ART. XXIV.—*On the Correction of the Elements of the Orbit of a Comet;* by JAMES C. WATSON, M.A., Professor of Physics in the University of Michigan.

WHEN a new comet has been discovered, its orbit may be determined approximately from three observations made immediately after its discovery. If the intervals between the observations are nearly equal, the method of Olbers may be applied, but if the intervals are considerably unequal, a nearer approximation may be made by the method of Legendre. When the approximate elements have been found, and it is required to find a system of parabolic elements which will best satisfy all the observations available, the following method will be found very convenient in practice, and will invariably give satisfactory results.

Let t, t', t'', be the times of observation, corrected for the time of aberration and reduced to the same meridian; λ, λ', λ'', the geocentric longitudes, and β, β', β'', the geocentric latitudes of the comet at the date of the first, second and third observations respectively. The observations must be corrected for parallax and reduced to the mean equinox of a fixed epoch, which is usually taken at the beginning of the year. Let us also denote by R, R′, R″, the distances of the earth from the sun, and by $\odot$, $\odot'$, $\odot''$, the longitudes of the sun, for the dates of the observations respectively.

The coördinates of the first place of the earth, referred to the third, are:

$$x = R''\cos\odot'' - R\cos\odot,$$
$$y = R''\sin\odot'' - R\sin\odot.$$

If we represent by g the chord of the earth's orbit between the places corresponding to the first and third observations, and by G the longitude of the first place of the earth as seen from the third, we shall have

$$x = g\cos G,$$
$$y = g\sin G;$$

and consequently,

$$R''\cos(\odot''-\odot) - R = g\cos(G-\odot),$$
$$R''\sin(\odot''-\odot) \quad = g\sin(G-\odot). \qquad (1)$$

The coördinates of the first place of the comet referred to the third place of the earth are:

$$x_1 = \varDelta \cos\beta \cos\lambda + g \cos G,$$
$$y_1 = \varDelta \cos\beta \sin\lambda + g \sin G,$$
$$z_1 = \varDelta \sin\beta,$$

where $\varDelta$ is the distance of the comet from the earth at the first observation.

Let us now put

$$x_1 = D \cos B \cos L,$$
$$y_1 = D \cos B \sin L,$$
$$z_1 = D \sin B,$$

and we shall have

$$\begin{aligned} D \cos B \cos (L-G) &= \varDelta \cos\beta \cos(\lambda - G) + g, \\ D \cos B \sin (L-G) &= \varDelta \cos\beta \sin(\lambda - G), \\ D \sin B &= \varDelta \sin\beta. \end{aligned} \tag{2}$$

If we represent by φ the angle at the third place of the earth between the first and third places of the comet, we obtain

$$\cos\varphi = \cos B \cos\beta'' \cos(\lambda'' - L) + \sin B \sin\beta''.$$

Let us now put

$$\begin{aligned} n \sin m &= \sin\beta'', \\ n \cos m &= \cos\beta'' \cos(\lambda'' - L), \end{aligned} \tag{3}$$

and we shall have

$$\cos\varphi = n \cos(B - m). \tag{4}$$

Let $\varkappa$ be the chord of the orbit of the comet between the first and third places, and we get

$$\varkappa^2 = D^2 + \varDelta''^2 - 2D\varDelta'' \cos\varphi,$$

or

$$\varkappa^2 = (\varDelta'' - D\cos\varphi)^2 + D^2 \sin^2\varphi, \tag{5}$$

where $\varDelta''$ is the distance of the comet from the earth corresponding to the third observation.

If ψ and ψ'' represent the angles at the earth between the sun and comet at the first and third observations respectively, we shall have

$$\begin{aligned} \cos\psi &= \cos\beta \cos(\lambda - \odot), \\ \cos\psi'' &= \cos\beta'' \cos(\lambda'' - \odot''). \end{aligned} \tag{6}$$

Then, if we denote by r and r'' the distances of the comet from the sun, at the times t and t'', we obtain

$$\begin{aligned} r^2 &= (\varDelta - R \cos\psi)^2 + R^2 \sin^2\psi, \\ r''^2 &= (\varDelta'' - R'' \cos\psi'')^2 + R''^2 \sin^2\psi''. \end{aligned} \tag{7}$$

Let us now put

$$\begin{aligned} D \sin\varphi &= A, & D \cos\varphi &= a, \\ R \sin\psi &= C, & R \cos\psi &= c, \\ R'' \sin\psi'' &= C'', & R'' \cos\psi'' &= c'', \end{aligned}$$

and equations (5) and (7) become

$$\begin{aligned} \varkappa &= \sqrt{(\varDelta'' - a)^2 + A^2}, \\ r &= \sqrt{(\varDelta - c)^2 + C^2}, \\ r'' &= \sqrt{(\varDelta'' - c'')^2 + C''^2}. \end{aligned} \tag{8}$$

These equations (8) together with Lambert's equation,

$$(r+r''+\varkappa)^{\frac{3}{2}}-(r+r''-\varkappa)^{\frac{3}{2}}=\mathrm{M}(t''-t), \qquad (9)$$

where log. M$=$ 9·0137327, will enable us to determine Δ'' by successive approximations, when the value of Δ is given.

We may therefore assume a value of Δ by means of the approximate elements of the orbit, and then find the value of Δ'' for which the corresponding values of r'' and $\varkappa$ will satisfy equation (9). It will be observed that the value of Δ'' must be found by trial; and, if we assume also an approximate value of Δ'', we may find r'' from the last of equations (8) and then determine $\varkappa$ from equation (9). Then we obtain a second value of Δ'' from the equation

$$\Delta''=a+\sqrt{\varkappa^2-\mathrm{A}^2}.$$

With the value of Δ'' thus obtained we recompute r'' and $\varkappa$ as before, and in a similar manner find a still nearer approximation to Δ''. A few trials will generally give the correct result.

When Δ'' has thus been determined we find the heliocentric places of the comet by the following:

$$\left.\begin{aligned} \Delta\cos\beta\cos(\lambda-\odot)-\mathrm{R}&=r\cos b\cos(l-\odot),\\ \Delta\cos\beta\sin(\lambda-\odot)&=r\cos b\sin(l-\odot),\\ \Delta\sin\beta&=r\sin b, \end{aligned}\right\} \qquad (10)$$

$$\left.\begin{aligned} \Delta''\cos\beta''\cos(\lambda''-\odot'')-\mathrm{R}''&=r''\cos b''\cos(l''-\odot''),\\ \Delta''\cos\beta''\sin(\lambda''-\odot'')&=r''\cos b''\sin(l''-\odot''),\\ \Delta''\sin\beta''&=r''\sin b'', \end{aligned}\right\} \qquad (11)$$

where b, b'', and l, l'', are respectively the heliocentric latitudes and longitudes of the comet at the times t and t''. The values of r and r'' should agree with those obtained from equations (8).

The elements of the orbit are then found from the heliocentric places by means of the well known formulæ. For the node and inclination, we have

$$\left.\begin{aligned} \operatorname{tang} i\sin\left(\tfrac{1}{2}(l+l'')-\Omega\right)&=\frac{\pm\sin(b''+b)}{2\cos\frac{1}{2}(l''-l)}\sec b\sec b'',\\ \operatorname{tang} i\cos\left(\tfrac{1}{2}(l+l'')-\Omega\right)&=\frac{\pm\sin(b''-b)}{2\sin\frac{1}{2}(l''-l)}\sec b\sec b'', \end{aligned}\right\} \qquad (12)$$

the upper sign being used when the motion is direct and the lower sign when the motion is retrograde, corresponding respectively to the cases where $l''>l$ and $l''<l$. In these equations, Ω denotes the longitude of the ascending node, and i the inclination of the plane of the orbit to the ecliptic.

The longitudes in the orbit are given by the equations:

$$\left.\begin{aligned} \operatorname{tang}(\theta-\Omega)&=\operatorname{tang}(l-\Omega)\sec i,\\ \operatorname{tang}(\theta''-\Omega)&=\operatorname{tang}(l''-\Omega)\sec i, \end{aligned}\right\} \qquad (13)$$

where θ and θ'' are the longitudes in the orbit.

As a check on the accuracy of the computation we have

$$\varkappa^2=\left\{r-r''\cos(\theta''-\theta)\right\}^2+r''^2\sin^2(\theta''-\theta).$$

For the longitude and distance of the perihelion we put

$$\operatorname{tang}(45^\circ+\omega)=\sqrt[4]{\frac{r''}{r}},$$

and then we shall have

$$\frac{1}{\sqrt{q}}\sin F=\frac{\operatorname{tang} 2\omega}{\sin\frac{1}{2}(\theta''-\theta)\sqrt[4]{rr''}},$$
$$\frac{1}{\sqrt{q}}\cos F=\frac{\sec 2\omega}{\cos\frac{1}{2}(\theta''-\theta)\sqrt[4]{rr''}}, \qquad (14)$$

where $2F=\frac{1}{2}(\theta+\theta'')-\pi$, q denoting the perihelion distance, and π the longitude of the perihelion.

Let v and v'' be the true anomalies at the times t and t'', and we have

$v=\theta-\pi$, $\quad v''=\theta''-\pi$, $\quad$ for direct motion, and
$v=\pi-\theta$, $\quad v''=\pi-\theta''$, $\quad$ for retrogade motion.

Then for the time of perihelion passage T, we have

$$T=t\pm\frac{q^{\frac{3}{2}}\sqrt{2}}{75k}(25\operatorname{tang}^3\tfrac{1}{2}v+75\operatorname{tang}\tfrac{1}{2}v), \qquad (15)$$

which should agree with the value of T found by using the values of t'', v'', instead of t and v,

$$\log\frac{\sqrt{2}}{75k}=0\cdot0398723.$$

The preceding formulæ are all that are required for finding the elements of the orbit from two observations, when one of the geocentric distances is given. To solve the problem proposed, we assume, in the first place, an approximate value of $\varDelta$, and compute the elements of the orbit from the first and third observations, by means of these formulæ. With the elements thus obtained we compute the place of the comet for the time t', and compare it with the corresponding observation, and if we denote the computed longitude and latitude by λ'_0, and β'_0 respectively, we shall have

$$\lambda'+u'=\lambda'_0, \text{ and } \beta'+w'=\beta'_0,$$

where u' and w' are the differences between computation and observation. Next, assume a second value of the distance of the comet from the earth at the time t, which we represent by $\varDelta+\delta\varDelta$, and compute the corresponding system of elements, and we shall have as before

$$\lambda'+u''=\lambda'_0, \text{ and } \beta'+w''=\beta'_0.$$

We also compute a third system of elements from $\varDelta-\delta\varDelta$, ($\delta\varDelta$ being the same as before,) and denote the differences between computation and observation by u and w, then we shall have[1]

$$u=f(\varDelta-\delta\varDelta),\ u'=f(\varDelta),\ u''=f(\varDelta+\delta\varDelta),$$

[1] The assumed values of $\Delta-\delta\Delta$, Δ, and $\Delta+\delta\Delta$, should be so taken that the correct value of Δ—viz, that for which the differences u and w are a minimum—shall be within the limits $\Delta-\delta\Delta$ and $\Delta+\delta\Delta$, which may always be effected.

and similarly for w, w', and w''. If these three numbers are exactly represented by the expression

$$\alpha+\beta\left(\frac{x}{\delta\Delta}\right)+\gamma\left(\frac{x}{\delta\Delta}\right)^2,$$

where $\Delta+x$ is the general value of the argument;—since the values of u, u', and u'' will be such that the third differences may be neglected, this formula may be assumed to express exactly any value of the function corresponding to a value of the argument not differing much from Δ, or between the limits $x=-\delta\Delta$ and $x=+\delta\Delta$.

To find the coefficients α, β, and γ, we have[2]

Argument.	Function.	1st diff.	2d diff.	x	Function.	1st diff.	2d diff.
$\Delta-\delta\Delta$	$f(\Delta-\delta\Delta)$			$-\delta\Delta$	$\alpha-\beta+\gamma$		
		$f'(\Delta-\frac{1}{2}\delta\Delta)$				$\beta-\gamma$	
Δ	$f(\Delta)$		$f''(\Delta)$	0	α		2γ
		$f'(\Delta+\frac{1}{2}\delta\Delta)$				$\beta+\gamma$	
$\Delta+\delta\Delta$	$f(\Delta+\delta\Delta)$			$+\delta\Delta$	$\alpha+\beta+\gamma$		

whence by comparison we find

$$\alpha=f(\Delta);\ \beta=\tfrac{1}{2}\left\{f'(\Delta-\tfrac{1}{2}\delta\Delta)+f'(\Delta+\tfrac{1}{2}\delta\Delta)\right\};\ \text{and } \gamma=\tfrac{1}{2}f''(\Delta).$$

Now in order that the middle place may be exactly represented in longitude, we shall have

$$\gamma\left(\frac{x}{\delta\Delta}\right)^2+\beta\left(\frac{x}{\delta\Delta}\right)+\alpha=0,$$

from which we find

$$\frac{x}{\delta\Delta}=-\frac{1}{2\gamma}\left(\beta-\sqrt{\beta^2-4\alpha\gamma}\right)=p, \qquad (16)$$

or

$$x-p.\delta\Delta=0. \qquad (17)$$

In the same manner, the condition that the middle place shall be exactly represented in latitude gives

$$x-p'.\delta\Delta=0. \qquad (18)$$

In order that the orbit shall exactly represent the middle place, it requires that both conditions shall be satisfied simultaneously, but it will rarely, if ever, happen, that this can be effected, and we must therefore find the most probable value of x from the equations (17) and (18); viz., that for which the sum of the squares of the residuals shall be a minimum. Having thus determined the most probable value of x, we compute a final system of elements, with the geocentric distance $\Delta+x$ corresponding to the time t.

The application of these formulæ is not limited to the case of three observations. With an approximate value of Δ we may compute the elements from the extreme observations, and compare any number of intervening places, each of which will furnish two equations of condition for the determination of x. Should it be found that the residuals resulting from the final elements exceed the limits of the probable errors of the observations, the orbit cannot be a parabola, and it will be necessary to determine the excentricity.

Ann Arbor, Mich., December, 1862.

[2] The coefficient β should not be confounded with the latitude β previously used.

Art. XXV.—*Geographical Notices.* No. XIX.

PHYSICAL GEOGRAPHY OF THE REPORT ON THE MISSISSIPPI RIVER, BY HUMPHREYS AND ABBOT.

The report of Captain Humphreys and Lieut. Abbot of the Corps of Topographical Engineers of the United States Army, on the "Physics and Hydraulics of the Mississippi River," has already been noticed in this Journal, in an article which gave a conspectus of the entire work.[1] The universal interest now felt in everything which illustrates the Physical Geography of the United States, the importance of this elaborate survey of the most characteristic region of our country, and the difficulty of obtaining copies of so costly a volume lead us to refer again to some of the statements which are made by the authors.

The immediate occasion of this work, as the reader will remember, was an act of Congress directing a scientific survey of the Mississippi Delta, including such investigations as might tend to determine the most practicable plan for securing it from inundation, and the best modes of deepening the channels at the mouths of the river. The report, consequently, is chiefly devoted to the Physics and Hydraulics of the river, that is to say, to the laws of velocity and volume, and the possibility of so controlling the current, as to protect the regions adjacent to the delta from destructive floods, and so as to maintain the facilities of navigation in the channels near the gulf. But the topography and hydrography of the entire basin of the Mississippi, including all its various tributaries, are likewise elaborately discussed. It is to this portion of the report, the Physical Geography, that we now call attention. Our object will be to condense within a limited space, some of the geographical facts which the volume contains, so that those who cannot consult the work itself may turn here for such information. In doing this we shall confine ourselves, without comment, to the statements of the authors, generally employing their own language. We regret that the limit of this article compels us to omit some of the interesting details which their scientific zeal and thoroughness have brought together.

Regarding the true Mississippi river as beginning at the confluence of the Upper Mississippi and the Missouri, eight of its tributaries are so important as to be distinguished from all the rest. In the order of the magnitude of their basins, these are the Missouri, Ohio, Upper Mississippi, Arkansas, Red, White, Yazoo and St. Francis. They are described in the order of their geographical position, first the right bank and then the

[1] [2], xxxiii, 181.

left, beginning with the southernmost, as follows: Red, Arkansas, White, St. Francis, Missouri, Upper Mississippi, Ohio and Yazoo.

1. *Red river Basin.*[2]—Few regions so limited in area, say the authors, are so diversified in character as this basin. While it includes only 97,000 square miles, large tracts of rich alluvion, a range of primitive mountains, numerous lakes, a rolling prairie, and a salt-desert tract are found within its borders. Capt. Marcy, U. S. A., first explored the sources of Red river in 1852. The general course of the stream is thus delineated in his report.

The Red river rises in the eastern rim of the vast desert plain known as *el Llano Estacado* at an elevation of about 2,500 feet above the sea. After flowing through a narrow ravine, some sixty miles in length, the river passes to the south of the Witchita Mts., the highest peak of which, Mt. Scott, is 1135 feet above its base. Beyond this, to the east, the river traverses "the cross timbers," an extensive belt of woodlands, which extend, between twenty and thirty miles in width, from the Arkansas river to the Brazos, some 400 miles. Still farther east, the celebrated Red river raft, an accumulation of drift logs, about thirteen miles long, obstructs the course of the stream. Below this, the river traverses a fertile and populous region, the character of which is well known.

The width of the Red river between its banks, eight miles below the point where it issues from the *Llano Estacado*, is 2700 feet; just below the mouth of the North fork, 2000 feet; about 50 miles below the mouth of this tributary, 2100 feet; at the mouth of the Big Witchita, 600 feet; at Alexandria, 720 feet; at mouth of Black river, 785 feet; at mouth, 1800 feet. These numbers indicate the characteristic variation in width. While traversing the sandy desert, the river spreads out to a width greatly disproportionate to the depth; but when the more fertile and clayey soil is entered, it contracts to the normal dimensions corresponding to its discharge.

The depth of Red river varies inversely as its width, being only 6 or 8 feet, even in floods, throughout the desert, while it is some 50 feet in the fertile region. In extreme low water, a depth of 3 feet may be depended upon below Alexandria, about 4 feet thence to the head of the raft, and one foot thence to Fort Towson.

Steamers of 4 feet draught can ascend to Shreveport at any time except in extreme low water, but to Fort Towson or even Fulton, for only about three months in the year, and they frequently only run in one direction during a single rise.

The river above the raft rises and falls more rapidly than the

[2] The river takes its name from the reddish color of the water, probably derived from the red gypsum over which it passes.

Arkansas, and thus is less favorable to navigation. The raft also is a serious obstacle, as it requires the boats to leave the channel and pass through lakes and bayous.

The high-water area of cross-section throughout the desert country is probably about 12,000 square feet, and in the cultivated region from 30,000 to 40,000.

The range of the river is greatly affected by the raft. Thus at Fort Towson it is some 45 feet, the maximum (January 27, 1843) being 51 feet; at Fulton it is 35 feet; at the head of the raft, 10 feet; at Shreveport, 25 feet; at Alexandria, 47 feet; at the mouth, 45 feet. These numbers illustrate the effect of lakes in moderating floods.

The only important tributary of the Red river is the Black river, formed by the junction of the Washita, (the Indian name for Black,) Little river, and Bayou Tensas. It is only 54 miles in length.

The following figures exhibit the high water slope of Red river.

Locality.	Distance above mouth.	Elevation above gulf level.	Fall per mile.	Authority.
	Miles.	*Feet.*	*Feet.*	
Source, - - - - - - -	1200	2450	0·00	Captain Marcy.
At Preston, - - - - - -	820	641	4·80	Captain Pope.
At Fulton, - - - - - -	595	242	1·80	Railroad levels.
At head of raft, - - - - -	405	207	0·20	Mr. C. A. Fuller.
At Shreveport, - - - - -	330	180	0·36	Railroad levels.
Mouth of Black River (high water 1828),	30	58	0·41	Delta Survey.
Mouth (high water 1828), - -	00	54	0·14	Delta Survey.

2. *Arkansas and White River Basin.*—This basin includes an area of 189,000 sq. m., the western portion of which lies among the summits of the Rocky Mountains, the middle portion comprises the great sterile plain between the mountains and 97° west long., and the eastern part, the rich alluvion of the Mississippi valley. Although diversified in climate and production, less than half this area is fitted to supply the wants of a civilized people.

Lieut. Pike, U. S. A., explored the sources of the Arkansas river in 1806. They lie among the Mts., west of the South Park, in lat. 39° and long. 106°, about 10,000 ft. above sea level. Half this elevation is lost in the first 150 miles. The stream then traverses a sterile hilly region, the hills gradually diminishing in size, till they subside into the plain westward of Bent's Fort, near 104° W. long. Maj. Emory's Report on Gen. Kearny's route in 1846 describes the river between Bent's Fort and Great Bend. It is seldom over 150 yards wide, and generally fordable. The bottom land a few feet above the water level varies from half a mile to two miles and is generally covered with good nutritious grass. Beyond Bent's Fort to the east, the 'big timber' is found, a thinly scattered growth of large cottonwoods.

Thence to Fort Smith, the river is described by Capt. Bell, who explored it in 1820. The bluffs here approach close to the river bed. Ravines become more abundant and like the river banks are well wooded. The water becomes slightly brackish from the saline springs near the right bank. Below the Cimmaron the river loses its pale clay hue and becomes reddish. Fort Gibson marks the head of navigation, beyond which the river, in the remaining 642 miles, traverses a fertile and settled region.

"The width of the Arkansas undergoes great variations. Near the mountains it does not exceed 150 feet. It gradually increases to about a mile, as it traverses the sandy desert. After entering the hilly and fertile region it varies from 1000 to 2000 feet.

The depth of the Arkansas also varies greatly in different parts of its course. Throughout the prairie region it averages about two or three feet, exclusive of shoals, but there are seasons when the water entirely disappears, being absorbed by the immense beds of sand in which its channel is formed. In the navigable part of the river the least depth found upon the bars in extreme low water, from the mouth to the Post of Arkansas, is from 2·5 to 3·0 feet; thence to Little Rock, two feet; thence to Fort Gibson, one foot.

The range of the river between low and high water is about 45 feet at Napoleon; 40 feet at South bend; 35 feet at Little Rock; 25 feet at Fort Smith; 10 feet at Fort Gibson, and still less at points above. These numbers do not represent the *extreme* ranges, although they are much greater than those that usually occur.

There are generally three annual rises in the Arkansas. As observed by Colonel Charles Thomas, U. S. Army, who served at Fort Gibson many years, they are as follows: One usually begins in February, owing to the winter rains, and lasts, on an average, about fifteen days. The next—the principal rise in the year—is occasioned by the melting snows in the mountains and the late spring or early summer rains. It occurs in May and June, and continues into July, and sometimes into August. The river generally keeps up, between these two rises, some one or two feet above its lowest stage. The last rise is in November, produced by the late autumn rains, and lasts from ten to twenty days.

Steamboats from three to four feet draught can almost always reach a point some 40 miles above Little Rock, and during the floods can reach as far as Fort Smith and Fort Gibson, with a fair prospect of being able to return. Both the Canadian and Arkansas have been navigated with small steamers as far up as the wants of the military service have required. Steamers of eight feet draught have reached Fort Smith, but their return during the same rise is not certain. The river is generally very low after the November rise. During the lowest stage it is difficult for boats of the lightest draught to reach Fort Smith.

The greatest flood of the Arkansas on record occurred in 1833. Authorities differ as to its relative height at Little Rock, but the evidence tends to the conclusion that it exceeded any subsequent flood by at least two feet."

The high water slope of the Arkansas is thus stated:

Locality.	Distance above mouth.	Elevation above sea level.	Fall per mile.	Authority.
	Miles.	*Feet.*	*Feet.*	
Source, - - - - - -	1,514	10,000	0·00	Captain Fremont.
Mouth of Boiling-spring river,	1,364	4,880	34·13	"
Mouth of Apishpa creek, -	1,323	4,371	12·41	Captain Gunnison.
Near Bent's fort, - - -	1,289	3,672	20·56	"
Near Fort Atkinson, - -	1,095	2,331	6·91	"
Great bend, - - - - -	992	1,658	6·53	Major Emory.
Near Fort Gibson, - -	642	560	3·14	
Near Fort Smith, - - -	522	418	1·18	Lieutenant Whipple.
Near Little Rock, - - -	250	252	0·61	Railroad levels.
Mouth, - - - - - -	0	162	0·36	Railroad levels.

The Arkansas has two noteworthy tributaries. The Canadian, which rises in the Raton pass, 6000 feet above sea level, after traversing in a course of 1000 m. the same barren region through which the Arkansas flows, empties into the latter midway between Forts Smith and Gibson. The White River drains the fertile region which crosses the Arkansas above Fort Gibson. Its sources are about 1200 feet above the Gulf.

3. *St. Francis Basin.*—This region, including an area of 10,500 sq. m., consists of the St. Francis bottom and its watershed.

"By the former is understood the belt of swamp lands and low ridges lying between the Mississippi river and the line of high hills which extends almost continuously from Cape Girardeau to Helena. Some small portions of this area do not drain into the St. Francis river, but, being similar in character, the entire region is properly designated by a general name.

A portion of the southern slope of the Ozark mountains constitutes the chief watershed of this region.

As the St. Francis bottom lands are the most northern of those regions which have been generally considered "vast reservoirs for the flood waters of the Mississippi," great efforts have been made to collect all possible information about their real character. Extended personal inquiries and measurements have been made in many different localities. The surveys of the military road from Memphis to the St. Francis river, made by Dr. William Howard, U. S. civil engineer, in 1833; those of the Memphis and Little Rock railroad company, made in 1854; those of the Fulton and Little Rock railroad company, made in 1855 (?); and those of the route from St. Louis to Fulton, made in 1850, under the direction of the Bureau of Topographical Engineers, War Department, by Joshua Barney, C. E., have all been carefully studied. Much assistance has also been derived from the admirable chapter upon the swamp lands of southeastern Missouri, contained in the report of Messrs. O'Sullivan and Morley, engineers of the St. Louis and Iron Mountain railroad company, and published with the second annual report of the board of directors of that road (St. Louis, 1854). Together with its accompanying maps, this work furnishes nearly all the general information which could be desired about the Missouri portion of these bottom lands.

Boundaries and areas.—The St. Francis bottom is bounded as follows: Starting at Cape Girardeau, on the Mississippi river, the line runs a little south of west to the northwest corner of T. 29, R. 11, east; thence southwest to the St. Francis river, near the northeast corner of T. 26, R. 7, east; thence south along the St. Francis river[3] to the southeast corner of T. 22, R. 8, east; thence southwest to the northeast corner of T. 14, R. 4, east; thence nearly south to the middle of T. 3, R. 3, east; thence to Helena, and thence, following the Mississippi river, to Cape Girardeau. Within these limits there are many isolated ridges entirely above overflow.

The limits of the watershed of the St. Francis basin can be readily and exactly traced upon Hutawa's sectional map of Missouri, by following the divide which separates small streams running to and from the bottom lands. The Ozark slope constitutes fully two-thirds of the entire region.

The following table has been carefully computed in accordance with the above boundary, and is believed to be quite accurate :—

	Square miles.
Watershed of St. Francis bottom lands, ...	3,600
Ridges known to be above overflow in St. Francis bottom lands,......	600
Lands liable to be submerged in " " "	6,300
Total area of St. Francis basin,...........................	10,500

Topography.—The northern watershed is a broken, hilly country, sloping very abruptly to the bottom lands. Its mean descent southward is about 1200 feet in 70 miles, or at a mean rate of about 17 feet per mile.

The swamp region is, in general character, a great plain sloping from north to south at a mean rate of about 0·7 of a foot per mile, judging by the fall of the Mississippi between Cape Girardeau and Helena; and from east to west at a mean rate of about 0·5 of a foot per mile, judging by the levels of the Memphis and Little Rock railroad, which crossed the bottom near the middle line. This country is separated from the rolling praries west of it, which drain into White river, by a single narrow ridge averaging 300 feet in height."

4. *Missouri Basin.*—[The account of this basin having already been given in these pages, [2], xxxiii, p. 185, we omit it in this place.]

5. *Upper Mississippi Basin.*—Although the Upper Mississippi is neither the longest tributary, nor the greatest contributor of drainage, nor the branch most like in character to the great Mississippi, it bears its name and has thus always been an object of especial interest to geographers.

"The distinguishing characteristic of this portion of the Mississippi basin is the entire absence of mountains. Near the source of the river, the country is only some 1600 feet above the level of the sea, and is covered with swamps and lakes, divided by hills of sands and boulders be-

[3] The St. Francis river, when in flood, loses some of its water in this vicinity by bayous connecting with Black river, a tributary of White river of Arkansas.

longing to the Drift epoch. The middle and southern portions of the basin consist of prairie land, and are rapidly becoming cultivated. The agricultural and mineral resources of this basin are great, the climate is salubrious, and the country must eventually sustain a large and wealthy population. Its total area is 169,000 square miles."

Lake Itasca, in which the Upper Mississippi rises, is described by Mr. Schoolcraft as a beautiful sheet of deep water, seven miles long and from one to three broad. Nicollet, in 1836, determined its geographical position and elevation to be 47° 14′ N. lat., 95° 02′ W. of Greenwich. The elevation of the lake, by barometrical observations, he places at 1575 feet above the ocean level.

The Mississippi passes through several lakes and by successive rapids and waterfalls to the Falls of St. Anthony where it falls in less than three quarters of a mile a distance of 65 feet. Two tables given in the report exhibit the most important facts respecting this region.

Low-water slope of Upper Mississippi.

Locality.	Distance above mouth of Missouri	Elevation above sea.	Fall per mile.	Authority.	Remarks.
	Miles.	*Feet.*	*Feet.*		
Utmost source, - -	1330	1680	0·00	Mr. Nicollet.	
Itasca lake, - - -	1324	1575	17·50	"	
Entrance to Lac Travers,	1234	1456	1·32	"	
Entrance to lake Cass,	1189	1402	1·20	"	10 miles through lakes.
Mouth Leech-lake river,	1109	1356	0·57	"	35 miles through lakes.
Head of falls of Peckagama,	1061	1340	0·33	"	
Mouth Swan river, -	998	1290	0·73	"	Rapids intervening.
Mouth Sandy-lake river,	960	1253	0·95	"	Rapids intervening.
Mouth Pine River, -	863	1176	0·79	"	Rapids intervening.
Mouth Crow-wing river,	815	1130	0·95	"	Rapids intervening.
St. Paul, - - -	658	670	2·93	R. road levels.	Sauk rapids, falls of St. Anthony, etc.
La Crosse, - - -	514	639	0·22	" "	
Prairie du Chien, -	453	600	0·64	" "	
Head Rock Island rapids,	310	505	0·66	" "	
Foot " " "	295	483	1·47	" "	Rapids intervening.
Mouth, - - -	0	381	0·35	" "	Des Moines rapids intervening (low-water fall 21 feet).

"These elevations refer to the low water of the Mississippi. The range between high and low water level is about 20 feet near Sandy-lake river; about 20 feet at St. Paul; about 10 feet (extreme, 14 feet) at La Crosse; about 12 feet (in 1858, 18·5 feet) at Prairie du Chien; about 16 feet at Rock Island; about 20 feet at Hannibal, and about 35 feet at the mouth. These ranges are much less than those of the Ohio, and, excepting the Missouri, of the other tributaries of the Mississippi, where they pass through the cultivable region. Their small extent is due to the generally flat character of the basin, from which the drainage is consequently slow; the existence upon it of numberless lakes; the great width of the river; the gradual change in season that takes place along its course; and the comparatively dry climate of the upper part of the basin."

The following table exhibits a correct list of the tributaries.

Name.	Distance of mouth above mouth of Missouri.	Length of Tributary.	Remarks.	Name.	Distance of mouth above mouth of Missouri.	Length of Tributary.
	Miles.	Miles			Miles.	Miles
Source branch,	1324		Itasca lake.	Crow river,	699	
Turtle river,	1180	40	Cass lake.	Rum river,	690	150
Leech-lake river,	1109	50		Rice river,	683	
Mash-kudens river,	1055			St. Peter's river,	663	
Swan river,	998		Rapids intervening.	St. Croix river,	631	168
Sandy-lake river,	960		"	Vermilion river,	630	
Willow river,	930			Cannon river,	611	82
Pine river,	863	140	"	Chippeway river,	581	165
Crow-wing river,	815		"	Embarras river,	562	
Nokay river,	806			White river,	560	
Belle Prairie creek,	796			Black and La Crosse rivers,	516	128[1]
Elk creek,	782			Root river,	511	83
Pike creek,	787			Upper Iowa river	489	
Swan river,	786			Wisconsin river,	448	338
Two rivers,	777			Turkey river,	425	
Spunk river,	773			Wabesipinnicon river,	320	205
Platte river,	771			Rock river,	291	245
Little Rock creek,	760			Cedar river,	245	255
Watab and Winnebago rivers,	757			Skunk river,	205	
Lower Watab,	754			Des Moines river,	165	402
Sauk river,	752		Rapids 1 mile.	Illinois river,	24	397
Nechoado river,	744			Missouri river,	0	
Clear-water river,	73 6					
Elk or St. Francis river,	705	100				

[1] Black river.

6. *Ohio Basin.*—

" The Ohio river drains the northeast portion of the Mississippi basin —a fertile and populous region throughout nearly its whole extent. The southern tributaries rise in the Alleghany mountains, and flow northward through an undulating and beautiful country to the main stream. The northern tributaries have their source in the crest of the level plateau which lies immediately south of the great lakes, at an elevation varying from 500 to 1000 feet above their water surfaces, and flow southward through a fertile prairie and undulating country to the Ohio. The boundaries of the basin are indicated on plate I, and its character is so well known as to require no description here. Its total area is 214,000 square miles.

Ohio River.—The Ohio is formed by the junction of the Alleghany and Monongahela rivers. The former, which is the principal branch, rises in the mountains of Pennsylvania, the latter in those of Virginia. Throughout its whole length (975 miles) the river flows with a gentle current, uninterrupted by rapids except at the "falls of Ohio" near Louisville, when it descends 26 feet in three miles. It traverses a beautiful valley and is constantly augmented by tributary streams.

The Ohio in low water is a succession of long pools and ripples, with a current alternately sluggish and rapid. The bars in the upper part of the river are mainly composed of gravel, and in the lower part, of shifting sand.

Of the Alleghany branch, nothing need be said except that near its sources it flows between hills, through a very narrow strip of fertile bottom land, and with a more uniform slope than near the mouth, where it traverses a rocky and precipitous ravine, with a bed composed mainly of sandstone or gravel-bars. [Captain Hughes, Topl. Engrs., U. S. A.]

Of the Monongahela branch, some curious facts stated by Dr. William Howard in 1833 merit attention. It rises in the Alleghany mountains and subordinate ranges in Virginia, and is formed by the junction of the East and West branches and Cheat river. The former streams head in Laurel ridge, and flow in rocky channels. The tributaries of Cheat river rise in the summit of the Alleghanies, and form mountain torrents until they unite in a river scarcely less wild than themselves. The Cheat forces its way through deep gorges with nearly perpendicular side-slopes to the Monongahela, falling 2400 feet in the last 80 miles. Below the junction the river is gentle in character. It winds with a serpentine course, without islands, through a terraced valley. Its slope here is *less than that of the Ohio.* Thus the fall from the mouth of Cheat river to Brownsville (35 miles) is 44 feet, or 1·26 feet per mile, and from Brownsville to Pittsburg (55 miles) only 31 feet, or 0·56 of a foot per mile; while the corresponding fall of the Ohio near Pittsburg is about one foot per mile. The fall of the Monongahela, above the junction of Cheat river, averages about two feet per mile for over 100 miles. The anomaly in slope near the mouth of this river is less in high than in low water, the usual range at Brownsville being 15 or 20 feet more than that at Pittsburg. At low water the Monongahela is a succession of pools separated by bars composed of gravel and loose stones, not subject to sudden changes. Its water is quite free from sedimentery matter."

Low-water slope of the Ohio, according to Ellet.

Locality.	Distance above mouth.	Elevation above tide.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
Mouth of Ohio,	0	275	0·00
Mouth of Wabash (approximately),	130	297	0·17
Evansville (approximately),	187	320	0·25
New Albany, below the falls,	358	353	0·20
Louisville, above the falls,	361	377	8·00
Cincinnati,	515	432	0·36
Portsmouth,	620	474	0·40
Mouth of Great Kanawha,	714	522	0·51
Head of Le Tart's shoals,	769	555	0·60
Marietta (mouth of Muskingum),	800	571	0·52
Wheeling,	889	620	0·55
Pittsburg,	975	699	0·92
Franklin,	1105	960	2·00
Warren,	1175	1187	3·24
Chautauque lake,		1306	
Olean point,	1225	1403	4·32
Mouth of Oswaya,		1419	
Smithport,		1480	
Coudersport,	1265	1649	6·15
Surface of lake Erie,		565	

"It will be noticed that these elevations correspond to the low-water period. The range between extreme low and extreme high water seems to be about 45 feet throughout the entire river. Thus, at Wheeling, it is 45 feet; at Louisville, 42 feet *on* the falls and 64 feet *below* them;[2] at Evansville, 40 feet; at Paducah, 51 feet; and at the mouth of the river, 51 feet. The usual range does not exceed 25 feet."

7. *Yazoo Basin.*—The Yazoo basin, having an area of 13,850 square miles, consists of the Yazoo bottom and its watershed. The Yazoo bottom is an alluvial tract, oval in shape, bordering on the Mississippi between Memphis and Vicksburg. It consists of 6800 square miles of lands liable to be submerged, 310 square miles of ridges and 6740 square miles of lands draining into the bottom. It is in general a vast densely timbered plain, sloping from the Mississippi toward the east at a mean rate of about 0·4 of a foot per mile. There are three classes of land in the Yazoo bottom, "high land," rarely overflowed, middle land, overflowed during the wet season, and the low "cypress swamps," parts of which always contain water.

The Yazoo river, from its proper source, Horn Lake, to the Mississippi, is about 500 miles long, and is navigable 240 miles to Greenwood, for boats drawing two or three feet. Indian mounds are found through the entire bottom.

8. *Basins of Small Direct Tributaries.*—Four of these will be noticed. Their total area is 32,400 square miles. This country is situated where the rain is greatest, and contributes more than is generally supposed to the discharge of the river.

"*Maramec basin.*—The northern slope of the eastern portion of the Ozark mountains drains into the Maramec river, a stream which enters the Mississippi a few miles below St. Louis. This basin is hilly in character, containing no lands liable to inundation. Its area, taken from Hutawa's sectional map of Missouri, is 5470 square miles. This estimate includes all the country between the Missouri and Cape Girardeau, on the right bank, which drains directly into the Mississippi.

Kaskaskia basin.—Under this head is included all the region draining into the Mississippi on the left bank, between the mouth of the Missouri and the mouth of the Ohio. It is named from its principal stream, although there are others of considerable size—the Big Muddy, for instance. The country is mainly prairie, but, upon the immediate bank of the Mississippi, a considerable area is liable to inundation in great floods. The "American bottom," between the mouths of the Missouri and Kaskaskia rivers, contains the greater part of this swamp country, but there is another limited belt above Cairo. The area of the whole basin is about 9420 square miles.

The Kaskaskia river itself resembles the Illinois. It flows with a very crooked course through a heavily timbered alluvial bottom, liable to be overflowed to a depth of eight or ten feet in freshets. Its bed is almost dry in the summer, but when high the stream has a strong current.

[2] At a medium stage of water, a rise of one foot on the falls makes a rise of about three feet below them, until the water on the falls is about five feet deep. Subsequently, the rate of rise below is rather less than two feet.

Obion basin.—Between the Ohio river and the head of the Yazoo basin lies an extended tract of country, which, for want of a better name, has been designated the Obion basin. It is drained by four nearly parallel rivers: the Obion, the Forked-deer, the Hatchee, and the Wolf; the Hatchee alone being, properly speaking, a navigable stream. The area of the entire region is about 10,250 square miles.

This region is in the main an upland, hilly country, but, as shown on plate II, the Obion and Forked-deer rivers flow through somewhat extensive swamps near their mouths. It is generally believed that the great earthquake in 1811, which depressed so much country on the opposite bank, materially increased the area of these swamps.

The Hatchee river, before certain railroads were built, was an important avenue for transporting cotton from the interior to the Mississippi. It is navigable to Bolivar—some 150 miles—from four to six months in the year; its usual range between low and high water being about 15 feet at Bolivar and 30 feet at its mouth. Its average high-water width is about 350 feet, and its high-water cross-section about 8000 square feet.

Big-Black basin.—The region draining into the Mississippi between the mouth of the Yazoo river and the alluvial lands below Baton Rouge is classed under this general head. It is drained by many streams, the two principal being the Big Black, which enters the Mississippi just above Grand Gulf, and the Homo Chitto, which enters below Ellis cliffs. Excepting a narrow strip along the immediate bank of the Mississippi, this whole basin is made up of a rolling, hilly country, entirely above any danger of inundation. Its area is about 7260 square miles."

Following this account of the various tributaries of the Mississippi, the authors proceed to discuss the river itself below the mouth of the Missouri. This is done in the second chapter of their volume, the contents of which have been given in the article already referred to (vol. xxxiii, p. 187). We hope to revert again to this portion of the report, and perhaps to other geographical discussions which the volume contains.

The figures which illustrate the character of the main river and also of the tributaries described in the present article, are summed up in the following tables, which will be of permanent value to all who are interested in the study of the great Mississippi valley. In conclusion, we desire to express our admiration of the thorough and comprehensive manner in which the investigations of Messrs. Humphreys and Abbot have been conducted. The work reflects the highest honor upon the fidelity, patience and science of the distinguished authors.

TABULAR VIEW OF THE MISSISSIPPI AND ITS TRIBUTARIES.

River.	Distance from mouth.	Elevation above sea.	Fall per mile	Width between banks.	Least low water depth upon the bars	Range between low and high water.	Area of cross-section at high water
	Miles.	Feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.
Ohio river.		low water					
Coudersport,	1265	1649					
Olean point,	1225	1403	6·15				
Warren,	1175	1187	4·32				
Franklin,	1105	960	3·24				
Pittsburg,	975	699	2·00				
Wheeling,	889	620	0·92			45	
Marietta,	800	571	0·55	1200			50,000
Head Le Tart's shoals,	769	555	0·52		1·0		
Mouth Great Kanawha,	714	522	0·60				
Portsmouth,	620	474	0·51				
Cincinnati,	515	432	0·40		2·0		
Above falls,	361	377	0·36			42	
Below falls,	358	353	8·00			64	
Evansville,	187	320	0·20		1·5	40	
Mouth Wabash,	130	297	0·25	3000			150,000
Mouth,	0	275	0·17		3·0	51	

Remarks.—Area of basin, 214,000 sq. m.—Downfall of rain, 41·5 in.—Annual discharge, 5,000,000,000,000 cu. ft.—Ratio between downfall and drainage, 0·24.—Mean discharge per second, 158,000 cu. ft.

River.	Distance from mouth.	Elevation above sea.	Fall per mile	Width between banks.	Least low water depth upon the bars	Range between low and high water.	Area of cross-section at high water
Upper Mississippi.		low water					
Utmost source,	1330	1680					
Itasca lake,	1324	1575	17·50	15			50
Entrance to Lac Travers,	1234	1456	1·32	150			
Entrance to Lake Cass,	1189	1402	1·20	175			1,400
Mouth Leech-lake river,	1109	1356	0·57				
Head falls of Peckagama,	1061	1340	0·33	120			
Mouth Swan River,	998	1290	0·73				
Mouth Sandy-lake river,	960	1253	0·95	300		20·0	
Mouth Pine river,	863	1176	0·79				
Mouth Crow-wing river,	815	1130	0·95	1200			
St. Paul,	658	670	2·93			20·0	
La Crosse,	514	639	0·22		2·0	14·0	
Prairie du Chien,	453	600	0·64			18·5	
Head Rock Isl'd rapids,	310	505	0·66	5000		16·0	100,000
Foot Rock Isl'd rapids,	295	483	1·47		2·0		
Mouth Missouri,	0	381	0·35			35·0	

Remarks.—Area of basin, 169,000 sq. m.—Downfall of rain, 35·2 in.—Annual discharge, 3,300,000,000,000 cu. ft.—Ratio between downfall and drainage, 0·24.—Mean discharge per second, 105,000 cu. ft.

River.	Distance from mouth.	Elevation above sea.	Fall per mile	Width between banks.	Least low water depth upon the bars	Range between low and high water.	Area of cross-section at high water
Missouri river.		low water					
Source Madison fork,	2908	6800(?)					
Three forks Missouri,	2824	4319	29·52				
Mouth Sun river,	2689	3573	5·54				
Foot of falls,	2670	2964	31·59				
At Fort Benton,	2644	2845	4·56	1500		6	
At Fort Union,	1894	2188	0·88				
At Fort Pierre,	1246	1475	1·10	2500	1·0		
At Sioux City,	842	1065	1·01				
At St. Joseph,	484	756	0·86	3000		20	75,000
At mouth,	0	381	0·77			35	

Remarks.—Area of basin, 518,000 sq. m.—Downfall of rain, 20·9 in.—Annual discharge, 3,780,000,000,000 cu. ft.—Ratio between downfall and drainage, 0·15.—Mean discharge per second, 120,000 cu. ft.

TABLE—CONTINUED.

River.	Distance from mouth.	Elevation above sea.	Fall per mile	Width between banks.	Least low water depth upon the bars	Range between low and high water.	Area of cross-section at high water
	Miles.	Feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.
Arkansas river.		high wat.					
Source,	1514	10000					
Mouth Boiling spring r.	1364	4880	34·13	150			
Mouth Apishpa creek,	1323	4371	12·41				
Near Bent's Fort,	1289	3672	20·56				
Near Fort Atkinson,	1095	2331	6·91	5000	0·0	6	30,000
Great bend,	992	1658	6·53				
Near Fort Gibson,	642	560	3·14		1·0	10	
Near Fort Smith,	522	418	1·18	1500		25	70,000
Near Little Rock,	250	252	0·61		2·0	35	
Mouth,	0	162	0·36			45	

Remarks.—Area of basin (including White r.), 189,000 sq. m.—Downfall of rain (including White r.), 29·3 in.—Annual discharge (including White r.), 2,000,000,000,000 cu. ft.—Ratio between downfall and drainage, 0·15.—Mean discharge per second (including White r.), 63,000 cu. ft.

River.	Distance from mouth.	Elevation above sea.	Fall per mile	Width between banks.	Least low water depth upon the bars	Range between low and high water.	Area of cross-section at high water
Red river.		high wat.					
Source,	1200	2450		2000		8	12,000
At Preston,	820	641	4·80			40	
At Fulton,	595	242	1·80		1·0	35	
At head of raft,	405	207	0·20			10	
At Shreveport,	330	180	0·36	800	3·0	25	40,000
Mouth Black river,	30	58	0·41			45	
Mouth,	0	54	0·14				

Remarks.—Area of basin, 97,000 sq. m.—Downfall of rain, 39·0 in.—Annual discharge, 1,800,000,000,000 cu. ft.—Ratio between downfall and drainage, 0·20.—Mean discharge per second, 57,000 cu. ft.

River.	Distance from mouth.	Elevation above sea.	Fall per mile	Width between banks.	Least low water depth upon the bars	Range between low and high water.	Area of cross-section at high water
Yazoo river.		high wat.					
Horn lake,	500	210					
Greenwood,	240	140	0·27	850	2·5	36	17,000
Mouth,	0	103	0·16			48	50,000

Remarks.—Area of basin, 13,850 sq. m.—Downfall of rain, 46·3 in.—Annual discharge, 1,350,000,000,000 cu. ft.—Ratio between downfall and drainage, 0·90.—Mean discharge per second, 43,000 cu. ft.

River.	Distance from mouth.	Elevation above sea.	Fall per mile	Width between banks.	Least low water depth upon the bars	Range between low and high water.	Area of cross-section at high water
St. Francis river.		high wat.					
Source,	380	1150					
Head swamp region,	275	230	7·81				9,400
Chalk bluffs,	225	280	1·00				2,300
M. and L. R. railroad,	55	209	0·42	700		40	21,000
Mouth,	0	200	0·16				37,000

Remarks.—Area of basin, 10,500 sq. m.—Downfall of rain, 41·1 in.—Annual discharge, 990,000,000,000 cu. ft.—Ratio between downfall and drainage, 0·90.—Mean discharge per second, 31,000 cu. ft.

River.	Distance from mouth.	Elevation above sea.	Fall per mile	Width between banks.	Least low water depth upon the bars	Range between low and high water.	Area of cross-section at high water
Main Mississippi.		high wat.					
Mouth of Missouri,	1286	416·0					
St. Louis,	1270	408·0	0·500		2·0	37·0	
Cairo,	1097	322·0	0·497			51·0	
Columbus,	1076	310·0	0·571	4470	5·0	47·0	191,000
Memphis,	872	221·0	0·436			40·0	
Gaines' landing,	647	149·0	0·320				
Natchez,	378	66·0	0·309	4080	6·0	51·0	199,000
Red-river landing,	316	49·5	0·266			44·3	
Baton Rouge,	245	33·9	0·220	3000		31·1	200,000
Donaldsonville,	193	35·8	0·156			24·3	
Carrolton,	121	15·2	0·147			14·4	
Fort St. Philip,	37	5·2	0·119	2470		4·5	199,000
Head of passes,	17	2·9	0·115			2·3	
Gulf,	0	0·0	0·171			0·0	

Remarks.—Drainage area, 1,244,000 sq. m.—Downfall of rain, 30·4 in.—Annual discharge (including 3 outlet bayous), 21,300,000,000,000 cu. ft.—Ratio between downfall and drainage, 0·25.—Mean discharge per second, 675,000 cu. ft.

RECENT EXPLORATIONS ENCOURAGED BY THE SMITHSONIAN INSTITUTION.

Those who have paid attention to the Reports of the Smithsonian Institution are aware that one method by which that establishment has contributed to the advancement of science has been the encouragement of expeditions in different parts of this continent, for the collection of specimens in natural history, and for the observation of physical phenomena. The report recently distributed, which covers the proceedings of the Institution for the year 1861, contains some interesting information respecting the progress of several explorations.

Explorations in the Peninsula of California, by Mr. John Xantus.—Mr. Xantus, having previously distinguished himself as a collector in natural history, by the researches which he made from the summer of 1857 to the autumn of 1858, in the neighborhood of Fort Tejon,—was placed by the superintendent of the Coast Survey, Prof. Bache, in charge of a tidal station at Cape St. Lucas. He reached the cape in April, 1859, and since that time he has made, says Prof. Baird, "collections which vie in thoroughness with those of Fort Tejon; and exceed them in number of species, embracing as they do marine as well as fresh water and land forms." In another connection, we learn from Prof. Baird, the following noteworthy facts. Besides the addition of a larger number of new animals to our fauna than has been made by one person in any single region of North America before, Mr. Xantus has shown that the most interesting relationship exists between the land species of the Cape and those of the region of the Gila, Upper Rio Grandé, and the southern Rocky Mountains. On the other hand, very few of the characteristic species of the coast of Upper California occur at the Cape; while, as far as observed, the same may be said of the strictly Mexican types. The entire Peninsula thus proves to be as specially related to North America in its land fauna as is Florida, although the number of peculiar species is much greater.

The marine fauna of Cape St. Lucas proves to be quite Panamaic in its general features—much more so than that of the opposite coast of Mexico.

The whole of the collection made by Mr. Xantus had not arrived in Washington when the report for 1861 was closed, but sixty boxes, some of large size, had been received. It is known that he has collected about twenty new birds, as many reptiles, large numbers of fishes, crustaceans, and other groups in proportion. The collection of shells is much larger than any ever made on the west coast, with the exception of that made by Mr. Reigen, forming the basis of the report on Mazatlan shells, by Mr. Carpenter, and is superior to any other in the extent of the species preserved entire in alcohol.

In addition to the thorough exploration of the region immediately round Cape St. Lucas and the mountains of the vicinity, Mr. Xantus pushed his examinations many leagues up the coast, both on the ocean and gulf side, and also to a number of the neighboring islands, Socorro, Tres Marias, etc. He also made a visit to Mazatlan, and secured a valuable collection of birds. Mr. Xantus has now returned to the east, and the new species which he discovered are in process of elaboration and will shortly be published. Partial reports have already been made by Mr. Xantus on the Birds; on the Reptiles by Mr. Cope; on the Fishes by Mr. Gill; on the Insects by Dr. Le Conte; on the Crustacea and Asteriadæ by Mr. Stimpson; on the Ophiuridæ by Mr. Lyman; on the Myriapoda by Mr. Wood; on the Bats by Dr. Allen; on the Plants by Dr. Gray. The conchology is in the hands of Mr. P. P. Carpenter.

It is proposed, when all these examinations are completed, to combine their results in one general memoir on the Natural History of the Cape, which will then be as well known, or even better known than the extremity of the corresponding peninsula of Florida.

We copy, from Prof. Baird's report for 1861, the following statements respecting the other recent explorations in which the Smithsonian Institution has been concerned.

"*Exploration of the Hudson's Bay territory by Mr. Kennicott.*—At the date of the last advices from Mr. Kennicott, when the Smithsonian Report for 1860 was presented, he was at Fort Resolution, on Slave lake, where he had spent the preceding spring and summer, principally in collecting eggs of birds. He left Fort Resolution in August, 1860, and returned to Fort Simpson and proceeded immediately down the Mackenzie to Peels river. From Peels river he crossed the Rocky mountains to La Pierre's house, occupying four days in the transit, and arriving September 18th; left the next day for Fort Yukon, at the junction of Porcupine or Rat river and the Yukon or Pelly river, in about latitude 65° and longitude 146°. Fort Yukon, the terminus of his journey, was reached on the 28th of September, 1860.

The latest advices now on file from Mr. Kennicott were written January 2, 1861, up to which time he had made some interesting collections; but these, of course, were limited by the season. He had great expectations of success during the following spring, (of 1861,) which have no doubt been abundantly realized.

No collections were received from Mr. Kennicott in 1861, with the exception of a few specimens gathered in July and August, 1860, on Slave lake. Those made at the Yukon will, however, in all probability come to hand in October or November of 1862.

Mr. Kennicott expected to remain at the Yukon until August, 1861, then to start for La Pierre House and Fort Good Hope, possibly to Fort Simpson, to spend some months, and endeavor by early spring to reach Fort Anderson, near the mouth of Anderson river, (a stream between the Mackenzie and Coppermine rivers,) and in the barren grounds close to the Arctic ocean. At Fort Anderson he expected to collect largely of the skins and eggs of birds, rare mammals, &c., and to return to Fort Simpson in the autumn, (of 1862,) then to arrive at Fort Chipewyan, on Lake Athabasca, by the spring of 1863, so as to get back to the United States by the winter of the same year.

For a notice of the continued aid to Mr. Kennicott, rendered by the gentlemen of the Hudson's Bay Company, I have to refer to the next division of my report.

Exploration of the Hudson Bay territory by officers of the Hudson Bay Company.—The gentlemen of many of the Hudson Bay Company's posts have largely extended their important contributions to science, referred to in the preceding report. A large proportion of the principal stations have thus furnished collections of specimens and meteorological observations of the highest value, which, taken in connexion with what Mr. Kennicott is doing, bid fair to make the Arctic natural history and physical geography of America as well known as that of the United States.

Pre-eminent among these valued collaborators of the Institution is Mr. Bernard R. Ross, chief factor of the Mackenzie River district, and resident at Fort Simpson. Reference was made in former reports to his contributions in previous years; those sent in 1861 are in no way behind the others, embracing numbers of skins of birds and mammals, some of great variety, insects, &c., besides very large series of specimens illustrating the manners and customs of the Esquimaux and various Indian tribes. Mr. Ross has also deposited some relics of Sir John Franklin, consisting of a gun used by him in his first expedition, and a sword belonging to the last one, and obtained from the Esquimaux. Mr. Ross is at present engaged in a series of investigations upon the tribes of the north, to be published whenever sufficiently complete, and illustrated by numerous photographic drawings.

In making up his transmissions to the Institution, Mr. Ross has had the co-operation of nearly all the gentlemen resident at the different posts in his district, their contributions being of great value. Among them may be mentioned Mr. James Lockhart, Mr. William Hardisty, Mr. J. S. Onion, Mr. John Reed, Mr. N. Taylor, Mr. C. P. Gaudet, Mr. James Flett, Mr. A. McKenzie, Mr. A. Beaulieu, &c.

Second in magnitude only to those of Mr. Ross are the contributions of Mr. Lawrence Clarke, Jr., of Fort Rae, on Slave lake, consisting of many mammals, nearly complete sets of the water fowl, and other birds of the north side of the lake, with the eggs of many of them, such as the black-throated diver, the trumpeter swan, &c.

Other contributions have been received from Mr. R. Campbell, of Athabasca; Mr. James McKenzie, of Moose Factory; Mr. Gladmon, of Rupert House; Mr. James Anderson, (a) of Mingan; Mr. George Barnston, of Lake Superior; and Mr. Connolly, of Rigolette. Mr. McKenzie furnished a large box of birds of Hudson Bay, while from Mr. Barnston were received several collections of skins, and eggs of birds, new and rare mammals, insects, fish, &c., of Lake Superior.

It may be proper to state in this connexion that the labors of Mr. Kennicott have been facilitated to the highest degree by the liberality of the Hudson Bay Company, as exercised by the directors in London, the executive officers in Montreal, (especially Mr. Edward Hopkins,) and all the gentlemen of the Company, in particular by Governor Mactavish, of Fort Garry, and Mr. Ross. In fact, without this aid the expense of Mr. Kennicott's exploration would be far beyond what the Institution could afford, even with the assistance received from others. Wherever the rules of the company would admit, no charge has been made for transportation of Mr. Kennicott and his supplies and collections, and he has been entertained as a guest wherever he has gone. No charge also was made on the collection sent from Moose Factory to London by the company's ship, and in every possible way this time-honored company has shown itself friendly and co-operative in the highest degree to the scientific objects of the Institution.

Northwest Boundary Survey, under Mr. Archibald Campbell.[3]—This expedition has finally completed its labors in the field and returned to Washington, bringing rich results in physical science, as well as important collections in natural history. These, with what were previously sent hither from time to time, are in progress of elaboration, and reports are in preparation to be presented to Congress when completed.

It is with deep regret that I have to announce the death at sea, on his homeward voyage in February last, of Dr. C. B. Kennerly, the surgeon and naturalist of the Boundary Survey. Connected with this expedition from its beginning, in 1857, and, in conjunction with Mr. Gibbs, making the principal portion of its collections, his report on them would have been one of great value. For many years prior to 1857, however, he had been in intimate relations with the Institution as a collaborator, first while resident at his home, at White Post, Clark county, Virginia, then in 1853, as surgeon and naturalist to the Pacific Railroad Survey of Captain Whipple along the 35th parallel, then in the same relationship to the Mexican Boundary Survey, under Colonel Emory, in 1855. No one of the gentlemen who have labored so zealously to extend a knowledge of the natural history of the west within the last ten or twelve years has been more successful than Dr. Kennerly. Many new species have been first described by himself or from his collections, while his contributions to the biography of American animals have been of the highest interest.

REPORT OF THE SUPERINTENDENT OF THE U. S. COAST SURVEY FOR 1860.

The promise of a paper illustrating the recent progress of the U. S. Coast Survey, has led us to postpone any notice of the report of the Superintendent for 1860, until it is almost time for us to expect the publication of the report for 1861. But as this

[3] Compare Dr. Hayden's account of this survey, Geog. Notices, No. XVII, this Journal, [2], xxxiv, 99.

Journal reaches many who do not see the Superintendent's elaborate review of the operations of the survey, we here transcribe those paragraphs which exhibit the chief geographical results of the year in question. The importance of the survey has never been more apparent than it is at present. The wisdom, energy and science of the Superintendent are more and more evinced as the work of successive years is made known to the public.

General Statement of Progress.—The Atlantic triangulation, as the accompanying sketch (No. 37) shows, is continuous along the coast of twelve States from Pasamaquoddy to the boundary of North and South Carolina, a stretch of more than twelve hundred miles, measured in the most general way. With an interval of some fifty-four miles, which is diminished every year by the party at work there, the triangulation is again continuous over the coast of South Carolina to Cumberland sound, on the coast of Georgia, two hundred and eighty miles. Then there is an interval of twenty-seven miles, which this season will fill up to the St. John's river, Florida; and the triangles are again continuous to Matanzas inlet, south of St. Augustine. Two parties are working, from Matanzas inlet south, and from Indian river inlet north, to fill up that interval, to which a third will next season be added, proceeding north from Cape Florida. Another season or two at most will fill up the whole space from Cape Florida to Cape Sable, and along the keys from Key Biscayne to Key West and the Marquesas. Charlotte harbor is triangulated, and the work extends from Anclote key to Cedar keys, ninety miles; from Ocilla river, by St. Mark's and Apalachicola, to Cape San Blas, ninety-five miles; over St. Andrews's bay; includes East bay, Maria de Galvez, Escambia, and Pensacola bays; touches the entrance of Perdido bay; extends from Mobile bay one hundred and fifty miles to Lake Pontchartrain, and over Chandeleur and part of Isle au Breton sound to the delta of the Mississippi, the greater part of which it now includes; over Isle Dernière and Caillou bay; over Atchafalaya and Côte Blanche bays; and from East bay (Galveston) two hundred and fifteen miles, passing over Matagorda, Aransas, and Corpus Christi bays and their dependencies, to within one hundred and fifteen miles of the Rio Grande.

The progress on the western coast has not been less satisfactory, taking the newness of the survey there into consideration. It has included all the harbors of California and Oregon, and many of those of Washington Territory, especially those of Washington sound, Puget's sound, and Admiralty inlet, the straits of Haro and Rosario, and part of the Gulf of Georgia, in the northwest.

Having given, in my letter of last year, a statement of the progress of the astronomical and magnetic work, I need not repeat it here. The longitude problem has been steadily kept in view, and the occurrence of the total solar eclipse, the path of which crossed from the northwestern part of the United States, through Washington Territory and the British possessions, leaving the continent on the coast of Labrador, has been made available for the correction of longitudes and of the lunar tables by parties sent out for the purpose in connection with those of other departments of the government, and in correspondence with the great astronomical expeditions of Europe.

The number of geographical determinations published by the Coast Survey, exclusive of those made within the past year, is seven thousand one hundred and seventy-eight; the magnetic variations given are upwards of two hundred; the tidal constants for harbors and coasts, one hundred and ten; and the maps and charts of harbors, bays, inlets, sounds, shoals, &c., drawn, engraved, and published, three hundred, exclusive of progress sketches and diagrams."

Maps and Charts.—" Within the past year, one hundred and eleven sheets have been worked on in the Drawing Division. Of this number, nine are finished charts, thirty-nine are coast maps and charts, twenty-one finished maps of special localities, sixteen preliminary, and two of the number are comparative charts. These are exclusive of twenty-four sketches of various kinds. Fifty-six of the sheets referred to have been completed, and fifty-five are in progress. Of those completed, twelve are maps and charts of the first class, and an equal number charts of special localities. Eight of the number are preliminary charts and two comparative charts; and the remaining twenty are sketches, amongst which are included those showing the field progress.

In the Engraving Division, eight first class maps and new editions of two have been completed during the year, and twenty-four are in progress. Of this class twenty-two were commenced in previous years and twelve within the present year. In addition, seventeen plates have been engraved of second class charts and sketches, and five plates of that class are yet in hand. This gives a total of twenty-seven plates completed and twenty-nine in progress, or of fifty-six plates engraved or engraving within the year.

The complete list, giving the titles of these maps and charts, is appended to the report of the assistant in charge of the office, and a general list of all that have been engraved up to the present date also accompanies it, (Appendix No. 19). The complete list includes three hundred and eleven titles, of which sixty-eight are of first class or finished maps. The total given is exclusive of seventeen plates of progress sketches.

Developments and discoveries.—During the year, in twenty localities important developments and discoveries were made, including the determination of various reefs and ledges, investigation of channels and currents, &c., with other like services to navigation.

Special Surveys.—Three special surveys, at the expense of local authorities, have been conducted during the year, viz: at Mobile, to ascertain the changes and condition of the bay; at Boston, for a like purpose; and on the peninsular of Cape Cod, to determine the feasibility of a canal connecting Buzzard's Bay and Cape Cod Bay.

Tidal Stations.—Six tidal stations have been maintained on the Atlantic coast, three on the Pacific, and two on the Gulf.

Measurements of heights.—In conjunction with the Smithsonian Institution, the Superintendent remarks, we have been engaged for some years in endeavoring to obtain all the data existing for heights in North America. During the past year a new circular has been issued to the engineers, presidents and superintendents of railroads, and to geologists, explorers, and other men of science, to obtain additional results, and with much success. To the entire number issued, two hundred and fifty replies have been received. These furnish data for the height above tide of about thirteen thousand points, of which a large portion has been contributed by the explorations for routes for the Pacific railroad, and a considerable number by other surveys of the Government. The material received has been mapped by Mr. W. L. Nicholson, who is charged with the details of the work, so as to indicate whether the data were likely to suffice for the construction of contour lines of the surface of the continent, and to show where they would be deficient for that purpose. Sources of information have been pointed out, of which we have not yet been fully able to avail ourselves, but the work has, in a general way, made good progress, and will be earnestly prosecuted."

Besides information on these various topics, the report contains an account of the expedition to Labrador, to observe the Solar Eclipse of July 18, Prof. Bache's Lecture on the Results of the Gulf Stream Explorations, a discussion of magnetic declination or variation, and the usual details respecting the apparatus and *personnel* of the establishment.

DESIDERATA IN EAST AFRICAN EXPLORATION.

The following Note was recently addressed to the Bombay Geographical Society, by a Committee of the Royal Geographical Society of London, in reply to certain inquiries.

"Beginning at the south, we may look upon the Nyassa as entirely in the hands of Livingstone and other Zambesi travellers, such as Count Thurnheim. Livingstone, as we know, has established easy access to the southern end of the lake, and announced his intention of exploring the whole of it at the earliest opportunity. It would be a waste of resources to direct new travellers to that same district.

Proceeding northward, the itineraries of native traders supply enough information for the present rude wants of African geography, of the country between Quiloa and Nyassa; and we have received slight but definite knowledge of the same through Röscher's ill-fated expedition, followed up as it was to some degree by Baron von der Decken.

Taking yet another step, we arrive at the track of Burton and Speke, who have certainly left nothing of primary importance undescribed. The fourth and last section of known country is to the eastward of Mombas, whence Baron von der Decken (accompanied by the English geologist, Mr. Thornton) has lately travelled to Kilimanjaro, and where he still proposes to travel.

"Thus there is no urgent call for a new expedition that should leave the coast of Africa between the Zambesi and Mombas; but Eastern Africa is almost untouched between Mombas and the Red Sea. The field that here awaits new explorations is too vast to be exhausted by any single expedition. Three distinct undertakings may be specified.

"The first is to ascend the Juba, the Ozi, and other rivers, as far as they are navigable. They have all been visited by slavers, and opposition might be experienced on entering them, partly from that cause and partly owing to hostilities between the Somauli and the Massai; but no serious obstruction need be apprehended by a well equipped party, large enough to command respect.

"The second and most difficult would be a land exploration through the Somauli. Their language is an obstacle to a traveller from the side of Zanzibar, where interpreters cannot be engaged; while the religious and the political fanaticism of their northern tribes is an equal bar to travellers from Aden, where a suitable expeditionary party might, perhaps, be collected. The most promising course would be to land at Mogadoxo, and to reside there some months, learning the language and acquiring a hold on the good will of the people, before attempting further progress.

"Additional interest is given to this exploration by the fact that Lieut.-Colonel Rigby, H. B. M.'s Consul at Zanzibar, is firmly persuaded that some Englishmen are now in captivity among the Somaulis; for a report to that effect has been confirmed by different witnesses. He believes them to be a part of the crew or passengers of an East Indiaman, supposed to have been wrecked near the Mauritius in 1855, but whose cargo, or rather a number of miscellaneous effects resembling those known to have been carried by her, are come into the possession of the Somaulis. An exploring party would find in this report an intelligible pretext for their presence in the land, and a stimulating object for their earlier movements.

"The last course would be to adopt Mombas as the head-quarters, and thence to pass into the interior by a route to the north of that travelled by Baron von der Decken. The country behind Mombas is a less unhealthy residence than other parts of the coast; and an expeditionary party might be organized there at leisure, with help from Zanzibar. The Rev. Mr. Krapf resides in its neighborhood; the natives are accustomed to Europeans; and the traders mostly speak Hindustani. It would be impossible, at the present time, to plan an exploration in Africa that would afford hope of a more interesting discovery than one leading from Mombas round the northern flank of Kenia, and thence onward toward Gondokoro."