For John McDuffee, Esq.

24th Congress, 1st Session. | [Doc. No. 190.] | Ho. of Reps. War Dept.

CANAL—WELLS'S RIVER TO BURLINGTON, VERMONT.

LETTER

FROM

THE SECRETARY OF WAR,

TRANSMITTING

A report of a survey of a canal route from Wells's river to Burlington, in Vermont.

March 25, 1836.

Read, and referred to the Committee on Roads and Canals.

War Department, *March* 24, 1836.

Sir: In answer to the resolution of the House of Representatives of the 21st instant, I have the honor to transmit a report of the topographical bureau, on the survey of the route of a canal from Wells's river, to Burlington, Vermont.

Very respectfully,
Your most obedient sevant,
LEWIS CASS.

Hon. James K. Polk,
Speaker of the House of Representatives.

Topographical Bureau,
Washington, March 23, 1836.

Sir: I have the honor to lay before you the report of the surveys called for by a resolution of the House of Representatives of the 21st instant.

This report relates to the completion of certain surveys commenced in 1827, but from which the officer then in charge of the same, was called to the command of this bureau. The completion of the duty was afterwards assigned to Major Graham, by whom the report now submitted, is made.

I am, respectfully, sir;
Your obedient servant,
J. J. ABERT,
Lieut. Col. Topographical Engineers.

Hon. Lewis Cass,
Secretary of War.

Blair & Rives, printers.

OFFICE OF TOPOGRAPHICAL ENGINEERS,
Washington, November 12, 1830.

SIR: I have the honor to submit to you herewith, a report upon the experimental surveys executed under my direction, and agreeably to your instructions, in 1829 and 1830, together with the note books and nine sheets of drawings, showing all the details in reference to the Montpelier canal route, through the valley of Wells's river, State of Vermont.

I beg leave here to state, that the same causes which delayed the completion of the drawings, and consequently my report, upon the Oliverian canal route, State of New Hampshire, which are mentioned in my letter to you of the 2d instant, operated equally to delay this report and the drawings which are now submitted with it.

I am, very respectfully,
Your obedient servant,
JAMES D. GRAHAM,
Major U. S. Topographical Engineers.

To Lieut. Col. J. J. ABERT,
Chief Topographical Engineer.

A list of drawings which accompany the following report.

MAP 1.—A map of the route surveyed up the valley of Onion river, from the mouth of Stevens's branch to one and a half miles northeast of Plainfield village.—Scale 4 inches to 1 mile = $\frac{1}{15840}$.

MAP 2.—A map showing the several routes from the last mentioned point, via Winooski pond, Hosmer's pond, and Kettle pond, respectively, to the northern extremity of Long, or Wells's River pond. Also, drawings of Winooski and Kettle ponds, upon a scale of twelve inches to one mile, showing the soundings throughout, and the positions and dimensions of dams for forming reservoirs upon those ponds.

MAP 3.—A map showing the route surveyed from the northern extremity of Long, or Wells's River pond, down the valley of Wells's river, to its junction with the Connecticut river. Also, drawings of Long pond and Lund's pond, on a scale of twelve inches to one mile, showing the soundings throughout, and positions and dimensions of dams for forming reservoirs upon those ponds.

MAP 4.—A map showing the manner in which the summit level is to be supplied with water from Molly's brook, Lyford's brook, and Cold brook.—

* PROFILES.—~~Also profiles of the feeder traces.~~ From one to six, inclusive, on five antiquarian sheets, showing the vertical projections of the traces of all the routes surveyed between the mouth of Stevens's branch of Onion river, and the ~~the~~ Connecticut river.—Horizontal scale, 4 inches to 1 mile, or $\frac{1}{15840}$. Vertical scale, 1 inch to 50 feet, or $\frac{1}{600}$.

J. D. GRAHAM,
Major U. S. Top. Engineers.

*Profiles - From 1, to 6, inclusive on five ~~Sheets~~ antiquarian Sheets, &c.

Report upon an experimental survey, to determine the practicability of a canal to connect the waters of Lake Champlain and the Connecticut river, by way of the valleys of the Onion and Wells's rivers; executed in 1829 and 1830, under the direction of Captain J. D. Graham, of the United States Topographical Engineers.

The object of this survey was to ascertain the relative advantages between the route above mentioned for the proposed Montpelier canal, after ascending the valley of Onion river as far as the mouth of Stevens's branch, and the route which was pursued from the last mentioned point, by a party under the direction of Lieutenant Colonel Abert, in 1827, by the valleys of Stevens's branch and White river.

Agreeably to instructions from that officer, dated in May, 1829, the survey, which I now proceed to report upon, was commenced at one of his bench marks at the mouth of Stevens's branch, (B. M, Map 1, herewith submitted,) which was ascertained by Lieutenants Bennet and A. D. Mackay, in 1827, to be 447.37 feet above the level of Lake Champlain, and 47 miles and 1,220 feet distant from the lake by the route of their survey, while acting under the orders of Lieutenant Colonel Abert. A horizontal plane, passing through this bench mark, is assumed as the plane of reference for all the vertical distances on the profiles accompanying this report.

Map 1, Profile No. 1.—The experimental line of levels passes up the valley of Onion river, and near the margin of its northern shore. We do not pretend by this line to indicate the trace which the canal would occupy in its location. It is only after the accumulation of facts by these preliminary surveys, by which the practicability of the object is developed, that a location can be determined upon with proper judgment by the engineer. The route here pursued was such as afforded the best means of laying down the topography of the whole valley of the river, and the side hills bounding it on either side, embracing an extent within which a location would be fixed.

The surface of Onion river was, on the day that this survey was commenced, (June 29, 1829,) and at the point already indicated, 8.593* feet below the level of bench mark No. 1, frequent showers of rain having prevailed for ten days previous. In a distance of half a mile and fifty-two feet, we arrive at the foot of a rapid, or ripple, near Goodenough's bridge; the surface of the river is here 0.267 feet above the plane of reference, showing a rise in that distance of 8.86 feet. This rapid extends as far as Hill's saw-mill, situated near the 2¼th mile. Within this distance, of two miles, the river flows over a slaty and gravelly bed, and has a pretty uniform inclination of 51.85 feet per mile. Half way between the foot and head of this rapid, (at 1¼ mile on the map and profile,) is situated Doten's dam, the surface of the river at the foot of which is 52.554 feet above the plane of reference, and the surface of the dam was, when passed, 9.997 feet higher. The surface of the river at the foot of the dam of Hill's saw-mill is 103.433 feet above the plane of reference. The dam, when passed, was in a state of dilapidation, and only 2.188 feet higher. From this point the inclination of the surface of the river lessens considerably, as will be presently shown.

* It will be observed, that the ordinates, or vertical dimensions, are laid down in feet and *decimals* of feet, generally carried to three places of figures.

At 400 feet beyond the $4\frac{4}{8}$th mile we reached Daggett's mills. The foot of the dam is here 114.046 feet above the plane of reference, and its surface 8.29 feet still higher. At the bridge situated at the 6th mile, ($\frac{3}{8}$ths of a mile beyond Smith's house,) the surface of the river is 122.563 feet above the plane of reference. From this point, the line was continued round the Big Bend, passing the mouth of Kingsbury's branch, in order that the topography of the valley, which here widens considerably, and that of the high grounds on both sides, might be the more minutely laid down. This circuit of $2\frac{1}{2}$ miles would, in a location, be cut off by a line across its gorge of about a mile in length. The surface of the river at the mouth of Kingsbury's branch, (a little beyond the $7\frac{2}{8}$ths mile on the map and profile) is 123.43 feet above the plane of reference.

It appears then, that the difference of level of the natural surface of the river, from Hill's saw-mill, to the mouth of Kingsbury's branch, a distance, following the sinuosities of the river, of $5\frac{5}{8}$ths miles, is 20 feet, showing an inclination in the surface of this section of the river of 3.555 feet per mile. About the same inclination continues as far as the upper extremity of the Big Bend, $1\frac{1}{2}$ miles further, according to the course of the river, making the whole distance of this gradual, and comparatively moderate inclination, equal to $7\frac{1}{8}$th miles.

Thence to the village of Plainfield, the banks of the river become steep, and the bluffs or high grounds extend close to its margin on either side. The inclination of the surface of the river also increases, attaining an elevation at the foot of the dam of that village, of 189.065 feet above the plane of reference. The surface of the dam is 12.5 feet higher. Hence there is a rise of about 60 feet in the $1\frac{1}{4}$ miles, (following the course of the river) previous to reaching the dam at the village of Plainfield.

The nature of the soil at the surface was observed at every change, and will be found minutely noted at the bottom of the profiles. These remarks, however, refer more particularly to the immediate vicinity of the line traced by the instruments, which, in many portions of the route, passes over a superstratum of alluvial formation. It is therefore proper to remark, that the geological character of the hills bounding the valley of the river on both sides, from the mouth of Stevens's branch to Plainfield village, is marked by the prevalence of several varities of slate, such as talcose and mica slate with frequent veins of quartz; also a blue slate containing lime, but not in sufficient quantities to render it profitable for the kiln. In the vicinity of Plainfield we also find granite lying in detached masses on the surface, and frequently of good quality for building purposes. This part of the Onion river, (between Plainfield and the mouth of Stevens's branch,) is subject to high spring freshets, which may be stated at from four and a half to six feet perpendicular, which sometimes overflow the valley or bottom lands to a considerable distance. They, however, subside as rapidly as they occur, and the inundated grounds soon become well drained by their natural inclination towards the margins of the stream.

At the village of Plainfield, the Onion river receives Perkins's branch from the southeast. It is a shallow but bold stream, and yielded on the 14th July, 1829, near its mouth, 1,354 cubic feet of water per minute. It was then stated to be considerably below its mean stage for the year.

Above this point, the valley of the Onion river becomes much narrower, exceeding in but few places a breadth of 300 yards, and the river less crooked. The Plainfield dam, when full, backs the water in the river, when at its summer stage, for a distance exceeding a mile and a quarter. Near the $10\frac{6}{8}$th mile, the surface of the river is 204.487 feet above the plane of reference.

Map 2, and Profile No. 2.—At 257 feet beyond the eleventh mile, we reach Pitkin's saw-mill. The surface of the river at the foot of the dam is 214,384 feet above the plane of reference, and the dam 7.5 feet high. A bench mark was made on the southwest corner post of this saw-mill, which is 223.629 feet above the plane of reference.

An inspection of the map will show the relative situations of the ponds or natural reservoirs of water which are found on the high ridge dividing the waters of Lake Champlain and those of the Connecticut river. No survey had ever been made, within our knowledge, to ascertain their relative heights, but the general idea in the neighborhood was, that Kettle pond occupied the lowest situation of them all, and it was evident that it offered the most direct route by which it was probable a transit across this ridge might be effected. On arriving therefore at Pitkin's saw-mill, the line of levels left the valley of Onion river, and was pursued up that of the Naesmith branch towards Kettle pond.

Map 2, and Profile No. 5.—At a little more than five-eighths of a mile the line strikes the margin of the Naesmith branch, from which point an offset was made and the course of this stream laid down to its junction with Onion river. Ascending the valley of this branch by a rapid rise we strike the mouth of Lie brook, which empties into it at B. M. 7, near the $12\frac{5}{8}$th mile. This bench mark is 477.63 feet above the plane of reference, and is nearly on a level with the surface of Lie brook at its mouth. We now leave the Naesmith branch* and pursue the margin of Lie brook until we arrive a little beyond the $14\frac{6}{8}$th mile, at which point the surface of the brook is 805.131 feet above the plane of reference. Near this, is B. M. 11, which is 807.306 feet above the same plane. Here the line leaves Lie brook, and pursues the ground of least elevation to Kettle pond, striking its western margin at 276 feet beyond the $15\frac{4}{8}$th mile. The surface of Kettle pond is 905.942 feet above the plane of reference.

This pond forms one of the sources of Wells's river, into which it affords a discharge of water even at the driest seasons. The brook by which it has its outlet has so rapid a descent, and is so obscured by large boulders of granite overspread with moss, which are found to cover all this high ridge between Onion and Wells's river, that it was impossible to gauge this stream with any degree of accuracy; we therefore contented ourselves with an estimate of its discharge, in comparison with other streams of about the same size which were gauged, and thus fixed it at a season of considerable drought, (the latter part of July) at two cubic feet per second. Its minimum would be perhaps one cubic foot per second during a period of six or seven weeks of greatest drought. The pond is $1\frac{1}{8}$th mile long from east to west, and has a mean breadth of 780 feet. Its area is 4,625,000 square feet, its greatest depth (see Fig. 2, Map 2) 24 feet, and its mean depth 10 or 12 feet. It is supposed to be principally fed by springs from the bottom, many of which are known to exist. A number of springs were also discovered running into it from the adjacent hill-sides, which rise to a considerable elevation on the north and south. The line

* The Naesmith branch has its source in Pigeon pond, situated in the high dividing ridge, about $2\frac{1}{2}$ miles south of Kettle pond. Pigeon pond is about three-fourths of a mile long from north to south, and about one-third of a mile wide.

of levels was continued from the eastern extremity of Kettle pond, down the valley of the stream issuing from it, to Long or Wells's River pond, in the township of Groton, the margin of which it reaches at 530 feet beyond the 18$\frac{6}{8}$th mile, and at the point marked B. M. 14. This bench mark is 558.224 feet above the plane of reference, and the surface of Long pond 537.988 feet above the same plane; hence the surface of Long pond is 367.954 feet below the level of Kettle pond.

Map 2, and Profiles Nos. 3 & 6.—Two lines of levels were now run between Long pond and Winooski, or Onion River pond, in the township of Peacham. The one commencing at the point A, on the margin of the former, and terminating at the point B, on that of the latter. This line follows the valley of the brook which issues from the Big and Little bogs, until within seven-eighths of a mile of Winooski pond; it then pursues what was thought the most depressed summit ridge to the margin of that pond, the surface of which was thus ascertained to be 318.404 feet above the level of Long pond.

The other line commences at the point C, on the margin of Winooski pond, and pursues the most direct route which the nature of the ground would admit, and over the dividing ridge of least elevation on that side, to Hosmer's pond, the northern end of which it reaches in a distance of 1$\frac{3}{4}$ miles and 352 feet. It passes over a maximum elevation of 254.078 feet above the level of Winooski pond, which point is just one mile distant from that pond by the route pursued. The surface of Hosmer's pond is, by this line of levels, 76.446 feet above the level of Winooski pond. Its length is seven-eighths of a mile, from north to south, and its mean breadth about 585 feet. Its area is 2,706,000 square feet. It is surrounded (except immediately at its outlet on the south) by very high hills, and is well calculated for a reservoir. A dam for this purpose might be erected at its southern extremity at a small expense, as its length would be small.

The line of levels was continued from the southern end of this pond, and following the margin of the stream which issues from it, to Long pond, in order to test the accuracy of the other line of levels previously mentioned. They agree in their results within .375 of a foot, having both passed over a very rough, rocky, and thickly wooded soil of great declivity, and seven miles in distance.

The results of these lines of levels showed the erroneous idea which had prevailed as to the relative heights of these ponds. Winooski pond being 49.55 feet below the level of Kettle pond, and 76.446 below that of Hosmer's pond. They thus indicated Winooski pond as the proper summit pass of the canal route, and the others as auxiliaries to which we were to look for the necessary supply of water. It also became evident that the route must be continued from the bench mark at Pitkin's saw-mill, up the valley of the Onion river, and its eastern branch, to the summit. The line of levels was accordingly continued from the northern margin of Winooski pond, by the route thus designated, and connected with the bench mark at the corner of Pitkin's saw-mill. In giving the detailed results of this part of the survey, however, we shall proceed, for the sake of continuity in the route, in the opposite direction, or that, agreeably to which the line pursued is graduated on the maps and profiles, into miles and eighths of miles.

We return then to Pitkin's saw-mill, near the eleventh mile.

Map 2, and Profile, No. 2.—The inclination of the surface of Onion river continues from this point to be very gradual for a distance of four and a half miles, averaging, in that distance, (which brings us to the 15$\frac{4}{8}$th mile,) a rise of 7.58 feet per mile. Thence to the foot of Stephen Pitkin's mill dam, at the village of Marshfield, three-eighths of a mile and 262 feet further, there is a rise of 42.423 feet; the top of the dam is 12.673 feet still higher, or 303.596 feet above the plane of reference. Within less than a mile further, which brings us to the mouth of the Cabot branch of Onion river, (within 480 feet of the seventeenth mile,) the surface of the river attains an additional elevation of 15.955 feet, being here 319.551 feet above the plane of reference.

This point may also be designated as the foot of Winooski falls. The eastern branch of Onion river is here precipitated with great violence over a ledge of granite rocks, forming a cataract, which presents to the admirer of natural scenery a beautiful spectacle, but which will be viewed with different emotions by the engineer interested in the location of a canal route. It is indeed a formidable obstacle, as the river here attains a difference of level of 202.904 feet in a horizontal distance of 1,805 feet. This, in a location, will oblige the line of canal to pass at a higher elevation along the side slope of the hills bounding the valley of the Onion river on the south; and as the multiplying of contiguous locks will have to be avoided as much as possible for the sake of economy in the expense of the summit supply of water, the length of this summit section of the canal must become considerably extended to allow of the requisite intermediate ponds, before it can be sufficiently depressed to receive a new supply of water from the Cabot branch. From the top of Winooski falls the inclination of the surface of the eastern branch is 120.5 feet in a distance of seven-eighths of a mile, it then becomes more moderate, being in a distance of 2$\frac{7}{8}$ miles immediately succeeding, not quite 45 feet. This brings us to the termination of the twenty-first mile, where the rise again becomes abrupt, being 141.437 feet in a distance of three-eighths of a mile further. Thence to the margin of Winooski pond, there is a more moderate rise of twenty-seven feet in a distance of half a mile and 129 feet.

The surface of Winooski pond (whose margin we reach at 129 feet beyond the 21$\frac{7}{8}$th mile) is 856.392 feet above the plane of reference. This pond is 4,450 feet long from northwest to southeast, and has a mean breadth of 2,037 feet. Its area is 8,964,775 square feet. Its greatest depth at low water is 54 feet, (see fig. 3, map 2,) and like Kettle pond, it is fed by springs, both from the bottom and sides. It affords a discharge of water after supplying the effects of evaporation, even at the driest seasons. We were not enabled to ascertain its natural discharge of water by gauging during the season of greatest drought, as there is a small dam near its outlet, which is used for collecting a head of water in dry seasons for the use of the mills which are situated near it. During the time our party remained in its vicinity, from the 29th of July to the middle of August, 1829, a period of uncommon drought, the gates of this dam were either closed for the purpose above mentioned, or were raised after having remained thus closed for some time, and the pond allowed to discharge rapidly the waters it had accumulated. No useful result was to be deduced from gauging under these circumstances. I think we may safely assume two cubic feet per second as the minimum discharge of this pond. It was accurately gauged by Mr. John McDuffie on the 7th of December, 1829, near its outlet, agreeably to a form furnished him. It then delivered 10 cubic feet per second. The gates of the dam had been kept raised for six weeks, and the true natural discharge for that season of the year obtained.

By connecting this survey with that executed in 1827, under the direction of Lieut. Col. Abert, before referred to, we find that the distance from Lake Champlain, near Burlington, Vt. to the northern margin of Winooski pond, by way of the valley of Onion river, is $69\frac{1}{8}$ miles and 29 feet, and that the surface of this pond is 1303.762 feet above the level of the lake.

Map 2, *and Profile No.* 3.—We proceed to examine the line of levels between the southern margin of Winooski pond, continued from the point B, and the margin of Long pond at the point A.

Passing up the margin of a small brook, which issues from the Little bog, in about $\frac{1}{8}$th of a mile we attain an elevation of 24.31 feet above the level of the pond; the elevation of the soil increases but little for $\frac{3}{8}$ths of a mile further, where it is found to be 25.85 feet above the same level. At $\frac{4}{8}$ths of a mile, and 250 feet from the margin of the pond; the elevation of the soil is 30.576 feet above the level of the pond. In a little less than $\frac{5}{8}$ths of a mile from the same margin we reach the surface of the Little bog 47.954 feet above the level of the pond. This bog consists of a very soft humid soil, covered at the surface with a species of grass, whose roots are strong and fibrous, and so closely interwoven as to be capable of sustaining a considerable weight while moving over its surface, which produces a vibratory motion, showing that it would be an improper foundation for any structure without the aid of piles properly driven. We had not the means of properly sounding it to ascertain its depth. Our line passes over its western extremity, where its breadth is 900 feet. From the southern edge of this bog the slope of the soil is pretty regular until it intersects the line produced on a level with the surface of Winooski pond, at a point $1\frac{3}{8}$ miles and 320 feet from the margin of that pond, showing that this would be the length of a deep cut (which would have an average depth of 26 feet) necessary to reduce the summit pass of the proposed canal to the level of the present surface of Winooski pond.

From the end of this proposed deep cut the descent is pretty regular to the margin of Long pond, a distance of $1\frac{6}{8}$th miles and 130 feet, the difference of level to be overcome by lockage in that distance, being 318.404 feet, or at the rate of about 180 feet per mile. From near the $25\frac{1}{8}$th mile on the profile, the levels should have pursued the valley of the small stream issuing from the bogs, by which the high ground, represented between that point and the margin of Long pond, would have been avoided.

The high ridge or section of country which we have passed, between the valley of the Onion river and Long pond, abounds in large forest timber of excellent quality for building purposes, and would become a source of considerable profit to this portion of country, could it have the advantage of a water transportation to Lake Champlain, or to the eastern seaports. We here find the fir, spruce, hemlock, birch, (red, white, and yellow); beech, yellow and white pine, red cedar, maple, sugar maple, and several other kinds. The surface of the ground is also rough and rocky. We find granite in abundance, both in the form of boulders on the surface, and in ledges or strata, extending below the surface. These would be valuable materials for the purposes of construction.

Map 3, *and Profile No.* 3.—Long, or Wells's River pond, is $2\frac{5}{8}$ths miles long from N. to S. and has a mean breadth of rather more than $\frac{1}{4}$th of a mile. Its area is 18,789,000 square feet; and its greatest depth at low water 38 feet. (See Fig. 1, Map 3.)

Lund's pond is $\frac{1}{4}$th of a mile distant from Long pond, and its surface is

24.756 feet below the level of that of Long pond. It is $\frac{3}{4}$ths of a mile long, and has a mean breadth of 927 feet. Its area is 3,671,500 square feet; and its greatest depth at low water is 26 feet. (See Fig. 2, Map 3.) The foot of the mill dam, near the outlet of this pond, is 10 feet below its surface.

Continuing the line of levels from Lund's pond down the valley of Wells's river, there is a pretty uniform fall in the surface of the river for a distance of $2\frac{1}{2}$ miles of 103.8 feet per mile. Within this distance there is, at 340 feet beyond the $30\frac{5}{8}$ths mile of the route, a fall of 7.19 feet in a horizontal distance of 75 feet; and another, at 130 feet beyond the 31st mile, of 10.9 feet, in a horizontal distance of 120 feet.

Map 3, *and Profile No.* 4.—Bench mark 4, near the $32\frac{1}{8}$th mile, is 277.442 feet above the plane of reference. Between this point and the foot of Burnham's saw-mill dam, at Groton village, a distance of near $\frac{7}{8}$ths of a mile, there is a fall in the surface of the river of 32.8 feet. There is a grist-mill 350 feet above this, and on the opposite side of the river. The fall in the surface of the river diminishes considerably between those mills and Craig's mills, a little more than $3\frac{1}{2}$ miles lower down, averaging in that distance 12.5 feet per mile. At the foot of Craig's dam the surface of the river is 183.466 feet above the plane of reference. In $\frac{7}{8}$ths of a mile and 350 feet further, we reach Miller's mills; the foot of the dam is here 161.658 feet above the plane of reference, showing a fall in that distance of 21.8 feet. Thence to the head of Bolton's falls, (another mill seat,) nearly $1\frac{7}{8}$ths miles, there is a fall of 39.203 feet. The banks are here steep and rocky, and confine the river within a narrower passage. There is a fall over a rocky bed of 56 feet, in a distance of about 220 yards. At $\frac{1}{3}$ mile below the head of these falls an offset was made to the surface of the river, showing a fall of 81.235 feet in that distance. The surface of the river is, at this last mentioned point, 41.22 feet above the plane of reference, and it intersects that plane in a distance of 120 feet less than 2 miles, and at 540 feet beyond the $41\frac{5}{8}$ths mile on the profile. From this point to the junction of Wells's river with the Connecticut river, (a distance of $1\frac{5}{8}$ths mile,) there is a fall of 131.187 feet, this being the vertical distance of the surface of Connecticut river below the plane of reference, and consequently 987.579 feet below the level of the surface of Winooski pond. A bench mark was made on the margin of the river, (B. M. 7, on map and profile,) which was 7.063 feet above the surface of the river at this point, on the 22d August, 1829, when it was reckoned to be at its lowest stage, an unusual drought having prevailed for three or four weeks previous.

The length of this route, by the survey, is $43\frac{1}{4}$ miles and 543 feet, and the total ascent and descent, considering the present surface of Winooski pond, in Peacham, as the summit level, 1843.971 feet. Adding the distance, from Lake Champlain at Burlington, to the bench mark at the mouth of the Stevens's branch of Onion river, as surveyed in 1827, together with the difference of level to that point, we have, for the whole length of this proposed canal route, $90\frac{1}{2}$ miles and 443 feet, with a total ascent and descent, to be passed by lockage, of 2291.341 feet, being an average of 25.3 feet of lockage per mile.

The valley of Wells's river is narrow, and the banks, on either side, frequently steep and rocky. A great quantity of water is discharged by this river during the spring freshets, caused by rains and melting of snows, but from the indications on its banks these freshets do not appear to cause a rise of more than five feet in its surface above the low water mark, owing to the great fall in its bed, which averages 46 feet per mile, throughout the whole length of the river.

Feeder.—*Map 4, with Profile attached.*—It has already been observed that the ponds situated near the summit pass, are well calculated for forming reservoirs for supplying the summit section of the proposed canal during seasons of drought, when the quantum of runing water, available for this object, is known to be insufficient.

A feeder line was traced from near the northwest extremity of Winooski pond, preserving a level of 10 feet above its surface, along the side slope of the intervening ground, to Molly's brook, which it strikes in a distance of a little less than 2½ miles from B. M. 1, of this map, or 2⅝ miles and 200 feet from the margin of the pond. Molly's brook was gauged at this point, and was found to yield on the 4th of August, 1829, 3.64 cubic feet of water per second; a quantity which may be safely assumed as its minimum supply, as it was a period of great drought. Continuing up the valley of Molly's brook, from the extremity of the feeder line thus traced, we reach the margin of Molly's pond, from which the brook issues, in an additional distance of nearly 2⅝ miles, and find the surface of this pond to be 236.189 feet above the level of that of Winooski pond. It is five-eighths of a mile long, and has a mean breadth of 577 feet. Its area is 1,904,150 square feet. The ground about it is such as to admit of a reservoir being conveniently formed by raising its surface eight feet above its present level. This will require two dams, the elements of which were determined as projected on the map.* The one near the outlet of the pond will be 344 feet long, and its mean height 5½ feet. The other will be placed at the opposite extremity of the pond, and will be 253 feet long and require a mean height of only eight-tenths of a foot. Besides the reservoir thus created, three perpendicular feet of water below the present or natural surface of Molly's pond may be made available by a cut at its outlet of 600 feet in length. Thus, by means of this pond, may be obtained a reservoir of at least 20,945,650 cubic feet of water to be used at pleasure, besides a minimum supply of 3½ cubic feet of running water per second, after supplying the effects of evaporation. Molly's brook yielded on the 6th of December, 1829, at the point before designated, when gauged by Mr. John McDuffee, 20.1 cubic feet of water per second.

The feeder line was continued from the position fixed for the dam at the northeast extremity of the pond, and preserved at a level of eight feet above the present surface of the pond. In a distance of 3¼ miles it intersects Lyford's brook, which yielded on the 19th of August, 1829, 1$\frac{1}{10}$ cubic feet of water per second which is assumed as its minimum supply. On the 5th of December, following, it yielded two cubic feet per second at the same place. At 2⅝ miles still further, the same level continued intersects Cold brook, (or Sleeper's brook) issuing from Cold pond, and now emptying into Joe's pond. This brook yielded on the 21st of August, 1829, at the point where intersected by the feeder line, 5.63 cubic feet per second, and on the 4th of December, following, it yielded 12.65 cubic feet per second.

We have now shown all the water that appears to be available in this direction, together with the length of the feeders necessary to conduct it to the summit.

* See e f, and g h; sheet containing trace of feeders.

Map 2.—The elements of a dam necessary to raise the surface of Kettle pond eight feet above its present level were determined. Its length would be 549 feet, and its mean height 7 feet. (See Fig. 2). A feeder line was commenced at the position proposed for this dam, and traced towards the summit, preserving the level of the present surface of Kettle pond, with a view of ascertaining the practicability of intersecting the stream issuing from Hosmer's pond, and conducting the waters of both these ponds to the summit by one continuous feeder. In a distance of a little more than seven-eighths of a mile, this line encountered so great an obstruction in the declivity of the peak known by the local name of the Owl's Head, which was increased by the apparent length of an aqueduct that would be necessary to connect it with the succeeding one bearing the name of the Devil's Head, added to the very rocky surface of these side hills, that the further continuance of the line was abandoned.

No feeder line was traced between Hosmer's pond and the summit; a reconnoisance of the intermediate ground, however, is sufficient to show that the waters of that pond, if used as a reservoir, may be conducted to the summit by a feeder of about 1¾ mile long.

SUPPLY OF WATER.

Middle or summit section, between Cabot branch of Onion river, and Long pond.

Distance, by route surveyed, 8¼th miles.

Ascent and descent, 855.24 feet.

The navigation of the canal would be suspended in consequence of ice and other causes, in this climate, (between latitude 44° and 44° 30′ N.) for about four months in the year. Let us suppose that it would be navigable for a continuous period of two hundred and forty days. We may divide this term into two periods, corresponding with the relative supply of running water that may be depended on for each.

We may safely assume the first period at 90 days to include the season of greatest drought, and base the calculations for supply, on the capacities of such reservoirs as may be conveniently formed, together with the minimum discharge of running water, as ascertained by gauging in August, 1829, during a period of unusual drought.

This will give us, of running water, as follows, viz:

From Winooski pond, as estimated Aug. 1st, 1829,	2	cubic feet per sec.		
From Molly's brook, as gauged Aug. 4th,	"	3.64	"	"
From Lyford's brook, as gauged Aug. 19th,	"	1.1	"	"
From Cold brook, as gauged Aug. 21st,	"	5.63	"	"
Total,		12.37		

Let us say 12 cubic feet per second, rejecting the fraction, which, in 90 days, will amount to 93,312,000 cubic feet.

Reservoirs.

Winooski pond will, by a dam to raise its surface 10 feet above its present level, and a cut to command 3 feet perpendicular below its present surface, form a reservoir of - - - -	116,542,075 cubic feet.
Reservoir proposed to be formed of Molly's pond	20,945,650 "
Hosmer's pond, by means of a dam to raise its surface 15 feet above its present level, will form a reservoir of - - - - - -	40,590,000 "
Total available by reservoirs - - -	178,077,725 "
Available running water during dry season -	93,312,000 "
Total available from all sources, within first period of 90 days - - - -	271,389,725 "

During the second period of 150 days, including the spring and autumn, or before and after the season of droughts, we may safely assume the supply of running water to be equal, on an average, to the quantity afforded by the streams when gauged in the early part of December, 1829, which was sometime before the commencement of the rainy season.

Throughout the month of April, and during a part of May, it is believed the supply would greatly exceed that average. I am strengthened in this belief by the reports of gentlemen of observation and intelligence residing in the neighborhood.

We have from gauging, at the period above alluded to, the following results, viz:

From Winooski pond, at its outlet, Dec. 7th, 1829,	10.	cubic feet	per sec.
From Molly's brook, Dec. 6th, 1829, -	20.16	"	"
From Lyford's brook, Dec. 5th, 1829, -	2.	"	"
From Cold brook, Dec. 4th, 1829, -	12.65	"	"
Total,	44.81	"	"

Let us, in the calculation, diminish this supply to 40 cubic feet per second. It will give, for the period of 150 days, an amount of 518,400,000 cubic feet of water.

Losses.

Filtration, soakage, leakage.—These items depend so much upon data only to be obtained satisfactorily from an actual location of the canal route, developing the nature of the soil, the greater or less declivity of the ground to be occupied, as well as upon the dimensions of the canal, the locks, and the feeders, and the faithful execution of the work, that we must be content with an approximate estimate, based upon a liberal average allowance, in estimating the expense of water from these causes. For the trunk of the canal $1\frac{1}{2}$ cubic feet per mile per second, and for the feeders $\frac{3}{4}$ cubic foot per mile per second, will be an ample allowance for these items.

Evaporation.—The loss from this cause depends upon the mean temperature of the climate; the elevation of the country above the level of the sea; upon the quantity of rain known to fall annually; also upon the surface of the country, its being more or less hilly, and more or less timbered. As we have not the advantage of any known experiments, necessary to give the elements for the most important part of this calculation, we will suppose the loss from evaporation to be equal $28\frac{1}{2}$ inches per annum upon any given surface. This allowance is known to be sufficient in calculations of this kind, for climates considerably south of the State of Vermont. Let the breadth of the canal be assumed at 36 feet at the water surface, and that of the feeders at 12 feet.

The length of the middle, or summit section, has already been stated at $8\frac{1}{8}$ miles by the line surveyed; but it is quite evident, that in order to depress the line of canal advantageously, in descending from the head of Winooski falls, so as to receive a new supply of water from the Cabot branch, it would be necessary to extend this section to about 11 miles in length. This, together with $8\frac{5}{8}$ miles of feeders, would be attended with a loss, from all the causes mentioned, as follows, viz:

During the first period of 90 days - -	158,502,133 cubic feet.
During the second period of 150 days -	264,966,083 "
Total loss	423,468,216 "

leaving an effective quantity applicable to the purposes of lockage, as follows, viz:

For the first period of 90 days - -	112,887,592 cubic feet.
For the second period of 150 days - -	253,433,917 "
Total, applicable to lockage within the navigable period of the year - - - -	366,321,509 "

We will suppose the dimensions of a lock chamber to be 90 feet long, 13 feet wide, and 10 feet lift, that is, to require 11,700 cubic feet of water to fill it, and that two locks full of water be required to pass each boat over the summit section. This is a maximum allowance for a series of single or detached locks, and may be considered sufficient in the event of a series of two contiguous locks at every point of lockage, provided the ascending and descending trade be equal, and admit the mode of passing, most favorable to economy in the expense of water; that is, by a regular alternation of boats in opposite directions.

We shall then have as a result, that 15,654 boats may be passed over this summit section, by the supply of water which may be rendered available, within the navigable period of each year, which is an average of 65 boats per day, or 32 in each direction, daily.

Having arrived at the above conclusion, let us now suppose that a dam of dimensions capable of raising the surface of Winooski pond *fifteen feet* above its present surface, (instead of *ten feet*, as previously proposed,) be constructed at its outlet. This would create an additional supply of 44,823,875 cubic feet of water, applicable to the purposes of lockage, and would increase the number of boats that might be passed over the summit section within the navigable period of each year, to 17,570, being an average of 73 per day, or 36 per day in each direction.

This question now presents itself for investigation. What is the maximum content of a reservoir that may be formed by damming Winooski pond; and by what means are this and the other reservoirs for supplying the summit, to be annually replenished?

The quantity of snow that is known to fall annually upon this elevated region of country, and the abundant rains which attend the opening of spring, would, without doubt, furnish the requisite supply for filling these reservoirs, and also the whole trunk of the canal, within the period of suspended navigation. A reference to the accompanying maps will be sufficient to show the large surface of country that is drained of its surplus water in times of abundant rain, by those natural ponds, upon whose basins the reservoirs would be formed.

Winooski pond discharged at its outlet, on the 7th of December, 1829, as already stated, 10 cubic feet of water per second,* and Molly's brook furnished 20 cubic feet per second, on the day previous. These two sources of supply would alone, at that average, fill a reservoir at Winooski pond to a height of 15 feet above its present level, in the space of 52 days. But there is little doubt that the average supply would be at least three times the above quantity, during the first month after the opening of spring, particularly if we include that portion of the drainage of the surrounding country which would find, in the artificial feeder, a new avenue, conducting it to this reservoir, which, according to this hypothesis, would be filled in less than 18 days. From this it would seem that the capacity of the Winooski reservoir, might be still farther increased, for the ground bordering it on every side, except at its outlet, is so elevated as to admit of the convenient construction of a dam of any required height, not exceeding 25 or 30 feet. (See Map 2, Fig. 3.)

So important a consideration as the formation of these reservoirs, and the capacities to which they are susceptible of being extended, with a view of being annually replenished, should not be allowed, however, to rest in any degree upon conjecture, or upon appearances, even of the most flattering nature.

Before proceeding to the construction of the work, the means, and the time required, for filling these reservoirs should be fully ascertained by frequently gauging, at every season of the year, those streams which are to be relied upon for feeding them. And, indeed, these dams should be the first works constructed, in order practically to demonstrate the efficiency of the reservoirs, before incurring any other expense, as upon them the success of the whole summit section of the work must depend.

It must be borne in mind, that a great portion of this summit region is now covered by dense and umbrageous forests, which tend greatly to prevent evaporation, and cause the streams to yield more abundantly than they would if the country were cleared, particularly during the summer season.

The necessity of preserving these forests in the immediate vicinity of the reservoirs, and upon the summit portion of the canal, will readily occur to those interested in this improvement.

Western section.

The portion of this section, included within the limits of this survey, would not, in a location of the route, exceed 14½ miles in length, terminating at the mouth of Stevens's branch, and having a difference of level of 328.14 feet.

* Winooski pond discharged, at the same place, when gauged by Lieutenant French, the beginning of August 1830, 10.2 cubic feet of water per second. Copious rains had, however, prevailed for several days previous.

The streams which would be relied on for supplying this portion, are

1. The Cabot branch;
2. The Naesmith branch;
3. Perkins's branch;
4. Kingsbury's, or the Calais branch; and, if necessary,

The Onion river.

The first of these yielded, on the 5th of August, 1829, a period of very dry weather, twelve cubic feet per second, which may be considered its minimum supply. The second yielded, on the 16th of July, 1829, 10.8 cubic feet per second; and the third yielded, on the 14th July, 1829, 22.5 cubic feet per second. The mean of the second and third may be safely assumed at 16 cubic feet per second. The fourth yielded, on the 6th July, 1829, 77 cubic feet per second. Let its minimum be assumed at 20 cubic feet per second, a reduction of nearly three-fourths. We have, then, for the supply of this portion of the canal, a minimum quantity of 48 cubic feet per second, which, when added to the supply from the summit, (which would be received by the passage of boats to and from that section,) will be found to be advantageously distributed, and would be sufficient for the purposes of lockage, after allowing for losses of every description, for the maximum of trade that could pass through the canal; and without resorting to the main stream of the Onion river, between the summit section and the mouth of Stevens's branch.

Eastern Section.

This section extends from Long pond, down the valley of Wells's river, to the Connecticut river.

Long pond and Lund's pond would be used as portions of this section, and would be rendered navigable for canal boats by the construction of proper tow-paths near their margins, and dams at their outlets. A reference to the details, upon a large scale, (Map 3, Fig 1 and 2,) ~~and~~ will show how easy these improvements may be made.

This would reduce the length of the remainder of the section to about 15 miles, in a location of the route, having a difference of level of 645 feet. The resources for a supply of water, are the Wells's river; the south branch of do.: the north branch of do. The south branch is received by two mouths, at a mean distance of two miles below Lund's pond. The north branch is received five-eighths of a mile still lower.

These streams were gauged in the latter part of August, 1829, a period of uncommon drought, which prevailed throughout that month. The inhabitants throughout that neighborhood concurred in the opinion that the streams had never, within their recollection, been lower than when we gauged them. They then yielded the following supplies, viz:

South branch, by two mouths, August 24, 1829,		13.	cubic feet per second,		
North branch, near its mouth,	do	do	3.4	do	do
Wells's river, above Bolton's falls	do	do	20.	do	do
Wells's river, near its mouth, August 22,	do		21.8	do	do

It is to be regretted that Wells's river was not gauged within the period of this great drought, immediately below Lund's pond. Its minimum supply cannot, however, be stated at less than ten cubic feet per second. This quantity, added to the supply from the north and south branches, will give 26 cubic feet per second, which may be relied upon during seasons of the greatest drought. This supply of running water, added to that which would be received from the summit section, together with the aid of a reservoir proposed to be formed upon the basin of Long pond (whose area is 18,789,000 square feet) would always ensure a sufficiency of water for the maximum of trade upon this section of the canal.

The annexed table, marked A, exhibiting the streams gauged on this survey, will show at one view all the resources of running water that may be commanded for supplying the several portions of this canal route, between the mouth of Stevens's branch, on the east, and the mouth of Wells's river, on the west, side of the summit level.

Having exhibited all the facts required by my instructions in reference to this survey, it only remains for me to express my opinion, that it is quite practicable to effect a communication by means of a canal between Lake Champlain and the Connecticut river, through the valleys of the Onion and Wells's rivers.

The quantity of water available by means of streams and reservoirs easily formed, has been shown to be sufficient, provided it is properly secured.

It is true, that the lockage upon the middle or summit section, is great in proportion to its length, and that much care will be required in the trace of the route, preparatory to construction, in order to avoid, as much as possible, the multiplying of contiguous locks.

Before deciding upon the improvement for effecting a communication between Lake Champlain and the Connecticut. river, a careful comparison should be instituted between this and the other routes which have been surveyed in reference to this object.

The surveys under the immediate direction of Lieutenant Colonel Abert, of the United States Topographical Engineers, in 1827, determined the summit pass between the head waters of Stevens's branch and White river, to be 485 feet lower than Winooski pond summit, as deduced from this survey, but the scarcity of water for supplying the summit of the White river route, seemed to render it impracticable for a canal. The suggestion of that officer, in reference to a rail-road communication,* ought, however, to be fully weighed, preparatory to a decision upon the route, and the nature of the work to be adopted for this important improvement.

I beg leave here to express my acknowledgments to Lieutenants A. D. Mackay, Edmund French, and George E. Chase, of the artillery, who served as my assistants on this duty, and to whom I am indebted for much of the information communicated in this report, as well as for the execution of a great portion of the maps. After those officers were withdrawn from my command, I was aided in the completion of the maps by Lieutenants J. F. Izard and John N. Macomb, of the army.

I take this occasion, also, to express my acknowledgments to Mr. John McDuffee, of Bradford, Vermont, for the valuable services he rendered, not only in the local information he constantly communicated, while accompanying us upon the the route, but also for the accurate and very important surveys executed by him upon the ice, in the months of February and March, 1830, of Winooski, Long, and Lund's ponds. His services were rendered chiefly at the expense of the State of Vermont, as the funds appropriated by the Government, and allotted to this survey, were not sufficient to enable me to employ him at a just compensation.

* See Col. Abert's report, printed document 173, H. R. 1st session of 20th Congress.

To Mr. J. Y. Vail, of Montpelier, we were also much indebted for the facilities afforded by him on all occasions, as the agent selected to accompany us bythe Executive of the State of Vermont.

All which is respectfully submitted:

JAMES D. GRAHAM,
Major U. S. Top. Engineers.

To Lieut. Col. J. J. Abert,
Chief Top. Eng'r, U. S. Army,
Washington City.

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A—*TABLE of streams gauged upon the Onion and Wells's river portion of the Montpelier Canal route, State of Vermont, in* 1829 *and* 1830; *showing the supply of running water afforded by each at the periods herein stated.*

Statement.	Names of streams.	At what point gauged.	When gauged.	By whom [illegible]. gauged.	Supply of water in cubic feet. Per second.	Per minute.	REMARKS.
1	Gallison's brook	Near station 10, comp. b'k No. 1	July 4, 1829	Capt. Graham & Lieut. Chase	2.96	177.6	It had been raining several days preceding the gauging of this stream, which caused its supply to be considerably increased.
2	Parson's brook	800 yards from station 68, do.	Do. do.	Do.	1.58	94.8	Do. do. do.
3	Davis's brook	Near station 85, do.	Do. do.	Do.	5.51	330.6	Do. do. do.
4	Dagget's brook	Near station 98, do.	Do 6, do.	Do.	11.28	676.8	Supposed to be twice the quantity afforded at the driest times.
5	Kingsbury's branch of Onion river	Near station 135, do.	Do. do.	Do.	77.67	4,660.2	
6	Northern branch of Onion river	700 yards above its mouth	Do. 9, do.	Do.	110.36	6,621.6	Water at about mean height.
7	Onion river	Near station 81	Do. 11, do.	Do.	212.54	12,752.4	Do. do.
8	Onion river	Near Abbot's house, Montpelier	Do. do.	Do.	271.73	16,303.8	Discharged on 3d August, 1829, (see statement 14) 6,121.8 cubic feet per minute.
9	Onion river	Near Pitkin's mills	Do. 13, do.	Do.	152.46	9,147.6	
10	Perkin's branch	Plainfield village	Do. 14, do.	Do.	22.58	1,354.8	Water a little below its mean stage for the year.
11	Naesmith's branch	Half mile above its mouth	Do. 16, do.	Do.	10.83	649.8	After several days of very warm and dry weather.
12	Winooski branch of Onion river	Near Barnes's house	Do. do.	Do.	14.11	846.6	
13	Outlet from Pigeon pond	Near margin of pond	Do. 17, do.	Do.	1.83	109.8	
14	Onion river	Same place in statement 8	Aug. 3, do.	Lieut. Chase	102.03	6,121.8	Discharge 10,182 cubic feet per minute less than on the 11th July, 1829.
15	Molly's brook	At proposed commenc't of feeder	Do. 4, do.	Do.	3.64	218.4	Eligible place for a dam.
16	Molly's brook	At do. do.	Dec. 6, do.	J. McDuffee	20.16	1,209.6	
17	Cabot branch of Onion river	At the bridge near sta. 116, c. b'k 3	Aug. 5, do.	Capt. Graham & Lieut. Chase	12.02	721.2	
18	Wells's river, at the village	By two mouths	Do. 23, do.	Do.	21.88	1,312.8	These streams were gauged at a period of uncommon drought, when they were stated by the neighboring inhabitants to be lower than they had been for many years previous.
19	South branch of Wells's river	At its two mouths	Do. 24, do.	Lieut. Chase	13.11	786.6	
20	North branch of Wells's river	Near Darling's house	Do. do.	Do.	3.47	208.2	
21	Wells's river	Above Boulton's falls	Do. do.	Do.	20.00	1,200.0	
22	Lyford's brook	Where required to supply feeder	Do. 19, do.	Lt. A. D. Mackay	1.09	65.4	
23	Lyford's brook	Where do. do.	Dec. 5, do.	J. McDuffie	2.02	121.2	
24	Sleeper's brook (from Cold pond)	Where do. do.	Aug. 21, do.	Lt. A. D. Mackay	5.63	337.8	
25	Sleeper's brook (from Cold pond)	Where do. do.	Dec. 4, do.	J. McDuffie	12.65	759.0	
26	Outlet of Winooski pond	270 feet below the pond	Do. 7, do.	Do.	10.01	600.6	
27	Outlet of Winooski pond	270 feet do.	Early in Aug. 1830	Lieut. French	10.21	612.6	Copious rains had prevailed for about a week preceding the gauging of these streams. The results are, therefore, much above their usual supply in summer.
28	South branch of Wells's river	Near its outlet	Do. do.	Do.	22.25	1,335.0	
29	North branch of Wells's river	Near do.	Do. do.	Do.	33.79	2,027.4	
30	Wells's river	Near Miller's mills	Do. do.	Do.	85.36	5,121.6	

J. D. GRAHAM, *Capt. U. S. Top. Engineers.*

APPENDIX, containing astronomical observations to determine the latitudes and magnetic variation at several points on the route surveyed for the Montpelier canal, State of Vermont, in 1829 *and* 1830, *by James D. Graham, Captain United States Topographical Engineers.*

The following observations for the latitudes of three important points on the route of the contemplated Montpelier canal, State of Vermont, were made in connection with the surveys for that work. The only instruments used in making these observations were a sextant of 7¾ths inches radius, made by B. Stancliff, of Philadelphia, and graduated to read, by aid of the vernier, to fifteen seconds, or the $\frac{1}{240}$th of a degree, and an artificial horizon of mercury accompanied by an excellent glass roof.

All the observations belonging to the same series, and referring to the same point, are stated separately, in order to show how near a coincidence was obtained.

They are, however, offered as approximations when considered in relation to results, which, by the same pains, may be obtained by the use of more perfect instruments.

It will be readily seen that the magnetic variation which resulted from the observations made at Montpelier, is three or four degrees greater than that angle is generally found to be in that part of the country, and it was not until the observations were verified by careful repetition, that I could be satisfied that an extraneous influence so great could result from local causes operating upon the magnetic needle.

Iron is however known to exist in great quantities, in its native state, throughout this part of Vermont, and this phenomenon is no doubt to be attributed to that cause.

Montpelier, Vermont.

July 7th, 1829. Observed meridian double altitude of the planet Jupiter, - - - - - - 50° 04′ 43″*
Latitude deduced, - - - - - - 44° 16′ 14″ N.

Same night. Observed meridian double altitude of the star A Ophiuchi, - - - - - - 116° 52′ 43″
Latitude deduced, - - - - - - 44° 15′ 59″

July 9th 1829. Observed double meridian altitude of the star A Ophiuchi, - - - - - - 116° 51′ 50″
Latitude deduced, - - - - - - 44° 16′ 25″

Same night. Observed double meridian altitude of star A Aquilæ, - - - - - - 108° 20′ 15″
Latitude deduced, - - - - - - 44° 16′ 17″

Thermometer, at time of last observation, 54° of Fahrenheit,

* This and all the other double altitudes are recorded as corrected for the index error of the sextant.

ophinchi. read, the

July 10th, 1829. Observed double meridian altitude of planet Jupiter, - - - - - - 50° 07′ 45″
Latitude deduced, - - - - - - 44° 16′ 02″

Same night. Observed double meridian altitude of star A Ophiuchi, - - - - - - 116° 52′ 30″
Latitude deduced - - - - - - 44° 16′ 05″

Same night. At 11h 44′ 33″ P. M., mean solar time, civil account, the star Polaris (A Ursæ Minoris) was found by calculation to be in its greatest eastern elongation, before passing the meridian. At that moment of time, indicated by a good lever watch, regulated by equal altitudes of the sun observed this day and yesterday, the magnetic bearing of Polaris was observed by means of a good surveyor's compass to be as follows, viz:

1st observation: reading of north end of the needle -	N. 14° 40′ E.
2d observation: reading of south end of the needle -	14° 45′
3d observation: by reversing limbs of compass; north end of needle - - - - - -	14° 40′
4th observation: compass as above mentioned; south end of needle - - - - - -	14° 45′
Mean bearing, per compass - - - - -	N. 14° 42½′ E.
Azimuth of Polaris, or eastern elongation - -	2° 14′ E.
Magnetic variation deduced - - - - -	N. 12° 28½′ W.

Same night (July 10). Observed double meridian altitude of star A Aquilæ - - - - - 108° 20′ 45″
Latitude deduced - - - - - - 44° 16′ 02″ N.

Thermometer, at the time of last observation, stood at 56° of Fahrenheit.

July 11, 1829. Observed meridian double altitude of star A Ophiuchi - - - - - - 116° 52′ 45″
Latitude deduced - - - - - - 44° 15′ 57″ N.

Same night. Calculated mean time of greatest eastern elongation of Polaris, to be 11 h. 40′ 39″ P. M. civil account. At which time, indicated by lever watch, regulated by observations of equal altitudes of the sun continued, the magnetic bearings of Polaris was observed by the compass, as follows, viz:

1st reading: north end of needle - - -	N. 14° 35′ E.
2d reading: south end of needle - - -	14° 40′
Limbs of compass reversed:	
3d reading: north end of needle - - -	14° 35′
4th reading: south end of needle - - -	14° 40′
Mean bearing, per compass, of Polaris - - -	N. 14° 37½′ E.
Azimuth, or eastern elongation of Polaris - -	2° 14′ E.
Magnetic variation deduced - - - -	N. 12° 23½′ W.

Magnetic variation deduced from observations of last night - - - - - - -	N. 12° 28½' W.
Magnetic variation, by a mean of observations, per compass, on nights of July 10 and 11, 1829 - -	N. 12° 26' W.

The elevation of Polaris being too great to observe it through the apertures in the upright vanes of the compass, its bearing was obtained in the following manner, viz: a cord, having a heavy weight attached to its lower end, which reached near the ground, was suspended from a projecting rod attached to the roof of the legislative hall, and the compass was placed in such a position that its upright vanes, the cord, and the star Polaris, were all in the same vertical plane at the moment calculated for the observation. The cord was then illuminated, and being free from oscillation, its bearing was observed, and considered to indicate that of the star. This was the only means in my power to adopt, as I was not, on this occasion, provided with a theodolite or any other instrument except the compass for making this observation.

The magnetic variation indicated by these observations being much greater than I had been induced to suppose it, determined me on my return to this place the following year, to verify them by means of a good theodolite, which, in the mean time, I had received from the topographical bureau.

The results of these additional observations will appear presently, and be found to coincide very nearly with those already recorded.

Same night, (July 11, 1829). Observed double meridian altitude of star A Aquilæ - - - -	108° 20' 30"
Latitude deduced - - - - - - -	44° 16' 7"

August 10, 1830. Observed double meridian altitude of sun's upper limb - - - - - -	123° 12' 30"
Apparent altitude of sun's upper limb - - - -	61° 36' 15"
Sun's semidiameter - - - - - -	15' 49"
	61° 20' 26"
Correction for parallax and refraction - - - -	28"
True meridian altitude of sun's centre - - -	61° 19' 58"
True meridian zenith distance of do. - - -	28° 40' 2"
Sun's declination when on meridian - - -	15° 36' 32" N.
Latitude deduced - - - - - -	44° 16' 34" N.

Same night. Made an observation for the magnetic variation, by means of the theodolite and an artificial horizon of mercury, provided with an excellent glass roof, as follows, viz: the time of greatest eastern azimuth of Polaris was found, by calculation, as heretofore. A few minutes before this time, (the theodolite having been previously placed upon its tripod and adjusted,) the artificial horizon was placed upon the ground in front of the theodolite, whose vertical limb was so adjusted, by means of the levelling screws of the tripod-head, that by one vertical sweep of the telescope, its vertical web passed through the Polar star and its image, reflected from the horizon of mercury, showing that the axis of the telescope, in its motion

up and down, coincided with the vertical plane passing through the North star.

Then at the moment of the greatest elongation of the star, indicated by the time-piece adjusted by previous observations, the vertical web of the telescope was again verified upon the star. The telescope was then revolved down, and, by means of a lantern, a peg was driven into the ground about 400 feet from the instrument, and coincident in direction with the vertical web. The position of the theodolite was now marked by a peg driven in the ground, perpendicularly, under the centre of the tripod head. By this means the instrument was, on the following morning, placed in its former position, and an angle laid off, by means of the horizontal limb, of *two degrees and fourteen minutes*, (the azimuth of the star when observed,) to the left from the direction of the first mentioned peg. A third peg was now driven, to coincide with the vertical web of the telescope in its last position, indicating the direction of the true meridian, from the position of the instrument.

The theodolite was now removed, and a compass, having a needle 8 inches long, occupied its place, by which the bearing of the peg marking the true meridian, was observed as follows, viz:

1st Observation	—mean reading of two ends of needle, - -	N. 12° 24' E.
2d Do	reversing limbs of compass, and taking a mean of readings of two ends of the needle as before, - - - -	N. 12° 28' E.
3d Do	compass as in 1st observation, and mean of two ends of needle taken, - -	N. 12° 23' E.
Magnetic variation, by a mean of the above,	- -	N. 12° 25' W.

Which differs but 1 minute from the mean of all the observations made for the magnetic variation on the nights of the 10th and 11th of July, 1829.

It is very evident, from the foregoing observations, that there is a strong local attraction of the needle in the vicinity of Montpelier, arising, no doubt from the existence of iron ore in the neighboring hills.

Recapitulation of latitudes of Montpelier, deduced from the preceding observations.

1829, July 7th.	Latitude, by observation	of planet Jupiter,	44° 16' 14" N.
" "	do	do	of * A Ophiuchi,	44 15 59
" 9th	do	do	of do	44 16 25
" "	do	do	of * A Aquilæ,	44 16 17
" 10th	do	do	of planet Jupiter,	44 16 02
" "	do	do	of * A Ophiuchi,	44 16 05
" "	do	do	of * A Aquilæ,	44 16 02
" 11th	do	do	of * A Ophiuchi,	44 15 57
" "	do	do	of * A Aquilæ,	44 16 07
1830, August 10th	do	do	of the sun,	44 16 34

Latitude of the legislative hall, Montpelier, Vermont, by a mean of the above ten observations, - - -	44° 16' 10" N.
Magnetic variation at same place, - - -	12° 25' W.

Plainfield Village, Vermont.

1829. July 13th.	Observed double meridian, altitude of star * A Ophiuchi, - - -	116° 51′ 00″
	Latitude deduced, - - -	44 16 51 N.
" July 14th.	Observed double meridian, altitude of the planet Jupiter, - - -	50° 09′ 30″
	Latitude deduced, - - -	44 16 50
" July 16th.	Observed double meridian, altitude of planet Jupiter, - - - -	50° 10′ 15″
	Latitude deduced, - - -	44 17 07
" Same night.	Observed double meridian, altitude of star A Ophiuchi, - - -	116° 50′ 30″
	Latitude deduced, - - -	44 17 06
" July 17th.	Observed double meridian, altitude of planet Jupiter, - - - -	50° 10′ 45″
	Latitude deduced, - - -	44 17 12
" Same night.	Observed meridian double, altitude of star A Ophiuchi, - - -	116° 50′ 15″
	Latitude deduced, - - -	44 17 11
" July 19th.	Observed double meridian, altitude of star A Aquilæ, - - - -	108° 18′ 45″
	Latitude deduced, - - -	44 17 02
" July 20th.	Observed double meridian, altitude of star A Ophiuchi, - - -	116° 50′ 30″
	Latitude deduced, - - -	44 17 05

Recapitulation of latitudes of Plainfield village (Williams's Hotel.)

1829.	July	13th.	Latitude by observation	of * A Ophiuchi,	44° 16′ 51″N.
"	"	14	do do	of planet Jupiter,	44 16 50
"	"	16	do do	of do	44 17 07
"	"	16	do do	of * A Ophiuchi,	44 17 06
"	"	17	do do	of planet Jupiter,	44 17 12
"	"	17	do do	of * A Ophiuchi,	44 17 11
"	"	19	do do	of * A Aquilæ,	44 17 02
"	"	20	do do	of * A Ophiuchi,	44 17 05

Latitude of Plainfield village, (Williams's hotel) by a mean of the above eight observations, - - - 44° 17′ 03″N.

Wells's River village, Vermont at the mouth of Wells's river.

1829. Aug. 22d. Observed double meridian altitude of * A Aquilæ, - - - - - -	108° 33′ 15″
Latitude deduced, - - - - -	44° 09′ 51″N.
1829. Aug. 23d. Observed double meridian altitude of the sun's lower limb, - - - - - -	113° 59′ 30″
(sun's semidiameter, 15′ 51″: correction for parallax and refraction 31″; sun's declination 11° 24′ 25″ N.)	
Latitude deduced, - - - - -	44° 09′ 20″
At night. Observed double meridian altitude of * A Aquilæ, - - - - - -	108° 33′ 30″
Latitude deduced, - - - - -	44° 09′ 43″
1829. Aug. 24. Observed double meridian altitude of the sun's lower limb, - - - - -	113° 18′ 15″
Latitude deduced, - - - - -	44° 09′ 30″

Recapitulation of latitudes of Wells's River village, Vermont (mouth of Wells's river.)

1829.	Aug.	22d.	Latitude by observation	of * A Aquilæ,	44° 09′ 51″N.
"	"	23	do do	of the sun,	44 09 20
"	"	23	do do	of * A Aquilæ,	44 09 43
"	"	24	do do	of the sun,	44 09 30

Latitude of Wells's River village, by a mean of the above four observations, - - - - - 44° 09′ 36″N.

Statement of results of the preceding observations.

Places of observation.	Latitudes.	Magnetic variation.
State of Vermont.		
1. Montpelier, - - - -	44° 16′ 10″ N.	12° 25′ W.
2. Plainfield village, - - -	44° 17′ 03″	
3. Wells's River village, - - -	44° 09′ 36″	

Respectfully submitted:

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