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VOLUME 60, NUMBER 16

REMAINS IN EASTERN ASIA OF THE RACE THAT PEOPLED AMERICA

(WITH THREE PLATES)

BY

DR. A. HRDLIČKA
Curator of the Division of Physical Anthropology, U. S. National Museum

(PUBLICATION 2159)

CITY OF WASHINGTON
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CURATOR OF THE DIVISION OF PHYSICAL ANTHROPOLOGY, U. S. NATIONAL MUSEUM

During the summer of 1912 the writer visited, partly under the auspices of the Smithsonian Institution and partly in the interest of the Panama-Californian Exposition of San Diego, certain portions of Siberia and Mongolia in search for possible remains of the race that peopled America, and whose home, according to all indications, was in eastern Asia. Upon the return of the writer from his journey in September this brief report was presented at the International Congress of Prehistoric Anthropology and Archeology at Geneva.

The journey extended to certain regions in southern Siberia, both west and east of Lake Baikal, and to Mongolia as far as Urga. It furnished an opportunity for a rapid survey, from the anthropological standpoint, of the field and conditions in those regions, and was made in connection with a prolonged research into the problems of the ethnic nature and origin of the American aborigines carried on by the writer on this continent.

The studies of American anthropologists and archeologists have for a long time been strengthening our opinion that the American native did not originate in America, but is the result of a comparatively recent, post-glacial, immigration into this country; that he is physically and otherwise most closely related to the yellow-brown peoples of eastern Asia and Polynesia; and that in all probability he represents, in the main at least, a gradual overflow from north-eastern Siberia.[1]

If our views concerning the origin of the Indian and his comparatively late coming into America be correct, then it seems there ought to exist to this day, in some parts of eastern Asia, archeological remains, and possibly even survivals, of the physical stock from which our aborigines resulted. For it could have been no small people that

[1] For a summary of these opinions see "The Problems of the Unity or Plurality and the Probable Place of Origin of the American Aborigines" in The American Anthropologist, Vol. 14, No. 1, January-March, 1912.

sent us in the course of several thousand years the various more pronounced sub-types of the American Indian, which according to all indications have developed outside of America. As a matter of fact, we have searched and watched for evidence concerning such remains for many years, and every publication that dealt with archeological exploration in eastern Asia or brought photographs of the natives, has in one way or another strengthened our expectations.

No archeologic work on an adequate scale, however, and no comprehensive anthropologic investigation of the natives of eastern Asia, have as yet been carried out, and in consequence many points on which light was needed remained uncertain.[1] Under these circumstances the writer was very desirous to visit personally at least a few of the more important parts of eastern Asia, to observe what was to be found there, and to determine what should be done in those regions by anthropologists and archeologists interested in the problem of the identity and origin of the American Indian.

An opportunity to undertake something in this direction came at last during the present year; but the means were limited and necessitated a restriction of the trip to the more important and at the same time more accessible territory. The choice was made of certain parts of south-eastern Siberia and of northern Mongolia, including Urga, the capital of outer Mongolia, which encloses two great monasteries and is constantly visited by a large number of the natives from all parts of the country. Besides the field observations a visit was also made to the various Siberian museums within the area covered, for the purpose of seeing their anthropological collections.

It will not be possible to enter here into details of the journey and I shall, therefore, restrict myself to mentioning in brief the main results. Thanks to the Russian men of science and the Russian political as well as military authorities, my journey was everywhere facilitated, I was spared delays, was shown freely the existing collections, and received much valuable information.

I have seen, or been told, of thousands upon thousands of as yet barely touched burial mounds or " kourgans ", dating from the present time back to the period when nothing but stone implements were used by man in those regions. These kourgans dot the country about the Yenisei and its affluents, about the Selenga and its tributaries,

[1] It is only fair, however, that attention be called here to the Bogoraz and Jochelson work among the natives of Northern Siberia, as a part of the Jessup Expedition, for the American Museum of Natural History, New York City. Regrettably this work did not extend far enough to the south.

along the rivers in northern Mongolia, particularly the Kerulen, and in many other parts regarding which reliable information could be obtained. The little investigation that has been made of these remains is due, in the main, to Adrianov and his colleagues at Minusinsk, and especially to Professor Talko-Hryncewitz of Krakow, who was for many years the government physician at Kiachta. The mounds yield, according to their age, implements of iron, copper, bronze, or stone, occasionally some gold ornaments, and skeletons. The majority of these "kourgans" date doubtless from fairly recent times, corresponding to Ugrian or Turk or "Tatar[1]" elements, and to the modern Mongolian, and the skeletons found in them show mostly brachycephalic skulls, which occasionally resemble quite closely American crania of the same form. The older kourgans, on the other hand, particularly those in which no metal occurs, yield an increasing number of dolichocephalic crania, in which close resemblances with the dolichocephalic skulls of the American Indians are very frequent. To what people these older remains belong is as yet an unanswered question; but there are in certain localities, as for instance on the lower Yenisei, to this day remnants of native populations among whom dolichocephalic individuals are quite common, and these individuals often bear a most remarkable physical resemblance to the American Indian.

Besides mounds, the writer saw and learned of numerous large caverns, particularly in the mountains bordering the Yenisei River, which offer excellent opportunities for archeological investigation. Very little research work has thus far been done in these caverns, but some have yielded, to Jelieniev, stone implements that indicate old burials.

In regard to the living people, the writer had the opportunity of seeing numerous Buriats, representatives of a number of tribes on the Yenisei and Abacan Rivers, many thousands of Mongolians, a number of Tibetans, and many Chinese with a few Manchurians. On one occasion alone, that of an important religious ceremony, he had an opportunity to observe over 7,000 natives assembled from all parts of Mongolia. He has also seen photographs of members of some of the eastern Siberian tribes. Among all these people, but more especially among the Yenisei Ostiaks, the Abacan Katchinci and related groups, the Selenga Buriats, the eastern Mongolians, the Tibetans, the east Siberian Oroczi and the Sachalin Giliaks, there

[1] The term "Tatar" in Siberia is applied to large numbers of natives and covers a number of physically heterogeneous types.

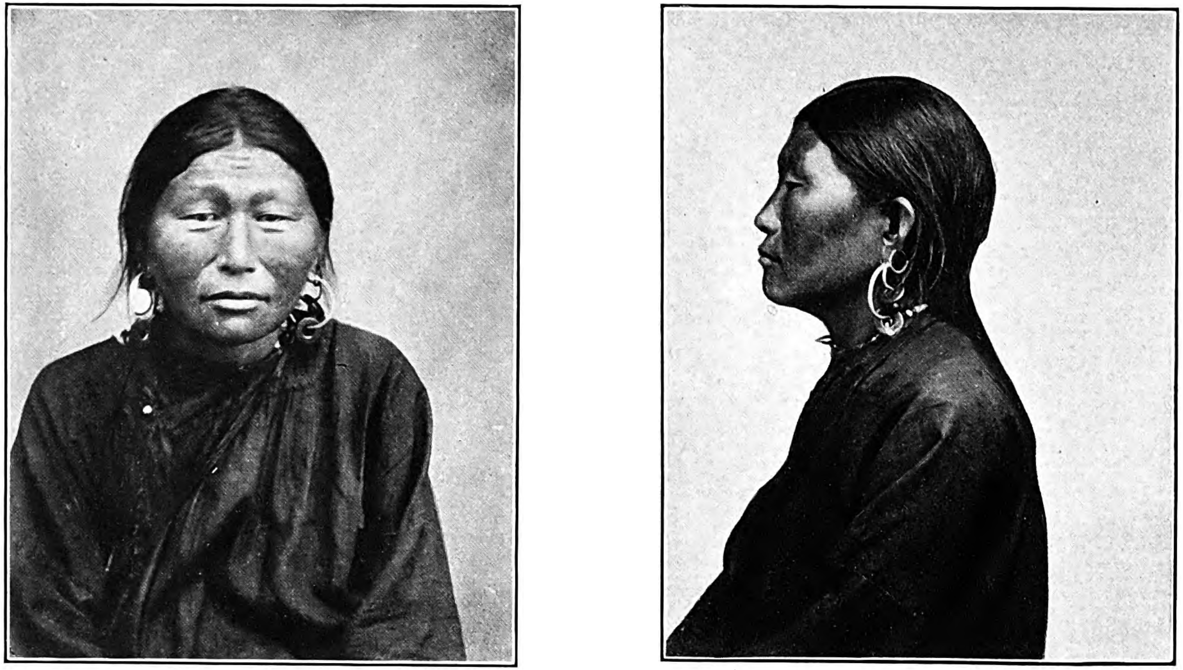
are visible many and unmistakable traces of admixture or persistence of what appears to have been the older population of these regions, pre-Mongolian and especially pre-Chinese,[1] as we know these nations at the present day. Those representing these vestiges belong partly to the brachycephalic and in a smaller extent to the dolichocephalic type, and resemble to the point of identity American Indians of corresponding head form. These men, women and children are brown in color, have black straight hair, dark brown eyes, and facial as well as bodily features which remind one most forcibly of the native Americans. Many of these individuals, especially the women and children, who are individually less modified by the environment than the men, if introduced among the Indians and dressed to correspond, could by no means at the disposal of the anthropologist be distinguished apart. And the similarities extend to the mental make up of the people, as well as to numerous habits and customs which new contacts and religions have not as yet been able to efface.

The writer found much more in this direction than he had hoped for, and the physical resemblances between these numerous outcroppings of the older blood and types of north-eastern Asia and the American Indian, cannot be regarded as accidental, for they are numerous as well as important and cannot be found in parts of the world not peopled by the yellow-brown race; nor can they be taken as an indication of American migration to Asia, for emigration of man follows the laws of least resistance, or greatest advantage, and these conditions surely lay more in the direction from Asia to America than the reverse.

In conclusion, it may be said that from what he learned in eastern Asia, and weighing the evidence with due respect to other possible views, the writer feels justified in advancing the opinion that there exist to-day over large parts of eastern Siberia, and in Mongolia, Tibet, and other regions in that part of the world, numerous remains, which now form constituent parts of more modern tribes or nations, of a more ancient population (related in origin perhaps with the latest paleolithic European), which was physically identical with and in all probability gave rise to the American Indian.

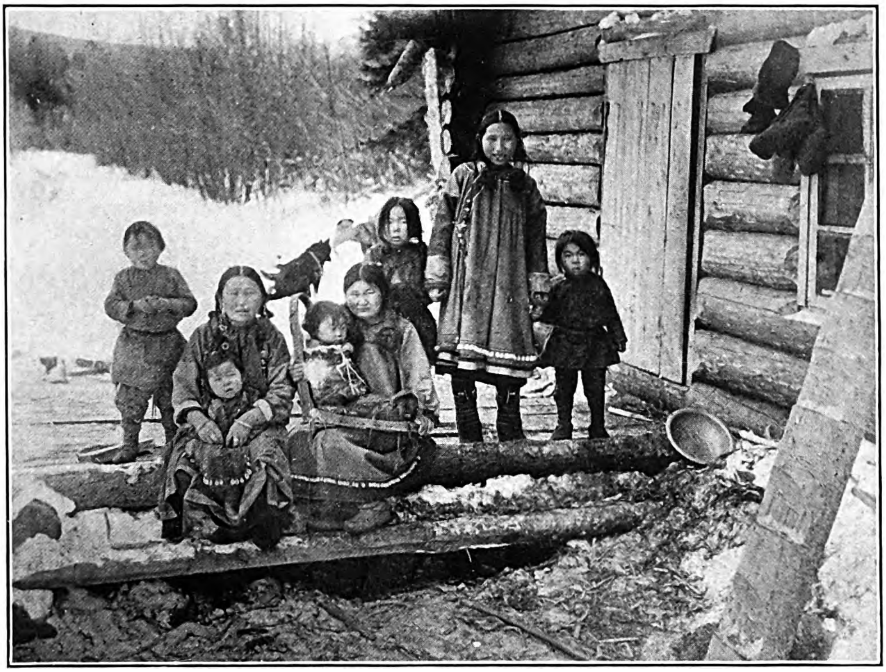
[1] The Mongolians of to-day are a mosaic or mixture of various local, southern and particularly western ethnic elements; while the Chinese present in the main a people that has undergone to a very perceptible degree its own differentiation, so as to constitute a veritable great subtype of the yellow-brown people.

The writer is able to merely touch on the great subject thus approached. The task of learning the exact truth remains for the future. In relation to opportunities for further investigation, he has satisfied himself that the field for anthropological and archeological research in eastern Asia is vast, rich, to a large extent still virginal, and probably not excessively complicated. It is surely a field which calls for close attention not only on the part of European students of the Far East, but especially on the part of the American investigator who deals with the problems of the origin and immigration of the American Indian.



A GILIAK WOMAN FROM SACHALIN

(Photograph from the Antropologicny Instytut, Krakow; donated to the U. S. National Museum by Prof. J. Talko-Hryncewicz)



OROCZI, ON THE STREAM KONI, EASTERN SIBERIA

OROCZI, ON THE RIVER IMAN, EASTERN SIBERIA
(Both photographs from the Antropologicny Instytut, Krakow; donated to the U. S. National Museum by Prof. J. Talko-Hryncewicz)

A FAMILY OF YENISEI OSTIAKS

(Photograph obtained by the U. S. National Museum through exchange, from the Ethnographical and Anthropological Museum of Peter the Great, St. Petersburg)

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 60, NUMBER 17

NOTES ON AMERICAN SPECIES OF PERIPATUS, WITH A LIST OF KNOWN FORMS

BY
AUSTIN HOBART CLARK

(Publication 2163)

CITY OF WASHINGTON
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By AUSTIN HOBART CLARK

While engaged in entomological investigations on the Isthmus of Panamá, Mr. August Busck collected a single specimen of a species of *Peripatus,* which he found beneath a palm frond at La Chorrera; and in the course of their studies on the marine resources of Porto Rico the naturalists of the United States Bureau of Fisheries steamer "Fish Hawk" gathered two additional specimens at Vieques, a small island off the southeastern corner of Porto Rico, a locality where the genus was not previously known to occur.

Our knowledge of the species of this genus is in the highest degree fragmentary; many species are known, but of none of them do we know even approximately the geographical range. It thus becomes incumbent upon all to whom opportunity may offer immediately to record such specimens as may come under their notice in order to accumulate records from which, in time, the geographical distribution of the various forms may be accurately mapped.

At the same time everyone who records species of *Oroperipatus, Peripatus,* (with its various subgenera) or of the other genus occurring in America, *Metaperipatus,* should take care that his specimens are properly preserved and placed in some museum where they will be easily accessible for review, for the species of the various genera of this group, like the species of the king crabs, crinoids, and many other ancient types are all cast, as it were, in the same mould, and it is astonishingly easy to make mistakes in their determination.

PERIPATUS (PERIPATUS) JUANENSIS Bouvier

Peripatus juliformis (part) 1880. PETERS, Sitzungsber. naturf. Freunde Berlin, 1880, pp. 29, 166.

Peripatus from Utuado 1880. SEDGWICK, Quart. Journ. Micros. Sci., vol. 28, pp. 479, 488.

Peripatus dominicæ var. *juanensis* 1900. BOUVIER, Bull. Soc. Ent. de France, 1900, pp. 394, 395.—1904. BOUVIER, Nouv. Archives du Mus. d'Hist. nat. (4), vol. 3, pp. 7, 20.—1906. BOUVIER, Ann. des Sci. Nat. (9), vol. 2 (zoologie), p. 266.

Vieques, near Porto Rico; " Fish Hawk " Porto Rican Expedition.—Two specimens, both females, agreeing well with Bouvier's description. The length of one is 35 mm., and the breadth 4 mm. There are 31 pairs of ambulatory legs. The coloration (in alcohol) is a deep, almost uniform, yellowish brown; the posterior portion of the body is slightly darker than the remainder, and there is a large lightish area just behind the anterior end. The primary papillæ are more yellowish than the general surface of the back. The ventral surface is somewhat lighter and more yellowish than the dorsal.

The other specimen, beautifully preserved, measures 45 mm. in length by 4 mm. in breadth. There are 31 pairs of ambulatory legs.

This species was heretofore known only from the island of Porto Rico, where it has been found at Utuado and Arecibo. A comparison between these specimens and others from various parts of the main island would be of interest, but no material for such a comparison is available.

PERIPATUS (MACROPERIPATUS) GEAYI Bouvier

Peripatus geayi 1899. Bouvier, Comptes Rendus Acad. des Sci., vol. 128, p. 1345.—1900. Bouvier, Ann. Soc. Ent. de France, vol. 68 (1899), pp. 389, 404-406.—1904. Bouvier, Bull. du Mus. d'Hist. Nat., 1904, p. 53.—1905. Bouvier, Annales des Sci. Nat. (9), vol. 2, p. 200.

La Chorrera, Panamá; from under a palm leaf; August Busck, May 17, 1912.—One specimen, agreeing well with Bouvier's description and figures. There are 32 pairs of ambulatory legs. The length is 45.5 mm. The color is a purplish brown, lighter beneath; the primary papillæ are darker than the rest of the back. Just behind the anterior extremity of the body is a broad transverse obscure yellow band, about 1.3 mm. wide, slightly constructed in the center.

This species was previously only known from French Guiana.

LIST OF THE AMERICAN SPECIES OF PERIPATUS, WITH THE ASCERTAINED RANGE OF EACH

The species belonging to the family Peripatidæ and to the subfamily Peripatinæ as now restricted, all but one of which are American, are as follows:

Genus OROPERIPATUS Cockerell

Oroperipatus ecuadoriensis (Bouvier).

Habitat.—Bulim, northwestern Equador.

Oroperipatus lankesteri (Bouvier).
HABITAT.—Paramba, near Quito, Equador.
Oroperipatus tuberculatus (Bouvier).
HABITAT.—Popayan, Colombia.
Oroperipatus quitensis (Schmarda).
HABITAT.—High regions of Equador.
Oroperipatus cameranoi (Bouvier).
HABITAT.—Cuenca and Sigsig, Equador.
Oroperipatus corradoi (Camerano).
HABITAT.—Equador; known from Quito, Balzar and Guayaquil.
Oroperipatus eiseni (Wheeler).
HABITAT.—Tepic, Mexico.
Oroperipatus belli (Bouvier).
HABITAT.—Equador; Duran, on the Guayas river.
Oroperipatus goudoti (Bouvier).
HABITAT.—Mexico.
Oroperipatus soratanus (Bouvier).
HABITAT.—Bolivia; Sorata.
Oroperipatus balzani (Camerano).
HABITAT.—Bolivia; states of Coroico and Chulumani.
Oroperipatus intermedius (Bouvier).
HABITAT.—Bolivia; Sorata.

Genus PERIPATUS Guilding

Subgenus MACROPERIPATUS A. H. Clark

Peripatus (*Macroperipatus*) *torquatus* von Kennel.
HABITAT.—Trinidad.
Peripatus (*Macroperipatus*) *perrieri* Bouvier.
HABITAT.—Mexico; Vera Cruz.
Peripatus (*Macroperipatus*) *geayi* Bouvier.
HABITAT.—Cayenne, on the French-Brazilian boundary; La Chorrera, Panamá.
Peripatus (*Macroperipatus*) *ohausi* Bouvier.
HABITAT.—Brazil; Petropolis, near Rio de Janeiro.
Peripatus (*Macroperipatus*) *guianensis* Evans.
HABITAT.—Demerara; east bank of the Demerara river.

Subgenus EPIPERIPATUS A. H. Clark

Peripatus (*Epiperipatus*) *brasiliensis* Bouvier.
HABITAT.—Brazil; Santarem, probably also San Pablo, Panamá.
Peripatus (*Epiperipatus*) *imthurmi* Sclater.
HABITAT.—Demerara; Maccasseema, on the Pomeroon river, Hoorubea, on the Demerara river, and other localities not specifically recorded; Essequibo; Surinam, Paramaribo; Cayenne, Haut Carsevenne.
Peripatus (*Epiperipatus*) *evansi* Bouvier.
HABITAT.—East bank of the Demerara river.

Peripatus (*Epiperipatus*) *edwardsii* Blanchard.
HABITAT.—Cayenne; banks of the Approuague river, also the interior; Surinam, Paramaribo; ?Trinidad; Venezuela, Haute Sarare, Bas Sarare, Mérida and Caracas; ?Colombia, vicinity of Lake Valencia; Panamá, Panamá Station; Darien.

Peripatus (*Epiperipatus*) *simoni* Bouvier.
HABITAT.—Brazil, Breves, on the island of Marajo, at the mouth of the Amazons; Venezuela, Caracas.

Peripatus (*Epiperipatus*) *biolleyi* Bouvier.
HABITAT.—Costa Rica, San José and Surubres, near San Mateo; ?British Honduras, Benque Viejo.

Peripatus (*Epiperipatus*) *nicaraguensis* Bouvier.
HABITAT.—Nicaragua, Matagalpa and San Benito.

Peripatus (*Epiperipatus*) *isthmicola* Bouvier.
HABITAT.—Costa Rica, San José, Cachi, plains of Santa Clara.

Peripatus (*Epiperipatus*) *trinidadensis* Stuhlmann.
HABITAT.—Trinidad.

Peripatus (*Epiperipatus*) *barbouri* Brues.
HABITAT.—Grenada; Grand Etang.

Subgenus PERIPATUS Guilding

Peripatus (*Peripatus*) *swainsonæ* Cockerell.
HABITAT.—Jamaica, Bath, and near Savanna lo Mar.

Peripatus (*Peripatus*) *juanensis* Bouvier.
HABITAT.—Porto Rico, Arecibo and Utuado; Vieques.

Peripatus (*Peripatus*) *danicus* Bouvier.
HABITAT.—St. Thomas, Danish West Indies.

Peripatus (*Peripatus*) *antiguensis* Bouvier.
HABITAT.—Antigua, Barlar, near Warburton; also other localities not specifically recorded.

Peripatus (*Peripatus*) *bavayi* Bouvier.
HABITAT.—Guadeloupe, French West Indies.

Peripatus (*Peripatus*) *dominicæ* Pollard.
HABITAT.—Dominica, Laudat and Prince Rupert.

Peripatus (*Peripatus*) *juliformis* Guilding.
HABITAT.—St. Vincent.

Peripatus (*Peripatus*) *brölemanni* Bouvier.
HABITAT.—Venezuela, Tovar, Raxto Casselo and Puerto Cabello.

Peripatus (*Peripatus*) *sedgwicki* Bouvier.
HABITAT.—Venezuela, Caracas, San Esteban, La Moka, Las Trincheras and La Guayra.

Subgenus PLICATOPERIPATUS A. H. Clark

Peripatus (*Plicatoperipatus*) *jamaicensis* Grabham and Cockerell.
HABITAT.—Jamaica, Bath, and near Savanna lo Mar.*

* This species has two varieties, *gossei* Cockerell, and *bouvieri* Cockerell, with the same habitat as the type form.

Genus **MESOPERIPATUS** Evans

Mesoperipatus tholloni (Bouvier).
HABITAT.—French Congo.

The subfamily Peripatoidinæ of the family Peripatopsidæ is represented in America by the following species:

Genus **METAPERIPATUS** A. H. Clark

Metaperipatus blainvillei (Blanchard).
HABITAT.—Chile, San Carlos, Chiloe Island, Corral and Villa Rica.

In addition to the forms listed above, Grube described, under the name of *Peripatus peruanus*, a species from Peru which cannot be placed with certainty in any group.

SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOLUME 60, NUMBER 18

SMITHSONIAN PYRHELIOMETRY REVISED

BY

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SMITHSONIAN PYRHELIOMETRY REVISED

By C. G. ABBOT, Director, and L. B. ALDRICH, Bolometric Assistant,
ASTROPHYSICAL OBSERVATORY OF THE SMITHSONIAN INSTITUTION.

In a paper entitled "The Silver Disk Pyrheliometer"[1] it was stated that in order to promote pyrheliometric measurements of the solar radiation in other parts of the world with instruments whose indications are quite comparable, several copies of the Silver Disk Pyrheliometer have been sent out by the Smithsonian Institution. The number of these instruments which have now been sent out has reached about twenty. The present paper gives a revision of the constants of these instruments and a statement of their dependence on experiments to determine the standard scale of radiation.

Three copies of the Standard Water-flow Pyrheliometer[2] have been prepared at the shop of the Astrophysical Observatory. The principle of these instruments consists in receiving the solar radiation in a blackened chamber composing a perfect absorber or "absolutely black body" and in carrying away the heat developed as fast as formed by a current of water circulating around in the walls of the receiving chamber. The rate of flow of the water, the rise of temperature due to the solar heating and the aperture through which the solar rays enter being known, the heating due to the solar rays is determined in calories per square centimeter per minute. In test experiments heat may be introduced electrically within coils in the absorption chamber, and this may be measured as if it were solar heat. The complete recovery of such test quantities of heat serves to prove the accuracy of the instrument.

Quite recently a new standard pyrheliometer which we have called "Standard Water-stir Pyrheliometer No. 4" has been devised and tested by us. This instrument employs the ordinary method of calorimetry. A blackened tubular chamber for the absorption of the solar heat is provided as for the water-flow pyrheliometer. In the new instrument the absorption chamber is enclosed by a known quantity of water in a copper vessel, so that the whole apparatus comprises what is in effect a calorimeter for the method of mixtures.

[1] Smithsonian Miscellaneous Collections, Vol. 56, No. 19.

[2] See Annals, Astrophysical Observatory, Vol. 2, pp. 39 to 47, 1908. Also The Astrophysical Journal, Vol. 33, pp. 125 to 129, 1911.

The water in the instrument is vigorously stirred[1] by means of a stirring device run by an electric motor. A platinum resistance thermometer, fully bathed by the water of the pyrheliometer serves to determine its rate of rise of temperature due to the absorption of solar rays, and also its rates of change of temperature before and after exposure to these rays, due to the influence of the surroundings. In this manner we may determine the intensity of the radiation of the sun in terms of the rise of temperature per minute of a calorimeter of known water equivalent, and we may be assured that the solar rays are completely absorbed to produce heat, because they are absorbed by a blackened surface forming the inside of a deep chamber closely approximating to the "absolutely black body." In this new instrument, as in the water-flow pyrheliometers, means are provided for the introduction electrically of known quantities of heat to test the accuracy of the apparatus. A full description of the new water-stir pyrheliometer and of the water-flow pyrheliometers, Nos. 2 and 3, will appear in Vol. 3 of the Annals of the Astrophysical Observatory, now in preparation.

The following table is a summary of the experiments made with test quantities of electrical heating with standard pyrheliometers Nos. 2, 3 and 4:

Pyrheliometer.	Dates.	Number tests.	Heat recovered.	Average deviation.
			Per cent.	*Per cent.*
Water-flow 2	1910—May 12, 16, 25, 26, 31; June 7	21	99.1	1.8
Water-flow 3	1910—April 18, 22, 23	16	99.85	0.63
Water-flow 3	1911—Oct. 10, 11	12	100.66	1.4
Water-stir 4	1912—Oct. 24, 25	6	100.05	0.53

From these experiments it appears that the test quantities of electrical heating were recovered by each instrument to within one per cent of the quantity introduced.

The results of comparisons of the standard pyrheliometers with secondary pyrheliometers are summarized in the following table:

Dates.	Number comparisons.	Standard used.	Secondary used.	Standard secondary.	Probable error.
1910—May 10, 17, 28; June 4	16	2	A.P.O. 8	0.3772	0.0022
1910—Apr. 22	6	3	A.P.O. 8	0.3765	0.0009
1910—Oct. 31; Nov. 1	8	3	A.P.O. IV	0.5149	0.0013
1911—June 27	3	3	A.P.O. 8bis	0.3792	0.0018
			A.P.O IV	0.5094	0.0011
1911—Oct. 14, 15, 16, 22, 25, 31; Nov. 2, 6, 7	21	3	A.P.O. 8bis	0.3770	0.0007
1912—Nov. 16, 19, 21	18	4	A.P.O. 9	0.3618	0.0012

[1] Successful use requires rapid stirring.

Intercomparisons between the secondary pyrheliometers named in the preceding table are as follows:

Dates.	Number comparisons.	Secondaries used.		Ratio $\frac{A}{B}$	Probable error.
		A.	B.		
1910—June 21	17	S.I. 5	A.P.O. 8	1.0242	0.0019
1911—Apr. 25	7	S.I. 5	A.P.O. 8bis	1.0389	0.0019
1912—Dec. 20	18	S.I. 5	A.P.O. 8bis	1.0281	0.0013
1909—Oct. 23, 31	9	A.P.O. 8	A.P.O. IV	1.3611	0.0021
1911—June 22, 28; Sept. 14	19	A.P.O. 8bis	A.P.O. IV	1.3518	0.0017
1910—July 28	6	A.P.O. 9	A.P.O. IV	1.3820	0.0008
1911—June 28	8	A.P.O. 9	A.P.O. IV	1.4102	0.0046
1911—June 28	8	A.P.O. 9	A.P.O. 8bis	1.0469	0.0010
1912—Feb. 6, 10	12	A.P.O. 9	A.P.O. 8bis	1.0328	0.0011
1912—Nov. 8	10	A.P.O. 9	A.P.O. 8bis	1.0470	0.0013
1912—Nov. 11	19	A.P.O. 9	A.P.O. 8bis	1.0445	0.0014

Combining the results of the two preceding tables we obtain the following constants which we now adopt for the secondary pyrheliometers named above. These constants and others which are derived from them in the remainder of this paper we designate as Smithsonian Revised Pyrheliometry of 1913:

From $\frac{\text{S.I. 5}}{\text{A.P.O. 8}}$ and $\frac{\text{S.I. 5}}{\text{A.P.O. 8bis}}$ we find $\frac{\text{A.P.O. 8}}{\text{A.P.O. 8bis}} = \frac{1.0311}{1.0242} = 1.0068$

From $\frac{\text{A.P.O. 8}}{\text{A.P.O. IV}}$ and $\frac{\text{A.P.O. 8bis}}{\text{A.P.O. IV}}$ we find $\frac{\text{A.P.O. 8}}{\text{A.P.O. 8bis}} = \frac{1.3611}{1.3518} = 1.0068$

From $\frac{\text{A.P.O. 9}}{\text{A.P.O. 8bis}}$ (49 values) we find $\frac{\text{A.P.O. 9}}{\text{A.P.O. 8bis}} = \ldots\ldots$ 1.0426

From $\frac{\text{A.P.O. 9}}{\text{A.P.O. IV}}$ and $\frac{\text{A.P.O. 8bis}}{\text{A.P.O. IV}}$ we find $\frac{\text{A.P.O. 9}}{\text{A.P.O. 8bis}} = \frac{1.3981}{1.3518} = 1.0343$

From $\frac{\text{A.P.O. 8bis}}{\text{A.P.O. IV}}$ (19 values) we find $\frac{\text{A.P.O. IV}}{\text{A.P.O. 8bis}} = \ldots\ldots$ 0.7398

These results leave no choice as to the values to be adopted for $\frac{\text{A.P.O. 8}}{\text{A.P.O. 8}_{\text{bis}}}$ and $\frac{\text{A.P.O. IV}}{\text{A.P.O. 8}_{\text{bis}}}$, but are less satisfactory as regards $\frac{\text{A.P.O. 9}}{\text{A.P.O. 8}_{\text{bis}}}$. However it will be seen that the discordance in this ratio almost wholly depends on the six comparisons $\frac{\text{A.P.O. 9}}{\text{A.P.O. IV}}$ of

July 28, 1910. It is possible that A.P.O. 9 was inadvertently not fully exposed at this time. We shall adopt:

$$\frac{\text{A.P.O. 8}}{\text{A.P.O. 8}_{\text{bis}}} = 1.0068. \quad \frac{\text{A.P.O. 9}}{\text{A.P.O. 8}_{\text{bis}}} = 1.0426. \quad \frac{\text{A.P.O. IV}}{\text{A.P.O. 8}_{\text{bis}}} = 0.7398.$$

From $\frac{\text{Standard 2}}{\text{A.P.O. 8}}$ and $\frac{\text{A.P.O. 8}}{\text{A.P.O. 8}_{\text{bis}}}$ we find $\frac{\text{Standard 2}}{\text{A.P.O. 8}_{\text{bis}}} = 0.3772 \times 1.0068 = 0.3798.$

From $\frac{\text{Standard 3}}{\text{A.P.O. 8}}$ and $\frac{\text{A.P.O. 8}}{\text{A.P.O. 8}_{\text{bis}}}$ we find $\frac{\text{Standard 3}}{\text{A.P.O. 8}_{\text{bis}}} = 0.3765 \times 1.0068 = 0.3791.$

From $\frac{\text{Standard 3}}{\text{A.P.O. IV}}$ and $\frac{\text{A.P.O. IV}}{\text{A.P.O. 8}_{\text{bis}}}$ we find $\frac{\text{Standard 3}}{\text{A.P.O. 8}_{\text{bis}}} = 0.5149 \times 0.7398 = 0.3809.$

also $0.5094 \times 0.7398 = 0.3768.$

From $\frac{\text{Standard 4}}{\text{A.P.O. 9}}$ and $\frac{\text{A.P.O. 9}}{\text{A.P.O. 8}_{\text{bis}}}$ we find $\frac{\text{Standard 4}}{\text{A.P.O. 8}_{\text{bis}}} = 0.3618 \times 1.0426 = 0.3772.$

Besides these values we have given two direct comparisons of $\frac{\text{Standard 3}}{\text{A.P.O. 8}_{\text{bis}}}.$

In combining the results to obtain the best value of the constant of Secondary Pyrheliometer A. P. O. 8_{bis}, we have been guided by the view that a completely independent set-up of apparatus is a more weighty condition than is a small probable error. This amounts to saying that we have considered constant errors of more importance than accidental ones. But admitting this, we have also taken some notice of the number of observations made on different occasions, and of their accordance. These considerations have led us to the following values for Constant of Secondary Pyrheliometer A. P. O. 8_{bis}:

Value	0.3798	0.3791	0.3809	0.3768	0.3792	0.3770	0.3772	Mean 0.3786
Weight	3	3	3	1	1	4	3	±0.0003
Standard at.	No. 2 Washn.	No. 3 Washn.	No. 3 Mt. Wilson	No. 3 Mt. Wilson	No. 3 Mt. Wilson	No. 3 Mt. Wilson	No. 4 Washn.	

The constants of the silver disk pyrheliometers sent out by the Smithsonian Institution to various observers are derived by comparisons of those silver disk pyrheliometers with one or the other of the pyrheliometers named above. The following table gives the results of these comparisons for determining the constants of the various Smithsonian pyrheliometers[1]:

Date.	Number comparisons.	Secondaries used.		Ratio $\frac{A}{B}$	Probable error.
		A.	B.		
1910—Apr 8	11	S.I. 1	A.P.O. 8	1.0182	0.0025
1911—Jan. 25	9	S.I. 1	A.P.O. 8bis	1.0357	0.0024
1911—Jan. 25	10	S.I. 1	A.P.O. VIII	1.3943	0.0031
1911—Dec. 6	7	S.I. 1	A.P.O. 8bis	1.0246	0.0060
1912—Feb. 10	8	S.I. 1	A.P.O. 8bis	1.0268	0.0028
1911—Jan. 20, 23, 24, 25	24	S.I. 2	A.P.O. 8bis	1.0162	0.0016
1912—Nov. 8	9	S.I. 2	A.P.O. 8bis	1.0144	0.0017
1912—Nov. 8	9	S.I. 2	A.P.O. 9	0.9698	0.0013
1911—Jan. 19	6	S.I. 3	A.P.O. 8bis	1.0477	0.0024
1911—Jan. 20	6	S.I. 3	S.I. 2	1.0271	0.0024
1910—Apr. 8	10	S.I. 4	A.P.O. 8	1.0117	0.0023
1911—Dec. 3	4	S.I. 4	A.P.O. 9	0.9803	0.0016
Data for S.I. 5 given in preceding table.					
1911—Mar. 10	8	S.I. 6	A.P.O. 8bis	1.0327	.0017
1911—Mar. 21	9	S.I. 7	A.P.O. 8bis	1.0408	.0022
1912—May 18, 20	22	S.I. 8	A.P.O. 8bis	1.0032	.0018
1911—Apr. 25	10	S.I. 9	A.P.O. 8bis	1.0130	.0021
1911—May 4	6	S.I. 10	A.P.O. 8bis	1.0013	.0012
1911—Dec. 18	6	S.I. 10	A.P.O. 9	0.9703	.0027
1911—Feb. 6	11	S.I. 11	A.P.O. 8bis	1.0044	.0024
1912—Sept. 28	9	S.I. 12	A.P.O. 8bis	1.0427	.0020
1912—Feb. 10	9	S.I. 13	A.P.O. 8bis	1.0466	.0017
1912—Feb. 10	15	S.I. 14	A.P.O. 9	0.9777	.0014
1912—Mar. 7	9	S.I. 15	A.P.O. 8bis	1.0491	.0014
1912—Mar. 11, 16	13	S.I. 16	A.P.O. 8bis	1.0352	.0018
1912—Mar. 16	15	S.I. 17	A.P.O. 9	0.9990	.0011
VARIOUS A.P.O. PYRHELIOMETERS.					
1906—Apr. 2	6	A.P.O. V	A.P.O. IV	1.0615	.0050
1908—Apr. 16, 29	9	A.P.O. V	A.P.O. VII	1.0786	.0035
1908—May 28	13	A.P.O. V	A.P.O. VIII	1.0815	.0016
1910—Dec. 8	5	A.P.O. V	A.P.O. 8	0.7864	.0012
1910—Dec. 13, 15	11	A.P.O. V	A.P.O. 8bis	0.7969	.0024
1911—Jan. 19, 20, 23, 24	34	A.P.O. V	A.P.O. 8bis	0.7927	.0013
1908—May 22–June 3	75	A.P.O. IV	A.P.O. VII	0.9905	.0010
1909—June 1–Sept. 1	160	A.P.O. IV	A.P.O. VII	0.9955	.0007
1910—May 17–Oct. 25	700	A.P.O. IV	A.P.O. VII	0.9892	.0005
1912—May 4–Aug. 12	60	A.P.O. IV	A.P.O. VII	0.9892	.0012

In accordance with the above table, the following values are now adopted as the constants of Smithsonian Silver Disk Pyrheliometers Nos. 1 to 17, which have been furnished to the parties mentioned in the table. The column headed "old value" gives the constant which was furnished at the time of sending out the instrument or subsequently when further data indicated some desirable change. These old values are to be displaced by the new ones which we now give. We believe that the new constants should enable observers to reduce their results to a consistent scale differing probably by less than 0.5 per cent from the true scale of calories per square centimeter per minute.

[1] Instruments which were broken in transportation are omitted from this list.

SMITHSONIAN REVISED PYRHELIOMETRY OF 1913.

Instrument.	New Constant 1913.*	Old values.	Where sent.
S.I. 1	0.3683	0.3709	U. S. Weather Bureau.
S.I. 2	0.3734	†0.3835	(1) Rykačev, Russia; (2) Obsy. Rio Janeiro, Brazil.
S.I. 3	0.3625	†0.3725	Violle, Paris, France.
S.I. 4	0.3713	0.3745	Chistoni, Naples, Italy.
S.I. 5	0.3672	0.3676 0.3662	U. S. Dept. Agriculture, Physical Laboratory.
S.I. 6	0.3666	†0.3771 0.3687	Officina Meteor. Buenos Aires, Argentina.
S.I. 7	0.3638	†0.3747 0.3662	Do.
S.I. 8	0.3774	0.3792	Central Observatory, Madrid, Spain.
S.I. 9	0.3737	†0.3843 0.3756	Imp. Coll. Science and Technology, London, England.
S.I. 10	0.3762	†0.3887 0.3798	K. Preuss. Meteor. Institut, Berlin, Germany.
S.I. 11	0.3769	0.3788	Meteor. Obs., Teneriffe.
S.I. 12	0.3631	0.3649	K. Preuss. Meteor. Institut, Berlin, Germany.
S.I. 13	0.3617	0.3636	Meteor. Centralanstatt, Zurich, Switzerland.
S.I. 14	0.3714	0.3767	University, Toronto, Canada.
S.I. 15	0.3609	0.3627	U. S. National Bureau Standards.
S.I. 16	0.3657	0.3672	University of Arizona, Tucson.
S.I. 17	0.3635	0.3687	Harvard Coll. Obs., Arequipa, Peru.

VARIOUS A.P.O. INSTRUMENTS.

A.P.O. IV	0.5118	‡0.902 ‡0.858	Mount Wilson, Cal.
A.P.O. V	0.4776	‡0.848	Washington, D. C.
A.P.O. VII	0.5072	.....	Mount Wilson, Cal.
A.P.O. VIII	0.5150	.....	(1) U. S. Weather Bureau; (2) Mt. Wilson.
A.P.O. 8	0.3760	.....	Washington and Mt. Wilson.
A.P.O. 8bis	0.3786	0.3805	Do.
A.P.O. 9	0.3631	0.3683	Washington, Mt. Wilson, Mt. Whitney and Algeria.

* These values are the factors by which the corrected temperature rise in 100 seconds is to be multiplied to reduce the readings to calories (15°C.) per square centimeter per minute.
† These oldest values were obtained from a round-about series of comparisons of several years standing, which now proves to have been erroneous.
‡ For 60-second exposures. From Annals Vol. II and later publications.

Note: On the relation between the Ångström scale and that of the Smithsonian Institution.—Observations made at the United States Weather Bureau, at Potsdam, and at Pawlowsk have been kindly communicated to the Smithsonian Institution, and we select from them the results of direct comparisons between the best instruments. From these we find the following ratios between readings on the Smithsonian (1913) and Ångström scales of pyrheliometry:

Observers.	Instruments.		Station.	Ratio. S. I. / Ångström.
	S.I.	Ångström.		
Kimball...........	S.I. 1	104	Washington	1.047
Marten............	S.I. 10	74	Potsdam	1.034
Savinoff...........	S.I. 2	79	Pawlowsk	1.037
			Mean..................	1.039

Summary.—A new form of standard pyrheliometer has been devised and tested. In this new instrument, as in the water-flow pyrheliometers, the solar rays are absorbed in a deep chamber approximating to the perfect absorber or "black body." Means are provided for introducing electrically test quantities of heat.

It is shown that with Standard Water-flow Pyrheliometers Nos. 2 and 3, and the new Water-stir Pyrheliometer No. 4, test quantities of heat may be measured to within 1 per cent.

A summary is given of all definitive comparisons of the three standards just named with Secondary Silver-disk Pyrheliometers, and also the net of inter-comparisons connecting all Smithsonian secondary pyrheliometers now in use. From these data are derived the best values of the constants of all these secondary pyrheliometers. This system of pyrheliometry we call "Smithsonian Revised Pyrheliometry of 1913."

It rests on 72 comparisons on 20 different days of 3 different years with 3 standard pyrheliometers of different dimensions and 2 widely different principles of measurement, all capable of recovering and measuring within 1 per cent test quantities of heat, and all closely approximating to the "absolutely black body." The 72 comparisons, 40 at Washington, 32 at Mount Wilson, were made in 6 groups. The maximum divergence of the mean results of these groups is 1 per cent. Hence it is believed that the mean result of all the comparisons made under such diverse circumstances must be within 0.5 per cent of the truth. The probable error is 0.1 per cent. It is believed that this standard scale is reproducible by the secondary pyrheliometers with the adopted constants given to within 0.5 per cent. The divergence of this scale from that of Ångström appears to be 3.9 per cent.