5th to 27th. A decided change to colder came with the rainstorm of the 27th, and the last three days of the month were unusually cold, with frost generally in Kentucky and parts of Tennessee. Special warnings were issued for the frost.—*F. J. Walz, District Forecaster.*

CHICAGO FORECAST DISTRICT.*

[Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, and Montana.]

Except during the last few days of the month September was unusually warm. The change to cooler weather set in over the Western States on the 25th and advanced slowly eastward, bringing unseasonably cold weather and general frosts for which warnings were issued well in advance. Frost warnings were again issued on the 30th in advance of another cool area. Special frost warnings were issued to the cranberry marshes of Wisconsin on the 1st, 2d, and 6th, and in each case frost and freezing temperatures were reported in the bogs. The drought conditions continued from the previous summer months, and they were not effectually broken until the passage of the storm of the last week. The only disturbance that justified storm warnings crost the upper Lakes on the 30th, and warnings were issued for this storm on the morning of that day.

The following action was taken by the South Dakota State Board of Agriculture in connection with a special forecast telegraphed from Chicago to the Local Office of the Weather Bureau at Huron, S. Dak., on September 8:

By resolution of the State Board of Agriculture, it is my duty and pleasure to express to you, and through you to the U. S. Weather Bureau, our sin ere thanks for the long forecast given us for the week of our Fair. It was of great value for us to know this as it saved much expense in preparing for rain as we felt we should. Besides this it was a great relief of mind to the management to know that we could expect such fine weather. J. W. CAMPBELL, *President*,

H. J. Cox, Professor and District Forecaster.

DENVER FORECAST DISTRICT.*

[Wyoming, Colorado, Utah, New Mexico, and Arizona.]

Except during the closing week the month was warm and dry. From the 23d to 26th a heavy storm of snow and rain moved from Wyoming to southern New Mexico. The storm was followed by one of the most severe cold spells on record during September in eastern portions of Wyoming, Colorado, and New Mexico. Timely warnings of frost and freezing temperature were issued in connection with the cold spell.—*P. McDonough, Local Forecaster, temporarily in charge.*

SAN FRANCISCO FORECAST DISTRICT.†

[California and Nevada.]

The most striking feature of the month was the storm that prevailed over southern California on the 23d to 25th. Generally speaking the rainfall was the heaviest during September since records have been kept. It varied in amount from half an inch to several inches. The raisin-making section had ample warnings of the rains and the benefit of the service has been acknowledged. No frost nor storm warnings were issued during the month.—*A. G. McAdie, Professor and District Forecaster.*

PORTLAND, OREG., FORECAST DISTRICT.†

[Oregon, Washington, and Idaho.]

The month was unusually dry in western and northern sections, and temperature was slightly above normal east of the Cascade Mountains. A moderate disturbance crost the northern portion of the district the last day of the month. Light frosts occurred on the 23d and 24th and heavy frosts on the 25th and 26th. Warnings of the storm and frosts were issued in time to be of service to those interested in them.—*E. A. Beals, District Forecaster.*

RIVERS AND FLOODS.

The feature of the month was the general drought that prevailed over the middle and northern districts east of the Rocky Mountains. Little or no rain fell over this extensive area until the end of the month, and all streams, except the Mississippi and Missouri, were at very low stages. The two larger rivers were not lower than usual for the season of the year.

The drought conditions were most severe in the Ohio Valley and the Middle Atlantic States, and in many places rivers were lower than ever before. Navigation was practically suspended on the Ohio, and many manufacturing plants in the upper Ohio Valley were compelled to suspend operations on account of lack of water.

Delayed reports of the flood of August and early September in the rivers of eastern South Carolina show that the damage caused thereby amounted to over $900,000, divided as follows: Property loss, excluding crops, $200,000; losses of crops, $700,000. The losses due to erosion of land and suspension of business were reported great, but detailed reports were not available.

The highest and lowest water, mean stage, and monthly range at 211 river stations are given in Table IV. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

* Morning forecasts made at district center; night forecasts made at Washington, D. C.

† Morning and night forecasts made at district center.

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

RÉSUMÉ OF EXPERIMENTS IN AERODYNAMICS

By Dr. A. F. ZAHM. Dated Washington, D. C., August 24, 1908.

INTRODUCTION.

Aerodynamics may be defined broadly as the science of motion of air, or an aeriform fluid. Commonly air alone is implied in the word. This is especially true when the name is used by engineers. With them it is the analog of hydraulics, which is the science of motion of water. Both sciences treat not only of the movement of their peculiar media, but also of its effects on objects, or machinery, connected with the fluids.

An important function of aerodynamics is to determine the velocity and stress of air at every point of this medium, when it flows past an obstacle, the physical conditions of the fluid being given or observed by means of suitable instruments. From the point-velocity the stream-lines may be mapped; from the point-stress about an object the resultant pressure and friction may be found by integrating over its surface.

Equivalent results may be obtained if the object move against the fluid, since only the relative motion is of consequence. Devices are in use, also, for revealing these integrated effects directly, without first finding the point-velocity and point-stress. Some of these will be described presently.

Experimental aerodynamics may be studied in its elements, as distinguished from its applications, by considering it under these heads: (1) velocity and stream-lines; (2) normal stress and resultant pressure; (3) shearing stress and resultant friction; (4) combined pressure and friction. To trace the development of even this much of the science would require a large volume.

The following pages present a brief sketch of such of the writer's experiments as may be classed under the above heads, no reference being made to analytical studies, or to any applications in aeronautics, or engineering. A fuller account of the studies here outlined may be found in the following papers by the present writer:

"Measurement of air velocity and pressure," Physical Review, December, 1903.

"Atmospheric friction with special reference to aeronautics," Bulletin of the Philosophical Society of Washington, Vol. XIV.

"Law of resistance of rods and wires," in "Navigating the air," Doubleday, Page & Co., 1907.

"Resistance of the air determined at speeds below one thousand feet a second," printed privately as a doctor's thesis.

GENERAL METHODS.

Two general methods may be used to secure relative motion of the air and model. In one case the object is placed in a wind, either natural or artificial; in the other case it moves against still air, either by riding on a car or whirling arm, or by falling, or by propulsion from a gun. In both cases a uniform relative wind is usually desired. This can not be obtained regularly out of doors, except for very high speeds, because the atmosphere is usually in irregular motion. Hence indoor experiments are more reliable and, moreover, the flow of air can be more definitely specified.

To secure a uniform wind of constant velocity, a wind tunnel is employed. This may be a wooden tunnel, a yard or two in diameter, having a suction fan at one end to generate a current, having a screen or "honey-comb," at the other, to straighten the inflowing air. A fine mesh screen or two may eliminate eddies from the air-stream and deliver it to the tunnel in fairly uniform current, but with diminished speed. A honey-comb made of sheet metal, is preferable, for this straightens the flow without diminishing the speed materially. If the tunnel be horizontal, it should be placed well above the floor and away from the wall, to symmetrize the wind-flow. With such a tunnel, as the writer has found, it is possible to maintain a uniform velocity, constant to 1 per cent, by use of an electric fan controlled by a boy with a tachometer and resistance coil.

The reverse of a wind tunnel is a long room thru which the model moves on a car at constant speed, the room being closed and the car being so designed as not to disturb the air preceptibly, near the model. No such plant has ever been used on a large scale, but it is a great desideratum for exact measurements of air resistance, especially on objects intended for standards of comparison, and for the determination of physical constants. In such a room it would require a short period for the car, starting from rest, to attain full speed, during which period the entire volume of air in front of the car would be slightly compressed and reach its steady state, after which the circumstances of motion would remain constant and definable. One might use for this purpose a long railroad tunnel provided with light doors to close its ends and keep the air still during the short period of experimentation. A closed circular tunnel also might be used, the model being carried either on a car, or on a whirling table arm. But here arise the objections of drift-wind and centrifugal force, unless the tunnel be very long.

Assuming, then, that a plant is available, furnishing a uniform constant relative velocity of air and object, we may proceed to more detailed studies.

DETERMINATION OF VELOCITY AND STREAM-LINE.

Having a uniform artificial wind, the next requsite is an instrument for measuring its velocity at all points, not only in the unchecked stream, but also near the model. The first measurement is easy, the latter much less so. The speed in the unchecked stream may be found by any ordinary good anemometer; but near the model it can be found only by special devices presently to be described.

To measure the wind-speed in a uniform current, the writer has devised a pressure-tube anemometer whose observed indications seem to conform to those computed for it from theory. It is an adaptation of the Pitot tube, and consists essentially of a double pressure-nozzle combined with a delicate pressure-gage.

A "pressure-tube" held along stream transmits the impactual pressure of the air from the front nozzle or open end of the tube, and the static pressure from the side nozzle or slot in the side of a coaxial outer tube, to the cups of a differential pressure-gage. These cups, symmetrical in size and placement, are inverted over coal oil, and counterpoised from a meter-stick. A sliding weight, and a pointer measure the difference between the static and kinetic pressures of the two nozzles; and from this difference can be computed the speed of the air, if its density be known either by observation or by computation from its temperature, pressure, and humidity.

This instrument when placed in a uniform current measures the speed very accurately and is adapted to a wide range of velocities. In a sinuous current, however, it is unreliable, because such a current does not strike the impact nozzle squarely, nor flow undisturbed over the static nozzle. If the pressure-tube were mounted on a universal wind-vane, so as always to point along stream, it might be serviceable even for a varying wind. But such currents can not be specified, and hence are not used in precise measurements.

In designing a Pitot tube, either for air or water, it is of cardinal importance that the impact nozzle face the wind, while the static nozzle be so placed as to allow the air to glide over it with undisturbed stream-lines. When, as sometimes occurs, the static nozzle is a simple tube placed across stream, suction is produced. This can be prevented by terminating the tube with a thin flange-like disk, as done with good effect by the writer, and by Doctors Finzi and Soldati of Milan, Italy.

The velocity at any point of the air stream, to within an inch or two of the model, may be measured by use of the pressure-tube anemometer if its nozzle be made small; but for points immediately adjacent to the model, no very accurate and convenient instrument has been invented. A device that gives the speed approximately, even very close to the surface, is intermittent photography of fine particles floating in the air stream. A very elegant method invented by Professor Marey, makes use of narrow smoke streams to manifest the stream-lines and velocity thruout the medium. A hollow comb planted across the current, and vibrating ten times a second, emits from the ends of hollow teeth, wavy smoke streams of a quarter-inch diameter, which are photographed instantaneously. Evidently the length of a wave indicates the local speed, while the general course of each stream shows the direction of flow.

DETERMINATION OF NORMAL STRESS AND RESULTANT PRESSURE.

The normal pressure may have to be measured either in still or in moving air. In still air it is determined by the ordinary barometer; but in moving air this instrument may give false readings owing to suction, unless the barometer drift with the current, as when carried in a balloon. To obviate the error caused by suction when an ordinary barometer is placed in the wind, the instrument may be provided with a stream-line static nozzle.[1]

The resultant pressure on any body may be found by integrating the normal stress of the air all over the surface of the body. In this case the absolute normal pressure is not required, but merely the relative pressure at all parts of the body. For example, let it be required to determine the resultant wind pressure on a torpedo-shaped body pointing along stream. Holes are made at various points of a longitudinal element of

[1] See also, Abbe, Treatise on Meteorological Apparatus and Methods. Report Chief Signal Officer, 1887, pt. 2. p. 215–16, 253–7.

the surface. One nozzle of a pressure-tube anemometer is then permanently connected with one of the holes, while the other nozzle is connected successively to each of the other holes, the conditions of flow being constant. Having thus measured the differential pressure at all points, the total or resultant pressure may be found by summing over the surface. This summation is zero in the case of a perfect fluid, but for natural fluids the resultant is always an appreciable quantity.

It may be remarked in passing that the resultant pressure, as determined in the manner above, is not always the same thing as the resultant wind-force on the object, the latter being the sum of the resultant pressure and resultant friction, all taken in the line of the wind. Sometimes the total wind-force alone is required, but for the scientific designing of wind-shapes, it is important to study the point-pressure and point-friction at all parts of the body's surface. It may be noted that in the limiting cases for thin planes set edgewise to the current the wind-force is all friction, and when set crosswise it is all pressure; but in general the wind force may comprise both elements, pressure and friction, to such an extent as to make their separate study desirable.

DETERMINATION OF SHEARING STRESS AND RESULTANT FRICTION.

No exact method has been devised for measuring directly the shearing stress of moving air at any point of the fluid; but the total shearing resistance on bodies in relative motion with the air may be measured, and from the law of this total friction the point-shearing stress may be deduced. This has been done by various physicists, who have determined the viscosity or internal shearing stress of moving air, and also the sliding friction at the boundary surface of bodies. These determinations, however, were made for low velocities.

Until recently the frictional resistance of bodies having rapid motion relatively to the air, was supposed, even by prominent experimenters, to be inappreciable. Langley, who measured the drift of planes at low angles of flight and at speeds up to 66 feet per second, reported in his published experiments no friction whatever, and declared it a negligible quantity for bodies of all shapes. Maxim reached a like conclusion. The writer found, however, that for bodies of fair outline, the friction or skin-resistance, is approximately one-half of the entire resistance. Roughly speaking, he found it to be as great for air as for water, in proportion to their densities, the measurements being made at various speeds from 5 to 40 feet per second.

In order to determine the tangential resistance of the air flowing freely over smooth surfaces, various skin-friction planes were suspended in a uniform current of air in a wind tunnel, by means of fine steel wires fastened to the top of the laboratory. As the wind-force moved the plane endwise, the displacement was shown by the motion of a sharp pointer attached to one of the wires and traveling over a fine scale lying on top of the tunnel. Thus, the swing of the plane could be accurately determined and the force on the plane could be computed, being directly proportional to the displacement of the pointer along the scale.

The friction on a plane of given length was first determined for various wind-speeds. To do this a smooth pine board measuring 4 feet long by 25.5 inches wide by 1 inch thick and provided with sharp "prow" pieces fore and aft was employed, just as an ordinary skin-friction plane is used in the water. The total resistance was observed at all speeds from 5 to 40 feet per second. Then the board was removed, the "prows" placed together, their united resistance measured for the same speeds, and this subtracted from the preceding values. The difference gave the skin-friction on the 4-foot plane alone for all the above speeds.

Having found the friction at many speeds, on a given plane, the data were plotted on logarithmic section paper. The resulting diagram was a straight line. This proves that for a fixt plane and moving air the law of friction for the actual range of velocities, may be exprest by the equation $F=av^n$, in which F is the observed friction, v the wind speed, a and n numerical constants given by the position and slope of the line on the section paper. The general value found for n from many experiments with smooth planes of various length and quality of surface coating, was $n=1.85$. It may then be concluded that the law of friction for the given range and conditions of experiment is exprest by the formula

$$F=av^{1.85}$$

in which a remains still to be determined.

It was found that tho a is constant for a plane of given length, subjected to various speeds, its value diminishes slightly with the length of plane, as might be expected. To determine a, therefore, all the other conditions were kept constant while the plane was varied in length from 2 to 16 feet, by dowelling pieces together accurately. Comparing the resistances determined for these various lengths, it was found that the coefficient of friction, a, can be exprest as a function of the length, by an equation of the form $a=0.00000778\ l^{0.93}$, l being the length of surface. Hence, the entire skin-friction on a plane surface 1 foot wide and l feet long is given by the equation:

F in lbs. p. sq. foot of surface skin.

$$\begin{cases} F=0.00000778\ l^{0.93}\ v^{1.85}\ (v \text{ in ft. p. sec.}). \\ F=0.00000158\ l^{0.93}\ v^{1.85}\ (v \text{ in mi. p. h.}). \end{cases}$$

Of course this value of F must be doubled for a material plane of length l, and width 1 foot, since a material plane has two sides.

In order to facilitate the computation of skin-friction in practise, Table 1 has been derived from the formula giving the *average skin-friction per square foot* for planes varying in length from 1 to 32 feet. Only the values in heavy type lie within the range of experiments above described.

TABLE 1.—*Skin-friction per square foot for various speeds and lengths of surface.*

Wind speed.	Average friction in pounds per square foot.					
	1′ plane.	2′ plane.	4′ plane.	8′ plane.	16′ plane.	32′ plane.
Miles per hour.						
5	0.000303	**0.000289**	**0.000275**	**0.000262**	**0.000250**	0.000238
10	0.00112	**0.00105**	**0.00101**	**0.000967**	**0.000932**	0.000878
15	0.00237	**0.00226**	**0.00215**	**0.00205**	**0.00195**	0.00186
20	0.00402	**0.00384**	**0.00365**	**0.00349**	**0.00332**	0.00317
25	0.00606	**0.00579**	**0.00551**	**0.00527**	**0.00501**	0.00478
30	0.00850	0.00810	0.00772	0.00736	0.00701	0.00668
35	0.01130	0.0108	0.0103	0.0098	0.00932	0.00888
40	0.0145	0.0138	0.0132	0.0125	0.0125	0.0114
50	0.0219	0.0209	0.0199	0.0190	0.0181	0.0172
60	0.0307	0.0293	0.0279	0.0265	0.0253	0.0242
70	0.0407	0.0390	0.0370	0.0353	0.0337	0.0321
80	0.0522	0.0500	0.0474	0.0452	0.0431	0.0411
90	0.0650	0.0621	0.0590	0.0563	0.0536	0.0511
100	0.0792	0.0755	0.0719	0.0685	0.0652	0.0622

Finally all the conditions of experiment were kept constant except the quality of surface of the skin-friction boards. Practically the same skin-friction was observed whether the board was covered with dry glossy varnish or with wet sticky varnish, with calendered or uncalendered paper, with glazed cambric, sheet zinc, etc. But when the plane was covered with coarse buckram, having sixteen meshes to the inch, the skin-friction, at 10 feet per second, was 10 to 15 per cent greater than for the smooth wooden surface; and the friction increased as the square of the wind velocity.

The fact that, for some surfaces, the coefficients of friction of air and water are roughly as their densities is of considerable importance. For the impactual resistances also vary as the densities of the two fluids. Hence the data obtained from water-resistance measurements may be fairly well applied to estimate the air-resistance on models of various shapes.

COMBINED PRESSURE AND FRICTION.

The total resistance of various regular geometrical forms was also measured. Among the forms were spheres, rods, wires, spindles, and wedge-shaped cylinders. An important purpose in studying the two latter shapes was to determine the forms of least resistance, and the relative magnitudes of pressure and friction on such forms.

To determine the spindle form of least resistance a number of models were made, of ogival outline and symmetrical in bow and stern. These were suspended in turn from the sheltered vertical arm of a bell-crank wind-balance, having a graduated horizontal arm outside and above the tunnel. Sliding weights on the horizontal arm outside were made to counterbalance the wind thrust against the models held by the sheltered vertical arm inside the tunnel. In this way the total resistance of each spindle was determined for many speeds.

On comparing the resistances at the same speed, of various symmetrical spindles, an interesting effect was noted. The spindles, which were all 4 inches in diameter at their middle, and of increasing lengths of ogive, showed a total resistance which decreased rapidly as the short models grew in length, but presently became a minimum, then increased as the models grew longer and more tapering. Among the symmetrical spindles the form of least resistance was found to be the one having a "12-caliber" outline, i. e., its contour from prow to stern is a circular arc struck with a radius of twelve diameters. A form of considerably less resistance was found when a 2-caliber bow was combined with a 12-caliber stern, the resistance in this case being about one-eighth that of a 4-inch disk. In this model the length was roughly five times the major diameter. Thus it appears that a well-designed torpedo shape is the form of least resistance for air as well as for water.

Having found the symmetrical form of least resistance, by gradually lengthening the shorter form, the torpedo shape was derived from that by gradually shortening its bow. By this procedure, the friction on the bow was diminished more than the head pressure was increased until the form of least resistance was attained. The same treatment could not be applied to the stern of the model without increasing the suction more than the friction was diminished. It was also observed that if the tail of the torpedo were placed frontward, the total resistance was approximately doubled.

Similar results were obtained with the wedge-shaped ogival cylinders placed across the current. Their thickness being kept constantly 1 inch, and starting with the blunt ones, their total resistance was found to fall rapidly with increase in width of the wedge. The symmetrical form of least resistance was found in the 40-caliber model, whose width is about 11 inches, or eleven times the thickness. Still less resistance was found on the shape having a 5-caliber bow and a 40-caliber stern, the total resistance on this being about one-eighth that of its major section. The reasons for the observed phenomena are about the same for the two classes of models, the spindles and wedges.

An effort was made to compare the resultant frictional and pressural forces on each of the wedges, as also on each of the spindles. As the models were lengthened the friction grew and the pressure waned. They became equal when the model was about passing its most favorable shape.

The same current and bell-crank wind-balance above referred to were used to find the resistance of rods and wires varying in diameter from 2 inches down to the smallest standard gage. The balance-arm and frame holding the wires were carefully inclosed in sheet metal shields, so shaped as not to disturb the current materially. The resistance of the rods varied directly as their diameters, but the coefficient of resistance of the wires increased as their diameters diminished, thus indicating that a molecularly fine wire must have a considerable finite resistance. Incidentally it was observed that the resistance of both rods and wires varied directly as the square of the wind-speed, a well-known relation at low velocities. The quantitative results of these experiments are to be published after the measurements have been extended to still finer wires.

A special method was devised to measure the resistance of the air to some shapes moving at speeds below 1,000 feet per second. The body was shot from a cannon horizontally thru the air, and its retardation found. From this and the known mass of the projectile, its resistance was computed. The accuracy of the method, therefore, depends upon the precision of measurement of the retardation.

To secure greater accuracy in this latter research some novel features were introduced. The experiment was made in a closed room in homogenous still air. The bullets were light wooden spheres, some solid, others hollow, whose retardation is twenty to forty times greater, and hence as many times more precisely measurable, than solid steel ones. A recording chronograph was devised which, without impeding the bullet, measured its time of passage from point to point accurately to one five-hundred-thousandth of a second. Across the path of the projectile at intervals of 7 feet were thrown three ribbons of sunlight, each one-hundredth of an inch thick. The bullet emerging from the gun past thru a number of screens, which stopt the blast, then cut the sunbeams squarely and landed in a box of cotton. The beams, suitably diverted, past thru an aperture in a tall columnar box and came to focus side by side on a very sensitive photographic plate which fell when the gun trigger was pulled, thus causing the sunbeams to trace three fine lines on the plate. As the bullet in its flight eclipsed successively the thin sunbeams, little breaks were made in their records on the plate. These records were then measured on a dividing engine, and from the data so obtained the velocity, retardation, and finally the resistance were computed.

The resistance was found to obey no very simple law. It varies more rapidly than the square, less rapidly than the cube of the velocity. For speeds from 250 to 1,000 feet a second, it is closely exprest by the equation,

$$R = 0.000008v^2 + 0.000000049v^3,$$

in which R is the resistance in pounds per square foot and v the speed in feet per second. This coincides with the general formula,

$$R = av^2 + bv^3,$$

derived by Colonel Duchemin from purely analytical considerations, taking into account the rarefaction in the rear of a projectile. Thus the law so earnestly maintained by him, early in this century, and controverted by nearly all later experimenters, seems to be corroborated by the measurements made in this research, as far as they go.

The preceding observations may be summarized as follows:

(1) The resistance of blunt bodies at low speeds is given by the equation,

$$R = av^2,$$

R being the resistance, v the wind-speed.

(2) The resistance formula for blunt bodies at speeds from 250 to 1,000 feet per second contains two terms, thus:

$$R = av^2 + bv^3.$$

(3) The resistance of thin planes is exprest thus:

$$R = av^{1.85},$$

in which a is a function only of the length of the plane.

(4) The total resistanse of a fair shaped body at moderate speed is:

$$R = av^2 + bv^{1.85}.$$

(5) The resistance of rods is proportional to their diameter, that of wires dimishes less rapidly than the diameter.

(6) The skin-friction of even surfaces is practically independent of the material composing them.

(7) The resistance of symmetrical spindles and wedges of easiest shape, as of simple planes gliding at the most efficient angle of flight, is roughly, one-half friction, one-half unbalanced pressure.

HYTHERS AND THE COMPARISON OF CLIMATES.

Under the above title we had the pleasure of publishing in the MONTHLY WEATHER REVIEW in June, 1907, page 267, a letter from Mr. W. F. Tyler of Shanghai that had been a long time delayed. At that time we had not read Mr. Tyler's recent memoir—"The psycho-physic aspect of climate. London, 1907,"[1] but were desirous to make known his exprest hope (MONTHLY WEATHER REVIEW, June, 1907, XXXV, p. 268) that someone would investigate the limiting conditions of temperature and humidity under which animal life can exist. By experimenting upon animals in confinement such a research can be pushed to the determination of the death point. So far as human life is concerned there are many occupations in which life continues under observable extremes of heat and cold, dryness and moisture, calm and winds. Those who will keep records of their sensations when employed in iron or steel works, or in gas works, and especially in the well-regulated furnace rooms of ocean steamships,—those on the other hand who labor in the sunshine and pure air of the Imperial Valley and Salton Sea or the Sahara Desert, and those who as aeronauts or mountaineers penetrate cold clouds, should be able to add considerably to the data that Mr. Tyler is collecting for study.

The Editor recalls vividly his own experience in going from the deck of a steamer down into the furnace room with the stokers; the temperatures then determined by him with the protected sling psychrometer were about as given by (1) and (2) in the table. Another experience in the hot, dry air of a room heated by a Russian furnace gave observations (3) and (4). In the warm dry air of sunny winter quarters in Washington, such readings as (5) and (6) were obtained.

Perhaps the most delightful conditions were those of (7), prevailing thru the night in a strong southeast trade wind on the summit of Telegraph Hill on the Island of Ascension in February, 1890, where we could sleep without protection in a wind whose temperature scarcely varied from those of (7).

TABLE 1.—*Indoor and outdoor humidities observed by Prof. C. Abbe.*

Locality.	Dry bulb.	Wet bulb.	Dew point.	Relative humidity.
Atlantic steamer:	°F.	°F.	°F	*Per cent.*
(1) In the free air	91	85	83	78
(2) In the furnace room	120	91	83	33
Russia:				
(3) In the free air	0	2	20	33
(4) Furnace-heated room	120	65	20	1
Washington, D. C.:				
(5) In the free air	33	30	25	70
(6) Warm, sunny room	80	54	26	12
Island of Ascension:				
(7) In the free air	66	65	64	95

Most of these seven different conditions are agreeable to the writer with a proper adjustment of the wind velocity, but the sensations produced are widely various: thus (7) is restful and relaxative; (1) is perfectly indolent; (2), (4), and (6) produce a restless, uneasy, creepy, cold sensation as the skin becomes dry and harsh, one must drink much water and can scarcely do enough muscular exercise to counteract the dryness and keep the skin moist by a rapid circulation of the blood; (3) and (5) stimulate to exhilaration and to excellent intellectual work.

The following conditions—

(8) Free air 55°, wet 50°, DP 45°, RH 73 per cent,

(9) Free air 60°, wet 52°, DP 45°, RH 68 per cent,

are admirable for outdoor exercise and the attendant intellectual stimulus, when the rapid circulation of the blood enables the brain to work rapidly, easily, smoothly, and with precision. One who works steadily for several hours in quiet until his food supply becomes low, the blood fills with effete matter faster than the purifying organs can eliminate it, and the circulation becomes feeble—will usually find himself growing apparently colder, and will require the temperature of the room to be raised from 50° to 60° and perhaps to 70° or 80°, *i. e.*, to temperatures that would have seemed very uncomfortable at the beginning of his work.

These experiences are worthy of record and study, they will on the one hand elucidate the needs of our human physiology and on the other hand help us to more clearly define the relation between natural climates and the evolution of the peculiarities of the races of mankind.

The great variety of climates offered by the stations of our Weather Bureau and the frequent interchanges of observers suggests to us that each make a list of the stations at which he has lived, the length of time in years and months and the impressions produced on him as to the influence of the respective seasons of the local climates.

This information may possible be condensed into tabular form and a few general conclusions be drawn from the experiences of so many men. Mr. Tyler reminds us that for uniformity's sake the influence of the climate should be recorded on a scale of 0 to 10 where 10 will represent the worst day, hot, damp, close, muggy, enervating, that the observer remembers to have experienced at any time; and 0 will represent an ideal summer day, warm, brisk, bright and bracing. In the first case no diminution of clothing makes the free air less uncomfortable and in the second case no increase is needed in order to make it more comfortable. Mr. Tyler recommends that the estimates relate especially to the sensation at the noon or mid-day hours, unless indeed the observer wishes to make a very complete record and determe the diurnal changes.

This is a subject that we earnestly commend to the attention of the experts in physiology and psychology who are considering appropriate researches in several of our best universities.—*C. A.*

[1] See Monthly Weather Review of May, 1907, p. 227, column 2.

THE RELATIVE HUMIDITY OF OUR HOUSES IN WINTER.

In connection with the above note on Hythers and Climates, it may be of interest to many readers to have an account of certain related observations carried out by Prof. R. DeC. Ward in Cambridge, Mass., eight or nine years ago.[1] His account and comments are given in slightly changed form here.

The observations.—The observations were made in the study of the observer by means of H. J. Green's Marvin sling-psychrometer, and extended over three weeks of November, 1899, from the 3d to the 23d. The hours of observation varied, but the number was from two to five daily. Each observation comprised a record of the readings of the wet and dry-bulb thermometers, the condition of the out-of-doors weather, the amount of ventilation by means of the window, the temperature of the air coming from the furnace, and the stage of the water in an evaporating pan placed inside the register of the room.

The study in which the observations were made was heated by hot air from an ordinary hot-air furnace provided with the usual small evaporating pan. Inside the delivering register stood a vessel holding a little more than half a liter of water.

[1] The results were first published in the Boston Medical and Surgical Journal, March 1, 1900; later revised and printed in The Journal of School Geography, I, 1902, pp. 310-317.