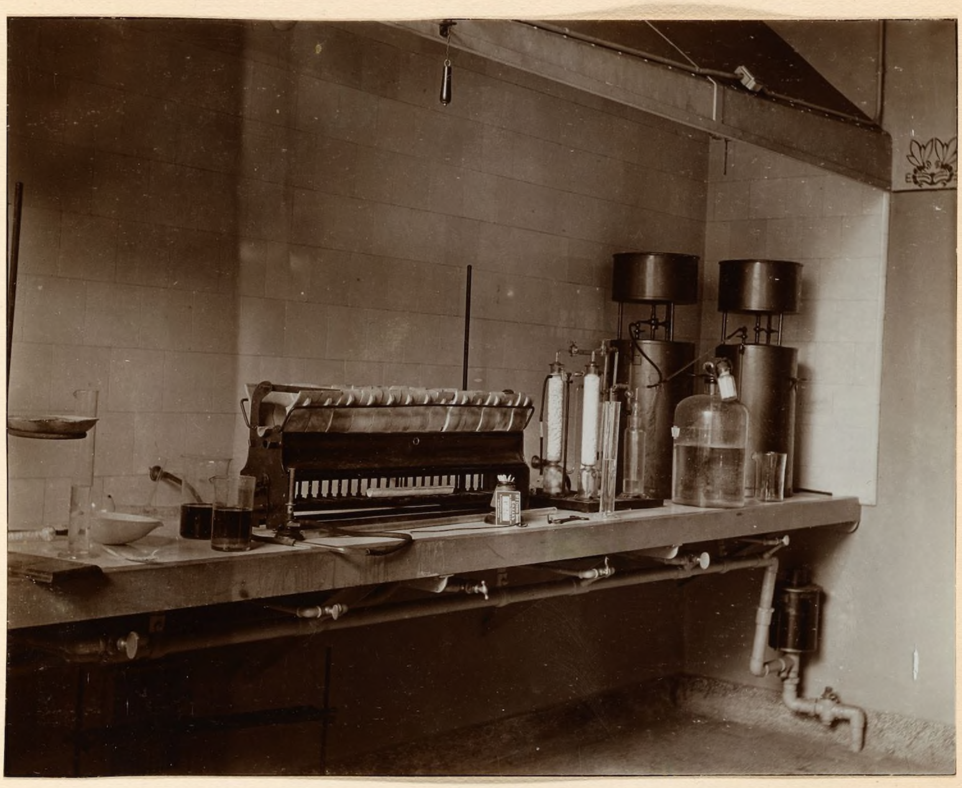


Fig. 100. <u>General view of combustion room, Hygienic Institute.</u>

The table is a sandstone slab covered with white tiles and supported on angle iron arms or brackets. A gas pressure regulator is placed on each gas main. The hood at the top is of sheet iron and illumined by electricity. The arrangement of the conduit and cut out box is plainly seen.

arrangement of the gas cock system is clearly shown in this photograph. The shelf is made of white tiles laid on top of a sandstone slab, supported on iron brackets. These brackets start about one foot from the floor. The gas and water pipes come up through the floor and out of the tiles at the back. This arrangement with a return bend, however, does not appeal to me as being not easily accessible in case of repairs. The concrete floor is rounded at the edges and carried up a little distance, thus making a mopboard itself.

A rack holding several sizes of glass tubing is placed conveniently near the blow-pipe table.

Moist combustion process for carbon.--In conjunction with several of his students, Prof. Rubner is making studies of the moist combustion process for determining carbon in small amounts of organic materials. The carbonic acid is liberated by the action of potassium bicarbonate and sulphuric acid and the carbonic acid is conducted through dilute solutions of barium hydroxide. Phenol-phthalein is used as an indicator and the determinations are made colorimetrically. The method, while at the time of my visit not completely worked out, gave promise of very satisfactory results. It was of expecial importance in determining the carbonaceous material in potable waters.

Experiments on bacteria.--Prof. Rubner has recently been making a large number of studies on the heat developed by bacterial action. He says that bacteria are much cheaper and easier to work with than dogs. His experiments are also being taken up by Tangl, and Dr. Henderson of the Harvard Medical School is now studying the same problems by the same method.

The method is essentially this: Two Dewar vacuum bulbs, silvered on the inside, are placed in a constant temperature oven, one containing water or some other liquid and the other containing the bacteria. This is maintained at body temperature and the temperatures of the two bulbs read either with mercurial thermometers or by electrical resistance thermometers, as does Tangl. Rubner has a telescope and reads the thermometer from across the room. Only a few hundredths of a degree difference is obtained but the reaction may continue several weeks or months. By this means, he says he can determine a heat production of but one small calorie per hour. As an interesting result of the use of silvered and unsilvered Dewar bulbs, it was found that the silvered Dewar bulb required ten times as long to adjust itself to temperature equilibrium as did the unsilvered bulbs.

Dr. Kisskalt's investigation on body temperature.--By means of a copper-constantan thermal junction, Dr. Kisskalt was making studies of the skin temperature of man under varying conditions. He was using a small permanent magnet Seitengalvanometer, obtained from Edelmann in Munich. This apparatus is very sensitive, is portable, and one has been ordered for the Nutrition Laboratory. By placing a thermal junction on the skin and keeping the comparing junction at a constant temperature, the temperature of the skin at any point can be determined. I believe that Kisskalt claimed an accuracy of one-tenth of a degree for his measurements. At the time of my visit, he was using a sailor for his subject and placing him in the large respiration chamber with air containing varying amounts of moisture. The experiments had not proceeded far enough to secure any important results as certain details in the method had not been arranged completely to his satisfaction.

Respiration calorimeter for small animals.--The respiration calorimeter for small animals devised by Rubner is in the laboratory at Munich. (See Fig. 101) While in Buda Pesth I saw a new calorimeter built by Rubner's mechanician which had not been installed but in

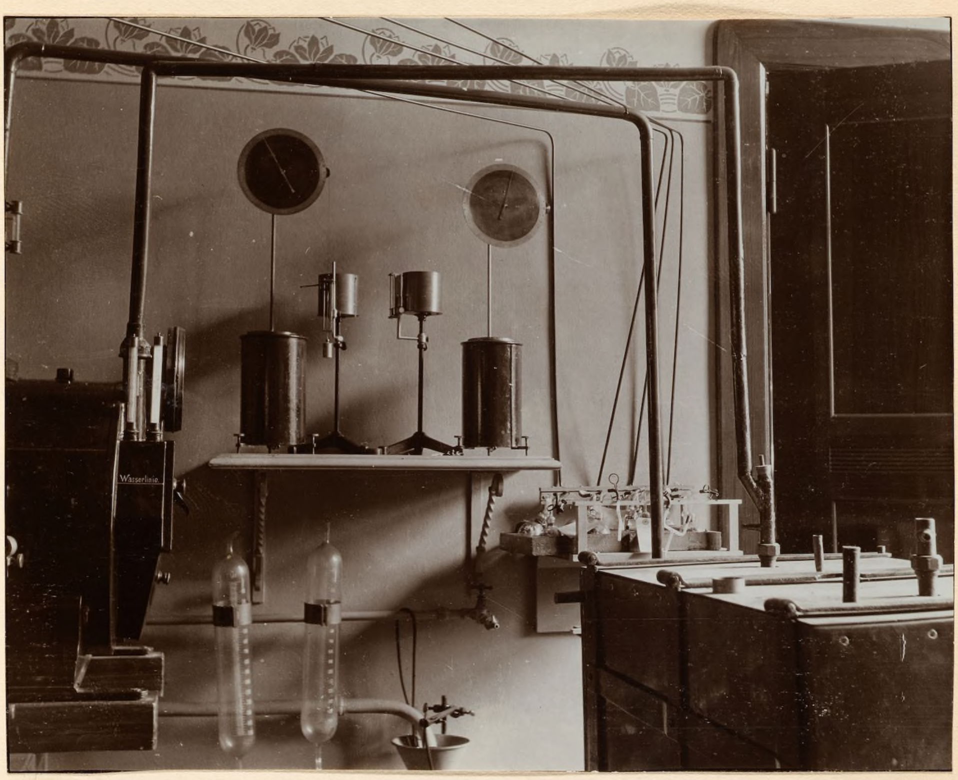


Fig. 101. General view Rubner's respiration calorimeter for small animals.

The door at the right leads to the respiration laboratory. The calorimeter is shown in the foreground at the right. On the shelf on the wall are two volumeters with graphic recording devices. At the left is the main meter for maintaining the main ventilating air current. Beneath the shelf are two large pipettes for the delivery of known amounts of oxygen into the system.

Rubner's laboratory, the apparatus is in perfect running order. The calorimeter occupies a small room adjoining the large respiration chamber laboratory, hence it was difficult to get an inner view of the apparatus. The door at the right leads into the respiration laboratory. In the foreground at the right is the calorimeter with the pipes leading to the gas meter at the left. On the walls at the back are the volumeters for recording the fluctuations in pressure inside the chamber.

The meters for the sampling system are shown in Fig. 102. the large meter at the right being the main meter actuated by the water wheel in the rear and the four meters at the top for the duplicate samples of ingoing and outcoming air. One corner of the calorimeter is shown in the lower right hand portion of the photograph. The valve system for the aliquoting of the air current is shown beneath the meters in Fig. 103. At the right are the special mercury pumps and the small glass or mercury valves are shown fastened to the table. One feature of this apparatus, which I was unable to understand, was a small chamber before the respiration chamber itself and not shown in Fig. 101, in which it was stated that the bulk of the carbonic acid and water were absorbed. As near as I can make out, no provisions were made for weighing this chamber during the periods and also the assistant was not sufficiently familiar with the manipulation to explain how the amount of carbonic acid and water was ~~transferred~~ apportioned during experiments of, say, 24 hours.

The water in the samples was absorbed in small ground glass weighing bottles, filled with pumice stone of a special construction, devised by Prof. Voit. These are imperfectly shown at the right of the shelf holding the volumeters in Fig. 101.

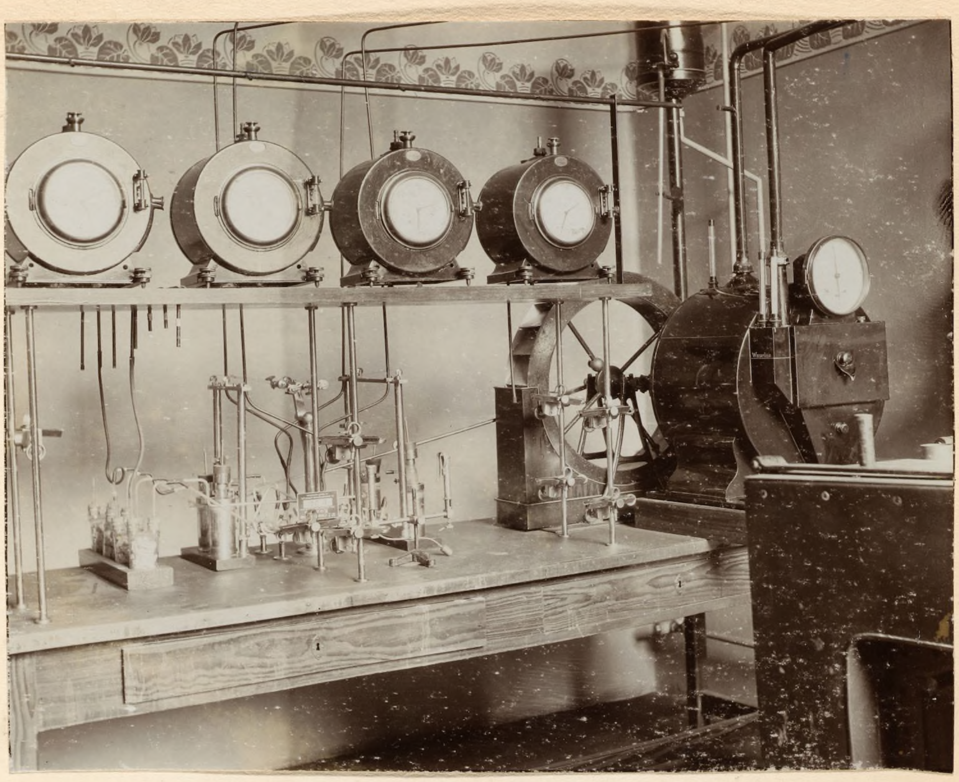


Fig. 102. Meter for main air current and meters for sampling the air currents, Rubner's apparatus for animals.

A corner of the calorimeter is seen at the lower right hand edge of the picture. The meter which serves also as a pump is actuated by a water wheel in the rear. The valve systems for sampling the air currents are on the table beneath the meters.

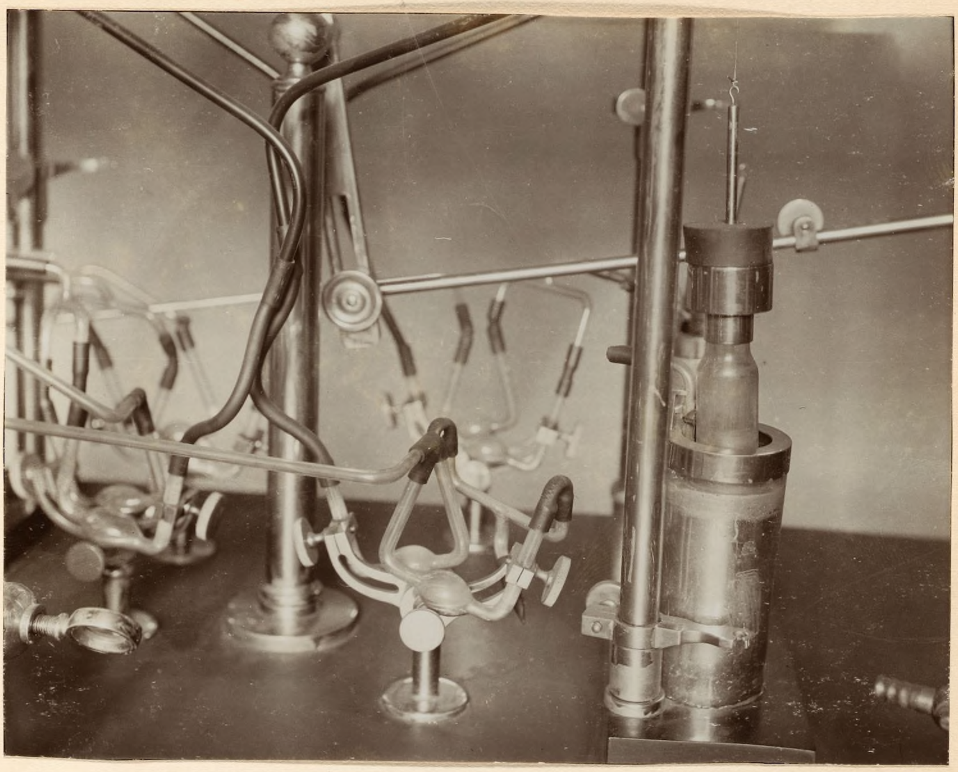


Fig. 103. Details of small mercury pump and valve system for aliquot samples in Rubner's apparatus for animals.

Respiration chamber for man.---In one of the largest rooms in the Institute, the room adjoining the chemical laboratory, is placed a respiration chamber for man after the principle of Pettenkofer. This represents the latest and probably the most improved form of respiration chamber in use in Europe at the present time. A general view of the chamber, with the door open, is given in Fig. 104. It is mounted on structural iron supports, is constructed of thin sheet iron and the door is closed with an ordinary rubber gasket.

The other end of the apparatus, showing the windows, is illustrated in Fig. 105. The air leaving the chamber comes out at the point just above the two windows and is carried to the point just before the large meter. The air entering the chamber is taken from out-of-doors, carried across the top of the laboratory and down into a box supplied with a large number of drawers containing soda lime. This is shown in the photograph at the right of the chamber. The air then passes along through a special compartment which may be used either to warm the air to the desired temperature or to saturate it with moisture to varying degrees. It then enters the respiration chamber for use.

The sampling system is essentially that in use with the small chamber just described. It consists of four meters, the details of which are given in Fig. 106 and they closely represent the system in use in the other room. The main gas meter which is driven by an electric motor and therefore serves in a measure as a pump, is shown in Fig. 107. This apparatus has not been extensively used, since the Institute has not been constructed long but, as stated previously, Dr. Kisskalt is engaged in a study of the effect of different hygrometric conditions upon the surface temperature of the skin. I believe other experiments have been projected although I was unable to secure any detailed information regarding the plans for the experiments.

Fig. 104. General view of Rubner's respiration chamber for man.

The chamber is constructed of sheet iron, painted, and the door closed with a rubber ring. The air current enters in the round opening at the lower left hand corner near the door.

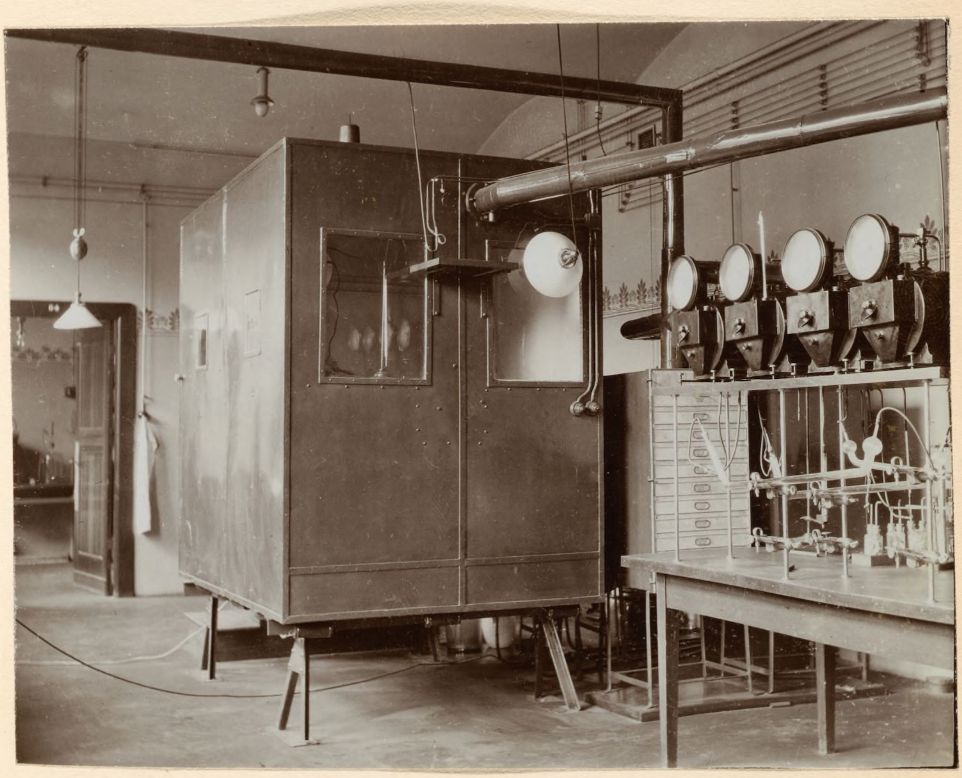


Fig. 105. General view of respiration chamber and air sampling meters of Rubner's respiration apparatus.

The air leaves the chamber through the pipe above the two windows. The long pipe crossing the ceiling is for taking air from outside. This air is drawn over soda lime in the box containing a large number of drawers at the immediate right of the chamber and then enters the chamber at the further end. The meter system, valves and barium hydroxide tubes are those commonly found on the Rubner-Voit apparatus. The door at the left leads into the calorimeter room for small animals. The main laboratory is well lighted by the Lilliput arc light shown suspended from the ceiling near the corner of the calorimeter.

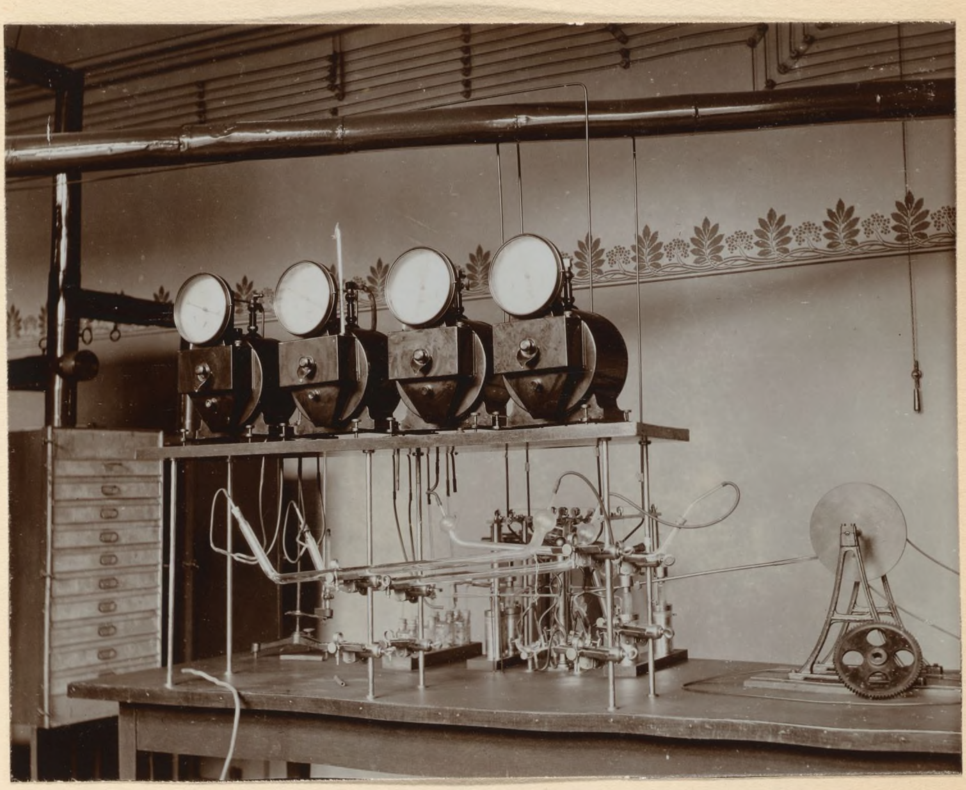


Fig. 106. Meter system for samples and mercury pumps, valves and barium hydroxide tubes of analytical apparatus for analyzing air current in the Rubner-Voit respiration apparatus.

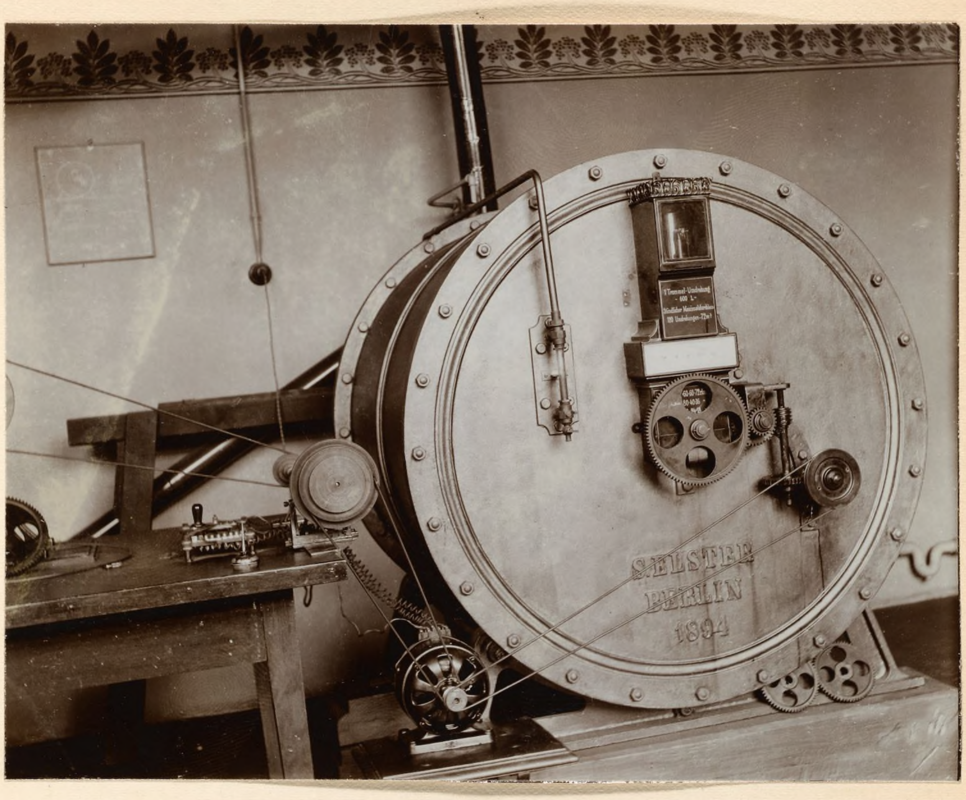


Fig. 107. Large Elster meter for maintaining main ventilating air current, Rubner's respiration apparatus.

Agricultural High School---Institute for Zootechny.

Prof. Lehmann, Drs. Voeltz and Mueller.

This laboratory has been but recently constructed and contains many innovations, especially in regard to minor points of construction. Prof. Lehmann is most ingenious and his hand is seen at every corner of the laboratory in its construction. A typical laboratory table is shown in Fig. ~~107~~ 108. The desks are 1½ meters wide and 6 meters long and the tables are 95 cm. from the floor. The tops are covered with sheets or slabs of the artificial stone called Xylolith, a substance previously noted in Exner's institute in Vienna. It has the disadvantage, however, of being attacked by acids and is not to be recommended.

Gas, water and compressed air are brought to the top of the table in the centre and different forms of handles for the different valves are used to indicate these three commodities. The hood system is very elaborate as can be seen from the background of Fig. ~~107~~ 108.

Apparatus of special note is the automatic sulphuric acid pipette shown at the left on the top of the table, the vacuum oven at the right and at the centre, in the rear, a small hand mill, sold by Altmann in Berlin has given great satisfaction.

A detail of one of the hoods in another room is shown in Fig. ~~108~~ 109, white tiling being used for the shelf and for the back of the hood. The gas cocks are brought up through the bottom of the shelf but the water for suction pump is brought up through the back wall, again involving considerable destruction of tiling in case repairs are necessary. All the cocks, as in Rubner's laboratory, are brought to the front of the table.

Fig. 108. General view of a laboratory table in the Zootechny Institute, Berlin, Prof. Lehmann.

The top of the tables consist of Xylolith. An automatic sulphuric acid pipette is shown at the left, a vacuum drying oven at the right, and a small hand mill in the centre. Cocks with different forms of handles supply gas, water, and compressed air. The hoods in the rear are very large.

No. 109. Details of a hood in Prof. Lehmann's laboratory.

The gas and water cocks are all brought to the front end of the table beneath.

Minor apparatus.--Much of the glassware, especially flasks, is packed on shelves having slats of different widths instead of a solid base, thus the flask can be inverted and allowed to drain after being washed.

The Kjeldahl distillations are carried out by placing a flat bottomed flask in an iron saucer a little larger in diameter than the bottom of the flask. The distillations are made hot but I had an interesting discussion with Dr. Völtz regarding it. Sodium thiosulphate is used to precipitate mercury. In the distillation, Dr. Völtz maintained that the evolution of ammonia would be much less if the caustic soda were poured into the flask and then the soda and acid allowed to mix by heat rather than by vigorous shaking, thus the sudden evolution of ammonia would not take place. When I pointed out to him that we found frequently in the acid receiving flasks that a layer of ammonia collected on the top of the acid, thus necessitating shaking, he raised the point as to whether our method of mixing the acid and alkali in the distilling flask did not cause such a tremendous rush of ammonia as to possibly cause an imperfect neutralization. This point should be carefully studied. Dr. Völtz intended to do some work on it himself.

Kjeldahl digestion apparatus.--Dr. Lehmann has constructed a very elaborate Kjeldahl digestion apparatus connected with a powerful hood draft. The apparatus is shown in Fig. ~~109.~~ 110 Three tiers of burners are employed and the best results have thus far been obtained with this apparatus. Small sized Kjeldahl flasks are used, since they are always transferred before being distilled.

Automatic acid pipette.--In the hood shown at the left in Fig. ~~109~~ 110 are two automatic acid pipettes used for concentrated sulphuric acid for Kjeldahl digestion. ~~Small~~ Such pipettes, ~~evidently~~ arranged for concentrated

Fig. 110. Kjeldahl digestion apparatus, Prof. Lehmann's laboratory.

Automatic sulphuric acid pipettes in the hood at the left.

acid and of a more precise graduation for standard acids, have been ordered for the Nutrition Laboratory.

Method for catheterizing dogs.--To avoid infection and to thoroughly wash out the bladder, the apparatus shown in Fig. ~~110~~ 111 is used for catheterizing dogs. Water is boiled in a flask supported on a tripod and maintained at 37° C., a thermometer being inserted in the flask. A T-tube is connected on the one hand with a rubber catheter and on the other with a bottle for collecting urine, both of which are lying on the table at the left. The catheter is immersed in a bottle containing potassium permanganate solution and thereby thoroughly disinfected. By use of the speculum, the ureter opening is readily found and the catheter inserted. After the urine has been drawn off into the bottle by manipulating the pinchcocks, warm distilled water can be passed into the bladder and the bladder washed out thoroughly. This has proved a most satisfactory method of catheterization.

Treadmill.--The treadmill seen in Buda Pesth, constructed by Tangl's mechanician, was made after the plan of Prof. Lehmann's in which a glass or aluminum plate is used for the under surface of the moving apron or cloth upon which the animal walks or runs. It is almost noiseless and Lehmann's apparatus has an aluminum sheet. The whole apparatus can be rotated by an electric motor at any given rate of speed.

Calorimeter for small animals.--Prof. Lehmann has devised a very ingenious calorimeter for small animals in which he proposes to use the emission type of calorimeter and maintain the heat evolution inside the chamber at a constant quantity. Thus, if the animal gives off less heat, an electric circuit will be automatically thrown in and heat produced electrically inside the chamber so that the sum total

Fig. 111. Apparatus for catheterizing dogs, Prof. Lehmann's laboratory.

Flask with distilled water on a tripod at the right. A T-tube connecting catheter and urine bottle on table at the left and bottle with potassium permanganate solution and a speculum. Note the distribution of gas on cocks suspended from the ceiling over the centre table.

of the heat from the animal plus that of the electric current will always remain a constant value. The apparatus is in an experimental stage and Prof. Lehmann has devised a most ingenious voltameter. It is constructed of two silver cylinders, suspended on the arm of a balance. The electric current passes in one direction until enough silver is deposited to swing the pendulum to close the circuit. As that circuit is closed, a numerical counter is actuated and the current reversed through the system. The silver is taken away from one cylinder and deposited on the other until again the equilibrium is upset. By counting the number of times the arm of the balance is changed, the total amount of electricity may be found. This apparatus is not yet in running order, only parts of it having been constructed, but the idea is practically that outlined above. It is a typical sample of Lehmann's wonderful ingenuity.

Discussion with Prof. Lehmann.--Prof. Lehmann is very enthusiastic over the possibilities of hypnotism as an agent of studying metabolism, especially of heat production and respiratory exchange. He believes that different races have markedly different metabolism, that even in the same race, women and men have different metabolism, that the muscle cell is actually different in women from that in man, citing the fact well known to all surgeons that women are less sensitive to surgical operations than are men. He would like to see a long series of experiments made on fat and thin men and women and on nervous and neurasthenic people. He believes that a Texas calf would have a very different metabolism from that of a calf from Scotland.

Use of treadmill in metabolism experiments.with dogs.--A most valuable point was obtained in this laboratory, bearing upon the well being of dogs during metabolism experiments. Lehmann finds that the confinement of the cage makes them very irregular as regards defecation and the separation of the feces of different experiments is very difficult. He finds that dogs are in much better health if given a definite amount of exercise each day. Consequently, each morning after catheterization, each dog is put upon a treadmill and made to run three kilometers. A peculiarly advantageous result from this practice is the fact that the dogs defecate regularly, in fact, so regularly, that in three or four minutes after beginning to run upon the treadmill, if the machine if stopped and a pan placed under the dogs, separations can be made almost to the hour or minute. He has found that this has been almost invariably the case with dogs that he has experimented upon.

The idea is a new one to me and is certainly of very great value.

Researches on the composition of the flesh with different foods.-- Dr. Mueller under the direction of Prof. Lehmann has been making a rather elaborate study of the variations in the composition of flesh following variations in food. The results have been published in Pflüger's Archiv, vol. 116, pages 207--228. Prof. Lehmann is much impressed with this line of investigation and proposes to carry it out with other assistants.

Agricultural High School---Institute of Animal Physiology.

Profs. Zuntz and Loewy, and Drs. Oppenheim and Caspari.

The laboratory in which Zuntz and his associates have been working for many years is very dingy, poorly lighted and ventilated and not at all suited to the needs of researches such as they are undertaking. In common with many agricultural institutions in Europe, they are now able to enter a new building especially constructed for their purpose. This building was partially completed at the time of my visit.

The special features in this building were a very fine suite of rooms for operating, an especially good arrangement for the maintenance and care of animals, including the preparation of their food, and a very large room for the respiration chamber for use with large animals, such as oxen and horses,

Respiration chamber on the Regnault-Reiset principle.---In competition for the Seegen prize for the best demonstration of the presence or absence of the gaseous excretion of nitrogen resulting from proteid disintegration, Dr. Oppenheim under the direction of Prof. Zuntz has developed a Regnault-Reiset apparatus which can be used for either small animals or infants. This apparatus has been described in the Biochemisches Zeitschraft and consists of an iron box with plate glass windows in the sides which can be immersed in water. The ventilating system consists of a pump with Voit valves filled with 60 per cent sodium hydroxide. The whole apparatus, including the pump, is supposed to be immersed in water. I noticed, however, that the upper portion of the pump was not completely submerged. Although the apparatus was placed in a basement room, poorly lighted, I was able

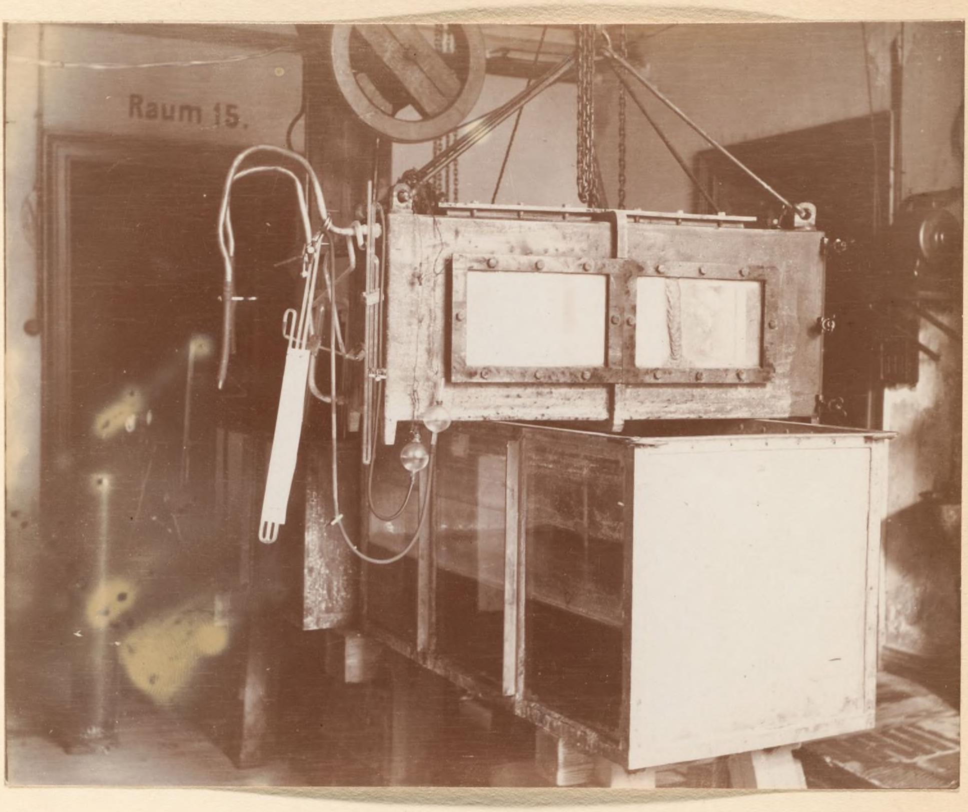


Fig. 112. Zuntz-Oppenheim respiration apparatus on the principle of Reiset-Regnault for determining the respiratory quotient with dogs and infants.

This apparatus was used for studying the possible gaseous excretion of nitrogen. The large chamber is immersed in the tank filled with water and the pump at the further end maintains the ventilating air current. Oxygen is admitted from the bomb at the left.

to secure a photograph which is shown here as Fig. ~~111~~ 112. The respiration chamber itself is here shown out of the bath, which is immediately beneath it. On one end of the respiration chamber are the pipes connecting with the pump system, a manometer, and a thermo-barometer. After the animal is put into the apparatus, it is lowered into the water bath and the ventilation pump system started. Oxygen is added from a bomb or from a receptacle which can be filled with water and the oxygen thus be expelled.

At the time of my visit, Dr. Oppenheim was using the apparatus for studying the gaseous exchange in atmospheres containing a large amount of hydrogen. The most extensive research ever carried out with this apparatus was that attempting to show the ~~known~~ elimination of gaseous nitrogen resulting from proteid decomposition and published in the journal above referred to. It is interesting to note that this research competed with the investigations of Krogh of Copenhagen for this prize and that the Copenhagen research was deemed the better.

The whole apparatus appeared to me to be extremely crude and assembled in a very unworkmanlike way. I am utterly astounded that results as accurate as those claimed by Oppenheim and Zuntz could be obtained with this apparatus.

Inside of the chamber is a confined portion of air which communicates with the thermo-barometer outside. This confined portion of air has a few drops of water in it so as to have it saturated with water at all times. It is assumed that if this portion of gas inside of the chamber fluctuates in temperature and pressure, the whole air in the chamber fluctuates in a similar manner.

In the experiments on hydrogen atmospheres, the dog was placed in the chamber, the chamber was then evacuated to 26 mm. pressure and oxygen allowed to flow in until the pressure had returned to 18 mm. Hydrogen from a steel cylinder was then admitted until the pressure was slightly positive, then the valves were opened until the pressure had reached atmospheric. This resulted in securing an atmosphere of about 16 per cent hydrogen.

After the chamber is submerged in water, the water is stirred during the whole experiment with a blast of air. The description of the apparatus is given with considerable detail in the article referred to above and some rough sketches are included in my notebook.

Samples of air were taken with a Tourniquet apparatus, which consists of a series of pipettes attached to a circular support. These pipettes were filled with acidified water and samples withdrawn from the atmosphere inside of the chamber. The gas samples are subsequently transferred over mercury and there retained until analyzed.

My impression of the whole apparatus was very unfavorable. Certainly, the technique could be improved upon in my judgment very markedly and I have very little confidence in the results that have thus far been obtained with it. It is true, however, that the discrepancies in the nitrogen content in the chamber at the beginning and end of the experiments are no larger proportionally than those found with the very exact apparatus used by Krogh, corresponding almost wholly with the differences in the body weight of the animals that were experimented on, since Krogh used rats and mice and Zuntz and Oppenheimer dogs.

While the original drawing of this apparatus shows the whole pump system immersed in water, as a matter of fact, the water does not cover what I consider to be one of the most important parts of this pump system, that is, where the piston rod passes through the packing. Mercury is then poured into the groove about this rod and it is assumed that the mercury seal is perfect. As a matter of fact, while watching the apparatus for two or three days, I saw that the mercury was frequently carried out of this groove in large measure.

Apparatus for studying the moisture and heat given off by animals.--A small apparatus on the Pettenkofer-Voit open circuit principle is installed in the Zuntz laboratory but apparently has not been in use for many years. A photograph was taken of it and is shown herewith as Fig. ~~112~~113. A gas meter on the floor at the right is used to measure the total ventilation and a hair hygrometer is in the air circuit both before and after the air passes through the respiration chamber, which is surrounded with felt. I could find little of the details of this apparatus and apparently its use was not successful.

Large respiration chamber for animals.--Prof. Zuntz was much interested in the development of accessory apparatus for use in connection with his large respiration chamber for animals to be installed in his new laboratory. This chamber will have a cubical contents of 100 cubic meters. Prof. Zuntz says that he decided upon this size since he saw in Stockholm how accurately Tigerstedt determined carbon dioxide with the Sondén-Tigerstedt chamber. The Zuntz chamber was not constructed at the time of my visit to Berlin but many ingenious plans were under way for the development of this apparatus, some of which had assumed a concrete form.

Proposed calorimetric features of the large respiration chamber.--Zuntz hopes ultimately to be able to measure the heat production of his animals by using an air current to cool the chamber. He proposes to have a closed circuit apparatus in which the air will leave the

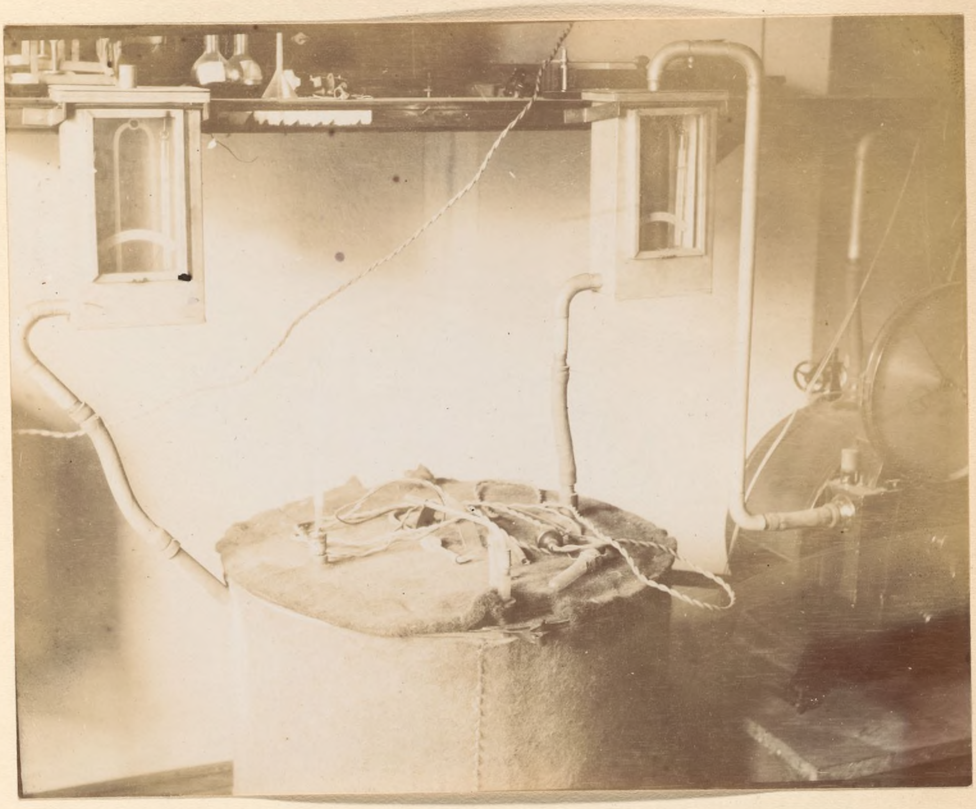


Fig. 113. Respiration chamber for studying the carbon dioxide output of an animal in Zuntz'z laboratory.

The hygrometers show the moisture content in the air before and after leaving the chamber. The chamber is surrounded with felt and is apparently so used for an attempt at calorimetric measurements.

chamber at 17° by artificial cooling so that it will re-enter the chamber at 15°. He plans to have the animal warm this air from 15° to 17° and thus use this heat as a measure of the heat production. As the air comes out of the chamber, it is proposed to pass it through an absorbing vessel of peculiar construction which will contain sodium hydroxide. This sodium hydroxide will be pumped by the circulating pump continually over a coil of refrigerating pipes and will be so strong as to absorb not only carbon dioxide but water, so the air leaving this absorbing vessel will be freed from carbonic acid and of a constant water content. By ammonia refrigeration, the sodium hydroxide solution can be cooled to 2° C. The paralleling of the ammonia brine pipes, the air pipe, and the circulation for the sodium hydroxide present several interesting engineering problems but Prof. Zuntz believes these are solved. As a matter of fact, I believe that the apparatus is already under construction.

At the beginning of the experiment, a definite amount of sodium hydroxide will be placed in the apparatus and put in circulation by means of the pump. At any period of the experiment, a sodium hydroxide sample can be drawn off and the carbonic acid content determined. Prof. Zuntz hopes in this way to determine not only the carbon dioxide products but also the water production. He proposes to use inside of the chamber a large liquid thermometer containing, perhaps, kerosene for getting the average temperature of the thermometer. I think that probably the resistance thermometer will appeal to him more after my giving him our experience.

<u>Combustion furnace for marsh gas</u>.--In connection with the large apparatus projected above, it is necessary to determine the very considerable amounts of marsh gas given off by ruminants and Prof.

Fig. 114. Quartz glass electrical combustion tube for determination of marsh gas.

An inner quartz glass tube is wound with a platinum spiral and telescoped with another quartz glass tube. The gas passes through the glass tube and over the platinum spiral which is heated to incandescence electrically.

Zuntz had had Heraeus of Hanau make an electrical combustion furnace for this purpose. This furnace is shown in Fig. ~~113~~ 114.

A quartz tube is so adjusted that gas passing through it comes in contact with a fine platinum spiral which is heated to incandescence electrically. There is an inner quartz tube, thus insuring that the gas passes in close contact with the platinum in the annular space. As a matter of fact, the furnace shown in Fig. 113 was wrong since Heraeus had there made entirely different electrical connections but Prof. Zuntz has had it modified since to suit his original specifications. It had not been tested when I left the laboratory.

Great differences in the value of quartz tubing are to be found in the German transparent quartz glass and that made by another process which gives a translucent, more or less fibrous, glass. In Paris I found a whole batch of tubes that were utterly useless because they had fine holes through them and could not be used for combustion tubes. In the particular apparatus used by Dr. Zuntz, no test had been made regarding its porosity. Clear quartz glass, however, is perfectly dense and has no holes through it.

Gas analysis apparatus for use with large respiration chamber.-- Working on an entirely new principle for determining carbonic acid, Zuntz is devising a method for studying the carbon dioxide in the sodium hydroxide solution to be used in connection with the large respiration chamber. This consists in taking a known weight or volume of solution, liberating all the carbon dioxide and passing this carbon dioxide into a vacuum chamber of known size. The tension of the gas in this vacuum chamber is then measured by the mercury manometer and from this tension, the quantity of carbonic acid determined. The apparatus is quite complicated and is shown in its general construction in Fig. 114. It consists of a large mercury

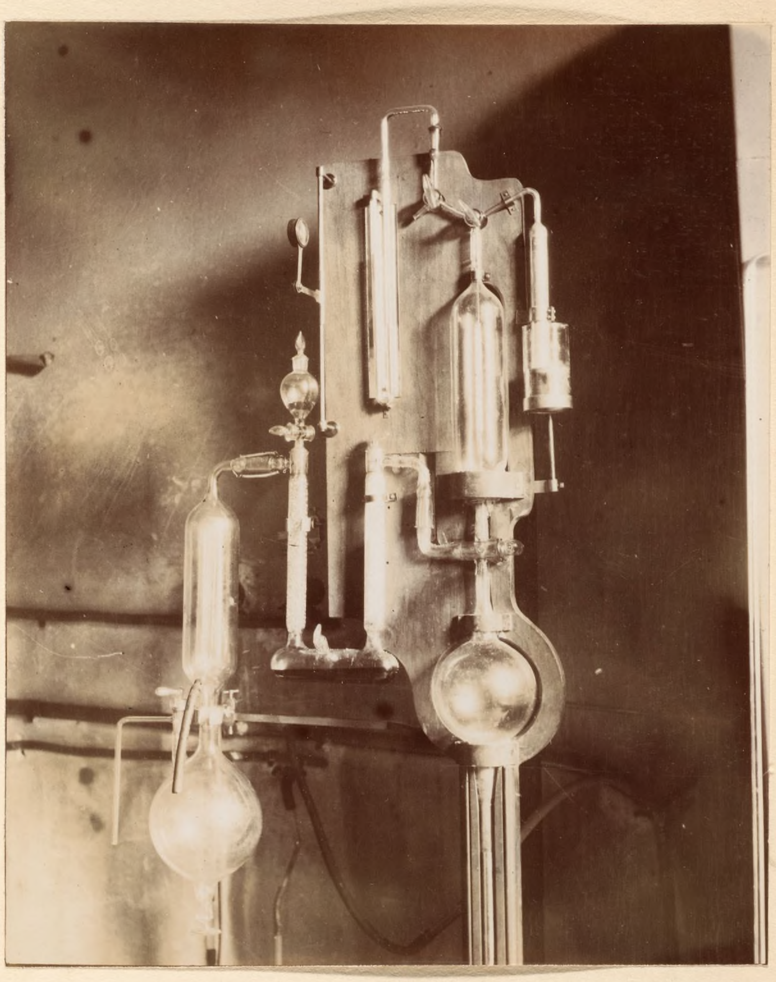


Fig. 115. General view of gas analysis apparatus of Zuntz and Oppenheim.

A mercury pump with vacuum chamber above, into which carbon dioxide liberated from a sample of sodium hydroxide solution is driven. The tension of the gas is measured by a mercury manometer and the amount of gas computed.

Fig. 116. Details of water cooler, sulphuric acid and phosphorus pentoxide drier for the carbon dioxide to be passed into the vacuum chamber of the Zuntz gas analysis apparatus.

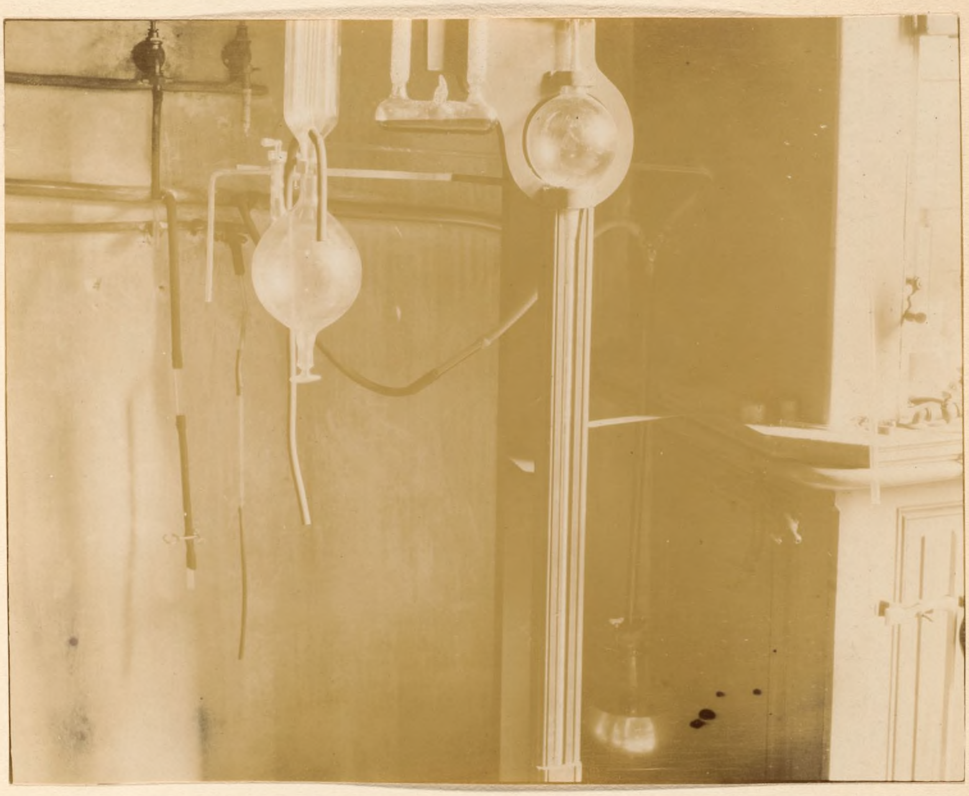


Fig. 117. Mercury reservoirs and water connections, gas analysis apparatus, Zuntz's laboratory.

pump with a vacuum chamber above it in which is sealed a thermometer. At the top of this vacuum chamber, connections are made with the gas burette whose end dips into mercury or with the manometer at the left. The carbon dioxide is liberated by allowing sulphuric acid to flow upon the solution in the large bulb at the left of the apparatus. The carbon dioxide, plus a certain amount of water vapor, is then pumped into the bulb in the vacuum reservoir at the top of the apparatus. A water cooler is attached between the gas liberating bulb and the sulphuric acid drier and hence a considerable portion of the water here condensed. The remaining water is absorbed by the sulphuric acid and the phosphorus pentoxide and the gas enters the vacuum chamber absolutely dry. The tension in the chamber is measured by the mercury manometer at the left. The details of the cooling system and the sulphuric acid and phosphorus pentoxide drying attachment are shown in Fig. ~~115.~~ 116 A somewhat closer view of the bottom of the apparatus, including the receptacle for the liberation of carbon dioxide is given in Fig. ~~116.~~ 117 The mercury is raised and lowered in this apparatus by means of the principle of Bohr and in the background is seen the other mercury reservoir which is attached to the water pipes.

While I was in Berlin, Dr.,Oppenheimer was working on this apparatus but it had not been perfected to his satisfaction. The large vacuum chamber above contains 600 cc. and if there were 120 cc. carbon dioxide liberated from the sodium hydroxide, there would obviously be an equivalent of one-fifth of the atmospheric pressure. Since it would be easy to measure the ~~temperature~~ pressure to one-tenth of a millimeter, it is hoped to secure ~~a~~ an accuracy of one part to ~~1/~~1500. While the principle is extremely interesting and so far as I know, original, the details have yet to be satisfactorily worked out and the perfected apparatus will be looked forward to with considerable interest.

Oppenheimer and Zuntz also agree with Bohr that the presence of water on top of the mercury in the lower mercury vessel does not result in any transfer of water into the mercury in the large bulb which is to be evacuated. Thus, if the bulb were evacuated and the water vapor was present, there would always be a tension due to the aqueous vapor. This they do not find.

Zuntz respiration apparatus for man and animals.--Zuntz and his associates have developed what is perhaps the most widely used method for studying the respiratory exchange that is at present in existence. This apparatus consists in breathing through a mouthpiece to which are attached two valves, thus enabling the expired air to be separated from the inspired air. The expired air is passed through an accurate gas meter and a sample of the expired air taken regularly as the gas passes through the meter. The principle of the sampling device has already been discussed in connection with the apparatus of Jaquet in Basel. With animals, while a muzzle has been used in place of the mouthpiece, it is more satisfactory to use a tracheal fistula.

In discussing the difficulties attending the use of the mouthpiece with Zuntz, he told me his method of training his subjects to use the mouthpiece.

First, they are told to breathe through the mouth as much as possible.

Second, the mouthpiece is inserted and they are told to breathe through either the nose or the mouth as they see fit until they become accustomed to the mouthpiece.

Third, they are told to breathe through the mouth.

Fourth, the nosepiece~~s~~ ~~are~~ is attached.

Zuntz claims that it is very easy to learn to use the apparatus in this way and he is surprised at the criticisms of others. Naturally, Prof. Zuntz himself and his associates are experienced in the use of this apparatus. He also tells me that many medical students and laboratory "dieners" have acquired the mouth breathing with no difficulty.

There are a number of criticisms to be raised regarding this method and the criticisms may be based upon several grounds.

First, the abnormal breathing through the mouth.

Second, the resistance required to overcome the motion of the meter.

Third, the nature of the valve system.

Fourth, the method of taking the sample.

Fifth, the method of analysis.

Unquestionably, there is a noticeable resistance required to force the gas through the meter. Thus, I was informed that while the ordinary volume of respiration in one minute was 4 liters without the gas meter, this was increased to 5 liters when the gas meter was put into the circuit. It is a matter of fact, however, that the increase soon attains constancy, i. e., after five or six minutes, and the ~~resistance~~ expiration is thereafter 5 to 6 liters per minute.

Every care is taken to suspend the mouthpiece and valves and tubing so as to produce the least resistance or annoyance to the subject. The apparatus is almost invariably used by the subject lying on a sofa and a side view of a subject breathing through this apparatus is given in Fig. ~~117~~ 118. The subject rests quietly upon the sofa, the valves lie upon the breast and the mouthpiece is held in a convenient position. Under these conditions, I noticed distinctly

Fig. 118. Man breathing through Zuntz's mouthpiece and valves connected with Zuntz's respiration apparatus.

however, that the cheek walls were distended at each expiration, thus indicating a positive pressure was necessary to force the expired air out of the mouth. This I consider a distinct criticism against the use of this mouthpiece. A front view of the subject using the mouthpiece is given in Fig. ~~118~~ 119.

The whole apparatus has been described in detail by Magnus-Levy and several years ago, Prof. Atwater commissioned Dr. Loewy, who was an associate of Prof. Zuntz, to write a complete description of the apparatus and its use to accompany an apparatus ordered for the Department of Agriculture for use in Middletown. A copy of this has been made and is preserved in the Nutrition Laboratory.

The taking of the sample by lowering the pipette containing acidified water is adjusted most perfectly by a system of pulleys and cords devised by Prof. Loewy. Probably very little, if any, resistance is required to lower this pipette.

It is the common experience when using the mouthpiece to find that at the first few moments there is a large production of carbon dioxide which corresponds to the pumping out of carbon dioxide in the system, while at the end, there is apparently a storage of carbon dioxide to compensate for this. Constancy is attained, however, in the output after two or three minutes' breathing. The drum of the motor has a content of 10 liters and each revolution of the dial corresponds to 10 liters. The mouthpieces are very long and the projection to be inserted between the teeth is used by some and not by others.

Conduct of a respiration experiment with man.--After the subject reclines on the sofa and begins breathing through the valve pieces, the meter is read every minute. This should be read exactly and the

Feb. 119. Front view of subject breathing through respiration apparatus.

In the rear a treadmill for animals is shown.

assistant may make use of a watch coomonly seen in Germany whereby the minutes are shown in figures on the dial. As each minute passes, there is a slight ~~difficulty~~ click owing to the motion of the wheel. Thus he can hear the watch and know when each minute is up. When the respiration volume per minute remains constant, the experiment can be begun.

First, the cock is opened to the sample pipette.

Second, the thermo-barometer is read.

Third, after being sure that the respiration volume is constant, open the cock on the rubber tube connecting with the "ausfluss" pipette and clamp this to the string over the pulleys. Be sure that this pipette is the same level as the water in the sample pipette in the bath.

Fourth, read the gas meter every two minutes.

Fifth, read the thermo-barometer at the beginning, the middle, and the end of the experiment. If any notable changes appear, it should be read oftener.

The gas is collected over water containing a little hydrochloric acid and rosolic acid as an indicator. This is used in the whole apparatus. There is enough hydrochloric acid added to give a distinct yellow color to the rosolic acid. After the sample collecting burette is full or nearly so, the meter is read exactly and then the "ausfluss" pipette stopped.

It is found best always to have two assistants at the same time beside the subject experimented upon.

Analysis of gas.--The regular Zuntz method for the analysis of respiratory gases is here used, oxygen being absorbed by phosphorus, carbon dioxide by potash, 35 per cent. More recently, Zuntz has been engaged in investigating the possibilities of absorbing oxygen, especially with atmospheres rich in oxygen, by an ammoniacal copper solution and then by hydrogen explosion. Oppenheim says that in exploding with hydrogen, it is necessary to have six times as much hydrogen as oxygen present as otherwise there will be oxides of nitrogen formed. In determining hydrogen in his artificial atmospheres in the small respiration apparatus, Oppenheim~~er~~ found that the determination of hydrogen by explosion was always affected by the fact that he must have an excess of oxygen and under these conditions some nitrogen is burned with the oxygen but if there is an excess of hydrogen, there is no trouble.

Zuntz respiration apparatus for animals.--While a mouthpiece or mask is usually out of the question when experimenting with dogs, Zuntz has been most fortunate in making a large number of tracheal fistulas with both dogs and horses. A dog which has been in the laboratory for a number of years and fully accustomed to experiments of this nature is shown connected with the apparatus in Figs. ~~119~~ 120 and ~~120~~ 121. The connection with the valve pieces is made by inserting a rubber tube containing an inflatable rubber gasket. This makes an absolutely tight joint with the silver tube in the trachea. At the first moment of inserting this tube, there is irritation but almost immediately, the dog lies quietly and he has been trained to lie in the characteristic position shown in the two figures for the length of time necessary to conduct an experiment. A very singular fact is that many of these dogs have had these tracheal fistulas and lived in the laboratory as long as six years and remarkably enough, two of these dogs died with carcinoma of the intestine. A number of fistulas have also been made on horses and after the experiments are over, the fistulas have healed in 14 days and the animals have

Fig. 120. Dog with tracheal fistula connected with valve pieces for Zuntz respiration apparatus.

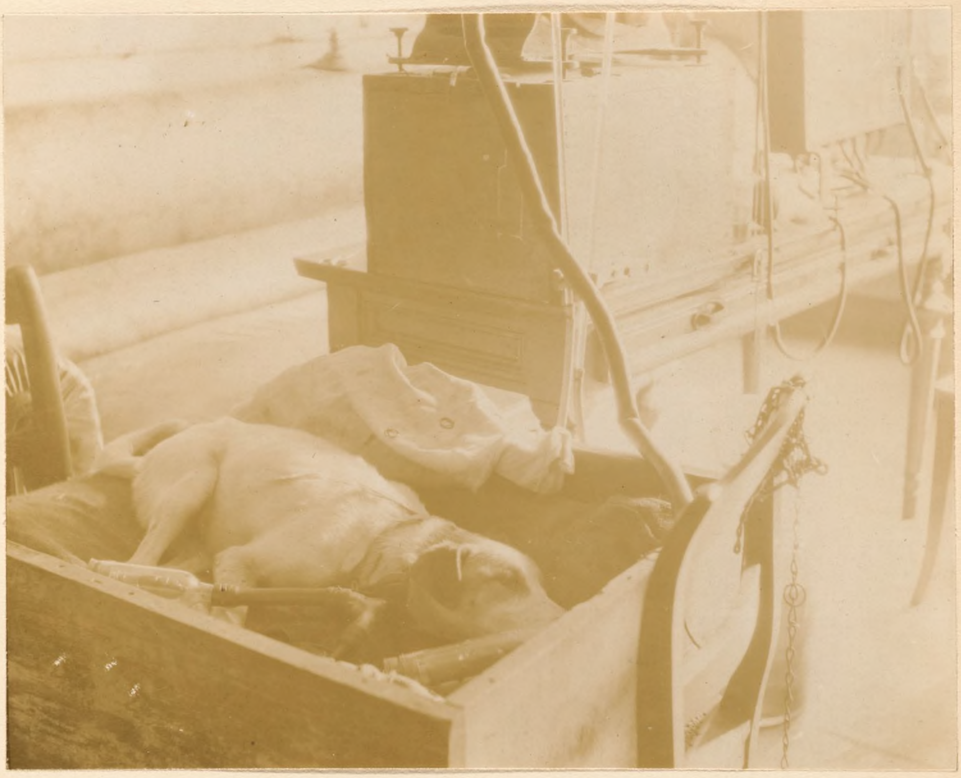


Fig. 121. Dog with tracheal fistula connected with Zuntz respiration apparatus.

The gas meter is immediately in the rear and at the further end of the table is the glass tank containing the sample pipettes and the gas analysis burettes.

been sold again, thus showing that the operation is not a serious one and does not incapacitate the animal from future usefulness.

Nose breathing vs. mouth breathing.--Zuntz and Loewy pointed out that nose breathing would be impossible for hard muscular work as the ventilation through the nose would not be sufficient. This is an obvious disadvantage in nose breathing for experiments in which muscular work is studied.