

SURVEYS OF THE TERRITORIES.

LETTER

FROM THE

ACTING PRESIDENT OF THE NATIONAL ACADEMY OF SCIENCES

TRANSMITTING

A report on the surveys of the Territories.

DECEMBER 3, 1878.—Referred to the Committee on Appropriations and ordered to be printed.

YALE COLLEGE, NEW HAVEN, CONN.,
November 26, 1878.

SIR: I have the honor to inclose herewith the report on the scientific surveys of the Territories, made by the National Academy of Sciences, in accordance with the requirement of law (H. R. 5130) approved June 20, 1878.

This report was adopted by the academy at its last meeting, held in New York, November 6, 1878.

I have the honor, also, to transmit the following documents, sent to the academy by the Secretary of War and the Secretary of the Interior, and containing detailed statements in regard to the surveys under their respective departments, namely:

(1) A communication from the Acting Chief of Engineers of the Army.
(2) A communication from the Commissioner of the General Land Office.

(3) A communication from Prof. F. V. Hayden.

(4) A communication from Maj. J. W. Powell.

Very respectfully, your obedient servant,

O. C. MARSH,
*Vice-President and Acting President of the
National Academy of Sciences.*

To the honorable the SPEAKER
Of the House of Representatives.

At a meeting of the National Academy of Sciences, held in New York on November 6, 1878, the acting president of the academy submitted the following report from the Special Committee on Scientific Surveys of the Territories of the United States:

The committee of the National Academy of Sciences, to whom has been referred the consideration of the following requirement of law contained in the act making appropriations for sundry civil expenses of the government for the fiscal year ending June 30, 1879, and for other purposes, approved June 20, 1878, namely:

And the National Academy of Sciences is hereby required, at their next meeting, to take into consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Department, and the surveys of the Land Office, and to report to Congress, as soon thereafter as may be practicable, a plan for surveying and mapping the Territories of the United States on such general system as will, in their judgment, secure the best results at the least possible cost; and also to recommend to Congress a suitable plan for the publication and distribution of reports, maps, and documents, and other results of the said surveys,

submit the following report:

The committee consider that the field of inquiry proposed to the academy is intended to embrace only such surveys as pertain to the public domain. They have not included in their plan of organization surveys and investigations, however scientific in method and character, which apply solely to engineering works, such as the improvements of rivers, harbors, lakes, &c.; the irrigation and drainage of public lands, reclamation of tidal lands, and protection of alluvial regions from floods. Such surveys and investigations being inseparably connected with engineering problems, should, in the judgment of the committee, be conducted by the Engineer Corps of the Army. Nor do the committee recommend any change in the organization of the survey of the great lakes, as this is now nearly completed.

The works which seem to fall especially within the limits of the meaning of the law are the geographical surveys west of the one hundredth meridian under the War Department, the United States Geographical and Geological Surveys of the Territories and of the Rocky Mountain Region under the Interior Department, and the system of land surveys under the supervision of the Land Office. Besides these, although not enumerated in the law, one of the most important works now in progress in the interior, under act of Congress, is the geodetic work of the coast and geodetic survey. Parties of this organization are now conducting a systematic triangulation at several points in the interior, and any general system such as is contemplated in the above law cannot be wisely devised without taking into account the object and organization of this survey. The objects of these various surveys are, 1. An accurate geodetic survey; 2. A general geographical and topographical reconnaissance; 3. Land-parceling surveys on which the government can part title to portions of the public domain; 4. The economic classification and valuation of the public domain. To these should be added the gradual completion of a general accurate topographical map of the whole territory of the United States, which shall serve as a basis for all the scientific and practical needs of the government and the people. All this work may be included under two distinct and separate heads: 1. Surveys of mensuration; 2. Surveys of geology and economic resources of the soil.

We will first consider the present operations of the surveys of mensuration. Such surveys are now in progress under five different independent organizations—that of the coast and geodetic survey; of the geographical

surveys west of the one hundredth meridian under the War Department; of the topographical work of the two surveys under the Interior Department; and of the land survey under the Land Office. The final object of all these works of mensuration is the accurate determination of position and the laying down of lines and points by measurement. There is at present no co-ordination between these five surveys. Their original determinations of position are independent; their systems of surveys discordant; their results show many contradictions, and involve unnecessary expenditure. The geographical reconnaissances carried on under the War and Interior Departments are of little value for the parceling of land, while the land surveys are of correspondingly slight topographical and geographical value. The operations of the coast and geodetic survey in the interior do not at present include topography and land parceling. To attain the desirable accuracy and economy, it is absolutely essential that there should be only one geodetic system, one topographical system, and one land-parceling system, all conducted under the same head. It is evident that both topographical and land-parceling surveys, to be properly co-ordinated and sufficiently exact, must be based upon a single rigid geodetic foundation. All these three divisions are departments of measuring, all are based upon accurate determinations of position, and, to be effectively and economically carried out, should be united into one comprehensive system. After a careful consideration of the facilities at the disposal of the several existing organizations engaged in this work, the committee believe that the coast and geodetic survey is practically best prepared to execute the entire mensuration system required. Within the public domain, the dominant interest of the United States is centered in the public lands which remain to be surveyed and sold. The administration of these lands, consisting of 1,101,107,183 acres, is necessarily within the Department of the Interior, while the coast and geodetic survey, having been originally inaugurated to meet the wants of commerce, has been hitherto under the Treasury Department. In view of the paramount importance of the public lands, the committee recommend that the coast and geodetic survey be transferred from the Treasury Department to the Department of the Interior, retaining its original field of operations, and assuming also the entire mensuration of the public domain, and that, so modified and extended, it hereafter be known as the United States Coast and Interior Survey. This organization would then embrace, in addition to its former work, a geodetic survey of the whole public domain, a topographical survey comprising detailed topographical work and rapid reconnaissance, and land-parceling surveys. The Superintendent of the Coast and Interior Survey should be appointed by the President, and should report directly to the Secretary of the Interior.

The best interests of the public domain require, for the purposes of intelligent administration, a thorough knowledge of its geological structure, natural resources, and products. The domain embraces a vast mineral wealth in its soils, metals, salines, stones, clays, &c. To meet the requirements of existing laws in the disposition of the agricultural, mineral, pastoral, timber, desert, and swamp lands, a thorough investigation and classification of the acreage of the public domain is imperatively demanded. The committee, therefore, recommend that Congress establish, under the Department of the Interior, an independent organization, to be known as the United States Geological Survey, to be charged with the study of the geological structure and economical resources of the public domain, such survey to be placed under a director,

who shall be appointed by the President, and who shall report directly to the Secretary of the Interior.

It should be specially provided that the director and members of the geological survey, charged as they are with the investigation of the natural resources of the public domain, shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations.

Officers of the Army and Navy, when not otherwise employed, might be detailed by the Secretary of War, or of the Navy, to take part in the operations of either survey.

With the inauguration of the two surveys above defined, the committee recommend a discontinuance, first, of the present geographical and geological surveys west of the one hundredth meridian under the War Department, except surveys necessary for military purposes and local internal improvements; second, of the geographical and geological surveys now in progress under the Department of the Interior; and, third, of the present land surveys under the Land Office.

The effect of the above changes will be to maintain within the Interior Department three distinct organizations: First, the Coast and Interior Survey, whose function will embrace all questions of position and mensuration; second, the United States Geological Survey, whose function will be the determination of all questions relating to the geological structure and natural resources of the public domain; third, the Land Office, controlling the disposition and sale of the public lands, including all questions of title and record. With this division should be secured a perfect co-ordination and co-operation between the three branches. The Land Office should call upon the Coast and Interior Survey for all surveys and measurements required for the sale and disposition of land. The Land Office should also call upon the United States Geological Survey for all information as to the value and classification of lands. The results of all the mensuration surveys, as soon as completed, should be immediately available for the Land Office and for the Geological Survey and for other branches of the government, as required. The Geological Survey should be authorized to execute local topographical surveys for special purposes, such, for instance, as the subterranean surveys of mining districts and metallic deposits, &c.

Each of the three organizations thus defined should make an annual report of its operations to the Secretary of the Interior. The publications of the Land Office should embrace reports of its business operations relating to the disposition and sale of land, together with the necessary maps. The publications of the Coast and Interior Survey, besides the annual report of operations, should consist of its geodetic results, geographical, topographical, and cadastral maps, coast charts, and such discussions and treatises connected therewith as the superintendent shall deem of value. The publications of the Geological Survey should consist of an annual report of operations, geological and economic maps, illustrating the resources and classification of the land, reports upon general and economical geology in all its branches, with the necessarily connected paleontology.

All collections made by the Coast and Interior and the Geological Surveys, when no longer needed for the investigations in progress, should be transferred to the National Museum.

The committee recommend that upon the organization of the United States Coast and Interior Survey and the United States Geological Survey, a commission be formed, to consist of the Commissioner of the Land

Office, Superintendent of the Coast and Interior Survey, Director of the United States Geological Survey, the Chief of Engineers of the Army, and three other persons to be appointed by the President, who shall take into consideration the codification of the present laws relating to the survey and disposition of the public domain, and who shall report to Congress within one year a standard of classification and valuation of the public land, together with a system of land-parceling survey. The necessity of this commission is evident from the fact that by far the larger part of the public domain lies in the region where, from geological and climatic causes, the lands are for the most part not valuable for field-culture, and where the system of homestead pre-emption and sale in accordance with existing laws is both impracticable and undesirable.

In regard to publications of the two surveys above defined, the committee recommend that, besides the number of copies of each report which Congress may order for its own distribution, three thousand copies be published for scientific exchanges by the heads of these surveys and for sale at the price of publication; that all literary and cartographic material received by the heads of these surveys in exchange be the property of the United States and form a part of the libraries of the two organizations; that the money resulting from the sale of these publications be covered into the Treasury.

The committee recommend that the annual reports of operations of the two surveys accompany the report of the Secretary of the Interior; that the special memoirs and reports of both surveys be issued in uniform quarto series; that the style and scale of the cartographic publications be determined by the head of each organization, so as to express the scientific results in the most effective and economical manner.

All of which is respectfully submitted.

O. C. MARSH,
Vice-President and Acting President.
 JAMES D. DANA,
 WILLIAM B. ROGERS,
 J. S. NEWBERRY,
 W. P. TROWBRIDGE,
 SIMON NEWCOMB,
 ALEX. AGASSIZ,
Members of the Committee.

NEW YORK, November 6, 1878.

At the meeting of the National Academy of Sciences, held in New York, November 6, 1878, the above report was adopted.

O. C. MARSH,
Acting President.

J. H. C. COFFIN,
Home Secretary.

WAR DEPARTMENT.

Letter from the Secretary.

WAR DEPARTMENT,
Washington City, October 30, 1878.

SIR: I have the honor to acknowledge the receipt of your letter of September 28 last, in reference to the "Act making appropriations for sundry civil expenses," &c. (H. R. 5130), Forty-fifth Congress, second session, relative to the consideration by the National Academy of Sciences of "all surveys of a scientific character under the War and Interior Departments and under the Land Office," and informing this department that a committee of the academy has been appointed and is now ready to consider the subject, and requesting that a communication may be addressed to you by this department conveying any information in regard to its plans and wishes in reference to such surveys.

In reply thereto, I inclose herewith a report of the Chief of Engineers upon the subject. The inclosures mentioned therein have been boxed and shipped to you by to-day's express as per address of this letter.

Very respectfully, your obedient servant,

GEO. W. MCCRARY,
Secretary of War.

Prof. O. C. MARSH,
Buckingham Hotel, Fifth Avenue, New York.

YALE COLLEGE, NEW HAVEN, CONNECTICUT,
September 28, 1878.

SIR: Referring to "An act making appropriations for sundry civil expenses," &c. (H. R. 5130, Forty-fifth Congress, second session), relative to the consideration by the National Academy of Sciences of "all surveys of a scientific character, under the War or Interior Department, and the surveys of the Land Office," I have the honor to say that a committee of the academy has been appointed, and is now ready to consider the subject.

I respectfully ask, therefore, that a communication may be addressed to me from your office, conveying any information in regard to the plans and wishes of your department as to the above surveys you may think proper to lay before the academy.

The next meeting of the academy will begin November 5, 1878, and an early reply, therefore, is desirable.

Very respectfully, your obedient servant,

O. C. MARSH,
Acting President of the National Academy of Sciences.

Hon. SECRETARY OF WAR.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 29, 1878.

SIR: Referring to the letter of the 28th ultimo, from Prof. O. C. Marsh, acting president of the National Academy of Sciences, inviting attention to that portion of an "Act making appropriations for the sundry civil expenses of the government," approved on the 20th June, 1878, which relates to the consideration by that academy of all "surveys of a scientific character under the War or Interior Department and the surveys of the Land Office," and requesting to be informed of the plans and wishes of the War Department in connection therewith, which letter has been referred to this office for the views of the Chief of Engineers, I have the honor to submit the following:

While surveys, of more or less detail, of those portions of the Territories of the United States which are suitable for agricultural purposes and for mining, are essential to the settlement and development of such portions of the public lands by emigrants from the

Eastern States and from Europe, surveys of the entire areas of these Territories are necessary to the War Department in its supervision of campaigns against hostile Indians, and the establishment of military posts, and to the troops in the execution of the orders of that department. As has been abundantly shown in the history of the operations in these campaigns from the first to those now in progress, they more frequently cover the arid, sterile, and worthless parts of the Territories, which form a very large portion of their whole area, than those parts which are inhabited, or are susceptible of settlement and cultivation.

No other department of the government is so much interested in, or has so many uses for, a complete survey of the entire area as the War Department, and the maps required for its use should exhibit all that is necessary to be known in the ordering of the movements of troops and supplies, including exactly all the localities of routes over which they can be moved, the resources of the country, the probable haunts of the enemy, and all the natural features of the ground which may in any way affect the movements of infantry, artillery, and cavalry. Not only are these maps of the entire area, including the most barren, necessary to those whose office it is to direct the movements of troops and supplies, but the engineer department of the Army should be able to furnish every officer in command of troops with good maps printed on strong paper for use in the field.

Any kind of survey fulfilling the above requirements, and covering so large an extent of country, involves so great an expenditure of time and money that well-arranged plans, in respect to the methods to be employed, the precision to be obtained, and the proper department for doing the work, should be considered. The methods to be employed, and the degree of precision to be obtained, depend upon the actual and prospective requirements of the government (especially of the War Department, which, as before stated, has a paramount need of a survey of *all* the portions of our public domain, the worthless as well as the valuable), the wants of the inhabitants, and of those who are looking toward the West with views of emigration or investment.

That minute surveys, such as the ordnance survey of England, executed by the corps of royal engineers; the surveys of the continental countries of Europe, carried on by their military establishments; the survey of the Atlantic and Pacific and Gulf coasts by the Coast Survey, and the survey of the great lakes by this department, are not required for our Western Territories, thinly settled or entirely unoccupied by civilized people, as they are, is manifest. Their area is immense; the cost would be enormous, and there are no necessities which demand them. None of the densely-settled States of the East, as far as this department is informed, have as yet been induced to authorize the expenditures required for such surveys of their comparatively small areas; and the War Department has not, and, it is believed, will not, ask Congress to appropriate the public moneys for any such survey of our Western Territories.

The propriety of this is apparent when it is considered that the cost of such a survey would not, in this country, be less than \$100 per square mile, that the area of the country west of the 100th meridian of longitude is about 1,500,000 square miles, and that the total cost would not be less than \$150,000,000. Furthermore, such a survey, with any probable expenditures which Congress would be likely to grant, could not be executed in less than two hundred years.

In the view of this department, a trigonometrical and topographical survey of the Territories, which shall be founded on accurate astronomical and geodetic methods; that is, *in which the frame-work of all extended surveys—the triangulation—is carefully executed*; which exhibits with sufficient accuracy, and with variable degrees of detail according to circumstances, the forms and elevation of the mountain ranges and passes, the roads, the trails, the lakes and ponds, the water-courses, the forests, and all the prominent natural features of the country, including its capacity for agriculture, for grazing, and for mining; which includes the gauging of streams with reference to the irrigation of those portions of the country which are susceptible of occupation by a grain-growing population; and which shows at a glance everything necessary to be known in connection with the movements of troops and supplies, is the survey which should be recommended for the adoption of Congress.

The frame-work of the map being accurate, limited areas can be surveyed from time to time with any degree of exactitude required for any special purposes, whether connected with the geography, the geology, or the natural history of those areas.

The survey of the territory west of the one hundredth meridian, carried on under the direction of the Chief of Engineers, by officers of the Corps of Engineers, officers of other branches of the military service detailed for the work, and by civilians of scientific attainments in the service of this department, which has already surveyed more than 300,000 square miles of area, is believed to fulfill all the foregoing requirements of the War Department, and of the nation at the present time, and until the Territories are not less thickly settled than the more recent of the States of the Union. The geodetic work on which the maps of this survey are based may be relied on as accurate; and that the topography is sufficiently in detail, is evident from an inspection of examples which are sent herewith for the information of the National Academy.

Respecting the survey of the northern and northwestern lakes and the river Saint Lawrence, carried on by this department, I beg to refer to pages 8 to 10, inclusive, of the accompanying report of the survey of the lakes for 1875, which gives a short history and shows the extent of this survey. The field work, which has embraced between the eastern limit (St. Regis, N. Y.) and the western limit (Duluth, Minn.) about six thousand miles of coast line, is now practically completed, and has been executed in a manner not inferior, it is believed, to any survey of the kind in any country. Examples of the maps of this survey are herewith.

A geological survey of the fortieth parallel, embracing a strip of country about one hundred miles wide between the one hundred and fourth and one hundred and twentieth degrees of longitude, executed by Mr. Clarence King, under the direction of the Chief of Engineers, has been completed. A copy of the atlas of the survey is herewith, and it is sufficient evidence of the excellent character of a work which has received so many well-deserved encomiums.

A survey of the Mississippi River is now being executed by officers of this department, under recent acts of Congress, for the benefit of the navigation of that river, and for the preparation of plans of works of improvements under this department, especially the works necessary for the protection of its alluvion against floods; a question now become of the first importance. The character of this work is essentially the same as the lake survey, and the officers and other persons and the public property employed in the latter have been to a great degree transferred to the former. Examples of the maps of this survey are also herewith.

In addition to the foregoing surveys, carried on by this department, are many special surveys of rivers and harbors under the river and harbor acts enacted by Congress from year to year, and the topographical surveys executed by the engineer officers attached to the headquarters of the generals in command of the western military divisions and departments. The former surveys, being limited in their nature by the requirements of works of improvement, need not be further mentioned in this communication.

Respecting the surveys by the division and department engineers, it may be stated that there is necessarily at each of these headquarters an engineer officer or acting engineer officer (generally of the rank of captain or lieutenant), and a part of their duties is to make such surveys and reconnaissances as they can execute by means of limited amounts of funds furnished them and the assistance of the troops. Many of these reconnaissances are made during marches of troops in campaigns, and they have been of very great utility in the preparation of campaign maps for the use of the troops in the before almost unknown areas of the country in which they have been operating. A recent computation shows that more than 175,000 miles of routes, lines, and marches have been plotted by these officers within ten years.

The foregoing relates to the plans of the War Department.

Respecting its wishes, it is suggested that in view of the considerations that refined methods of topographical survey were first used in the United States by officers of the Army in the performance of their varied duties under the government; that they were among the first to apply the refined methods of geodetic survey; that from the time the government had territories to explore the explorations have been mainly made by them; that so large a portion of the information contained in all of the maps of the United States west of the Mississippi River is due to their labors; that the War Department has under its orders a trained body of officers skilled in every operation of a survey, including the most refined and difficult problems in astronomy and geodesy, and in the administrative duties connected with extended surveys; that the officers of the War Department from the earlier years of this century—from the days of Pike and Long, Lewis and Clarke, and Bonneville—have borne the hardships and exposure of the preliminary examinations and surveys, when the region was an unknown wilderness, and have gone on improving their surveys from time to time by more accurate methods as the improvements in instruments and means of their transportation have increased; and of the further consideration that the supervision over the methods and the checks upon the expenses of the officers of this department, exercised by the Chief of Engineers, are watchful and constant, it is believed to be the desire of the War Department, and for the best interests of the government, that the surveys of the Territories of the West under the Engineer Department shall continue to the full extent that Congress may be willing and grant appropriations therefor.

Respecting the land surveys and the geological surveys of the Territories, it is not deemed necessary in this communication to mention them, since these special surveys are under another department of the government. It may be stated, however, that it would seem to be a waste of public money to make surveys of any portions of the public land for the purpose of making descriptions of area in passing the title of the United States, unless there is a probability of the sale of such portions (as, for instance, by reason of their value for agriculture or mining purposes), and it may be considered advisable that the War Department surveys, of the character already mentioned, should

precede the selection by the Interior Department of the portions of the public lands to be surveyed in detail for subdivision and sale.

If this plan should be adopted, not only would there be no difficulty in determining beforehand the limits of the areas over which the land survey should properly be carried, but the points and lines of the land surveys could be, with very little trouble or expense, plotted on the maps in their correct geodetic positions.

In regard to the geological surveys, no reason is foreseen why the maps of the War Department surveys cannot be drawn to any scale which may be considered necessary in plotting the geology of those portions of the country over which it may be considered necessary to carry investigations in that science.

The following documents and maps are sent herewith for the information of the National Academy of Sciences in its consideration of the matters referred to in this communication:

1. Thirteen maps of the series of maps of the survey west of the 100th meridian; 29 maps of this series have been published.

2. Ten charts of the series of charts of the survey of the northern and northwestern lakes and River Saint Lawrence; 65 maps of this series have been published.

3. Four charts of the series of charts of the survey of the Mississippi River; 9 charts of this series have been published.

4. A copy of the War Department map of the United States, exhibiting the distribution of military posts.

5. A copy of the atlas of the geological survey of the 40th parallel.

6. A copy of "Notes on European Surveys," by General Comstock, of the Corps of Engineers.

7. A copy of the report of the survey of the northern and northwestern lakes for 1875, containing (pages 8 to 10 inclusive) a short history and showing the extent of that survey.

The letter of the acting president of the National Academy of Sciences is herewith returned.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Acting Chief of Engineers.

HON. GEORGE W. McCRARY,
Secretary of War.

DEPARTMENT OF THE INTERIOR.

Letter from the Secretary.

DEPARTMENT OF THE INTERIOR,
Washington, D. C., November 2, 1878.

SIR: Pursuant to the request contained in your letter of the 28th September last for information concerning public surveys, under a paragraph in the sundry civil act of 20th June last (20 Stat., 230), which requires the National Academy of Sciences to take into consideration the subject of scientific surveys, as well as those conducted under the direction of the General Land Office, I have the honor to transmit herewith the following papers:

1. Copy of the Report of the Commissioner of the General Land Office, with exhibits, (a) Instructions to surveyors-general, in private; (b) Diagram, showing principal meridian, principal base, guide meridian, correction or standard parallels, and township lines; (c) Form of surveying contract; (d) Special instructions for the establishment and survey of boundary-line coincident with a degree of longitude; (e) Boundary-line on parallel of latitude; (f) Outline of rectangular system of surveying; (g) Blank township-plat, showing surveyable lines and corners.

2. Report of Maj. J. W. Powell, in charge of United States Geographical and Geological Survey of the Rocky Mountain Region, with exhibits, (a) Ex. Doc. No. 80, House of Representatives, 45th Congress, 2d session; (b) printed copy of Report of J. W. Powell for 1877; (c)

Schedule of the principal meridians used in the survey of the public lands; (d) Synopsis of the Annual Report of the Commissioner of the General Land Office for 1875; (e) Same for 1877; (f) Instructions to surveyors-general.

3. Report of Prof. F. V. Hayden, in charge of the Geographical and Geological Survey of the Territories, with exhibits, (a) Ex. Doc. House of Representatives, Report No. 612, 43d Congress, 1st session; (b) Catalogue of the publications of the United States Geological and Geographical Survey of the Territories; (c) Sketch of the origin and progress of said survey; (d) Ex. Doc. No. 81, House of Representatives, 45th Congress, 2d session.

Very respectfully, your obedient servant,

C. SCHURZ,
Secretary.

Prof. O. C. MARSH, *Yale College,*
Acting President of the National Academy of Sciences,
New Haven Conn.

I.

DEPARTMENT OF THE INTERIOR,
GENERAL LAND OFFICE,
Washington, D. C., October 28, 1878.

SIR: I have the honor to acknowledge the receipt, by reference from you, of a communication of the acting president of the National Academy of Sciences, announcing the appointment by that body of a committee, and its readiness to take into consideration the methods and expenses of conducting all surveys of a scientific character under the "War or Interior Department, and the surveys of the General Land Office," in accordance with a requirement contained in the act making appropriations for sundry civil expenses of the government, approved June 20, 1878.

The surveys conducted under the direction of this office are confined to the establishment of boundary lines of States and Territories, Indian reservations, private claims or grants, mineral claims, and the subdivision of the public domain into tracts suitable for disposal to individuals.

The work is performed under mileage and per diem rates, fixed by law, and chiefly in accordance with the published manual of instructions to surveyors-general, which, by act of Congress, has become a part of the laws governing the same. The manual is sometimes amplified as regards details by special instructions from this office. Wherever necessary, data are procured from the War Department, whose surveys are conducted by geodetic and astronomic methods.

In arriving at results sought for by this office under the present system of surveys, the employment of methods called into service in projecting extensive and connected geographical and topographical surveys is regarded unnecessary.

Regarding any proposed change in the method of surveying the public lands, I desire to say that any departure from the rectangular system or any change in the measurement or subdivision of the land would, in my opinion, create confusion, which no advantage gained by the change could compensate for.

There is no State or Territory to which the present system has not been extended save Alaska. All the citizens residing in those parts of the United States and Territories where the public lands have been surveyed under the present system are familiar with it, the mode of describing the subdivisions are exceedingly simple, the length of subdivisional lines accord with our national standard of linear measurement. For these and other reasons which might be given, no change should be made in the method of surveying the public lands as now provided by law.

I am, however, of the opinion that combining a geological and geographical survey with the survey of the public lands might be most beneficial and economical.

The law providing for the sale or other disposition of the public lands contains, among other provisions, the following: Mineral lands are reserved from grants and from appropriation by homestead and pre-emption settlers.

The sale of coal lands at from ten to twenty dollars per acre is provided for by law, and they cannot be lawfully taken by homestead and pre-emption settlers.

An increased price is placed upon lands in some parts of the country which is chiefly valuable for the timber growing upon it.

The survey of the public lands under existing laws requires that section lines shall be traced and established one mile apart, and this is all that is required for the accurate survey of the land. The surveyor is only required to make such notes as to the quality of the land as come within his vision from the line he is tracing. These notes must, from necessity, be very imperfect and unreliable as an accurate description of the quality of the land and of its mineral and timber resources or value. Either after or before the surveys are extended over the public lands geographical and geological surveys are made at great expense, which describe the country no doubt most accurately, but not with reference to the public surveys. It is impossible to determine from these surveys any fact concerning any subdivision of the public lands showing the value of it for mineral or agricultural purposes.

If the geological and geographical surveys were made simultaneously with the subdivisional survey of the land, this office and the local offices would, of course, be advised of the character of the land, and would thus be enabled to prevent the taking of coal, mineral, or timber lands under the laws for the disposal of agricultural lands, and would result in a great saving to the Treasury of the government.

I transmit herewith a copy of the manual of instructions to surveyors-general, copy of special instructions for the establishment and survey of a boundary coincident with a degree of longitude, abstracts of returns of survey of a boundary line on a parallel of latitude, showing the methods used in determining the same, an outline of the rectangular system of surveying, with diagrams A and B, and form of a contract for the survey of public lands.

Very respectfully,

J. A. WILLIAMSON,
Commissioner.

HON. CARL SCHURZ,
Secretary of the Interior.

OFFICE OF THE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL
SURVEY OF THE TERRITORIES,
Washington, D. C., October 29, 1878.

SIR: Your communication of October 3, inclosing a copy of a letter from Prof. O. C. Marsh, acting president of the National Academy of Sciences, requesting a report on the subject of said letter, was received at Cheyenne, Wyo., October 13, on my return from the Yellowstone Park.

In reply, I beg to say that any plans which I could offer for the survey of the Western Territories would naturally be based upon the organization now under my charge. However desirable might be some great comprehensive plan of surveys, which should include all the scientific organizations connected with the government, the question would arise, is any such plan practicable at this time? Is the country ready for a department or bureau of science. If not, we have simply to consider what plan may be most practicable, and what one may meet the approval of a majority of Congress and the scientific men of the country.

My own agency in the work of exploration in the West is well known to the president and the committee of the National Academy. My labors commenced as far back as 1853 and have been uninterruptedly continued to the present time, except for a period of about four years of the war, during which I served as a surgeon of volunteers.

My explorations in earlier years were made under unfavorable circumstances, when there was but little interest in such matters among our people, and it is only within a few years that I have begun to reap the rewards of those labors. The survey now under my direction began in a very small way in 1867, and has gradually attained its present size and position through my most strenuous personal efforts. It was, however, founded largely on my labors during the first eight years, or from 1853 to 1860.

1. I need not refer in detail to the numerous publications made as the results of the survey up to this time, as they are doubtless well known to the committee of the academy. Should the committee need any additional information, I shall be happy to furnish it without delay. In the mean time I beg the secretary to forward them the accompanying package of pamphlets (marked 1, 2, 3, and 4), and to refer them to the publications of the survey, named therein, which can be forwarded to them at any time.

2. The organization under my direction consists of men with peculiar fitness for and a large practical experience in the special departments of the work assigned to them. They have been engaged in Western exploration from five to twenty years each. The organization is complete in all its parts, and ready to perform any work which can be required of a geological and geographical survey in its most comprehensive senses. It is regarded by the most eminent men of science in this country and in Europe as the most important and effective survey in existence at the present time. Dr. Petermann, after spending a day in examining the work and the office of the survey, stated "that there was not such an organization in all Europe." The testimony of Dr.

Hooker and General Strachey (herewith, marked A and B) is to the same effect. I have many other letters from all parts of Europe testifying to the same statement. If this is the case, then no material changes in the organization could be productive of good, but, on the contrary, would cause much evil and expense, and greatly retard the progress of our Western surveys.

3. The proposition to combine the geological and geographical surveys and the public land surveys under one bureau, presided over by a surveyor-general, it is believed would prove fatal to the former. All experience shows that such combinations result in complete failures. The two departments may aid each other, as they do at present, but they should be kept entirely separate, or the practical part of the work of the latter, appealing to so large a majority of the people, would very soon absorb the more purely scientific and precise operations of the former. It would be as difficult and fatal, for example, as the combination of the Smithsonian Institution with the Patent Office. No objection applies to the public land surveys as now conducted, or the office of a surveyor-general for the supervision of such public land surveys.

4. The grade of work was fixed in a general way by the Department of the Interior in July, 1874 (see copy herewith, marked "C"). It seems to me that the grade of which the atlas of Colorado may be regarded as a standard is sufficiently high. The theory of our government is that all Territories will eventually become States of the Union, with all the powers, as it were, of independent sovereignties, and capable of taking care of their own interests, as has been already the case with the States east of the Mississippi. State geological surveys have been successfully established, and in most instances continued for many years, and it seems, therefore, that a general geological and geographical survey of the Territories, in accordance with the plan fixed by the Secretary of the Interior, is amply sufficient to show the scientific and practical resources of the public domain, while the Territories remain wards of the general government.

5. The geological surveys, so far as the Department of the Interior is concerned, should be directly under the Secretary of the Interior, and not under any bureau officer of the department. In the former case the chief of the survey receives his general instructions, and he is untrammelled by specific orders or the intermeddling of one who has little else to do. The office of a chief of bureau in Washington would be an obstructive sinecure.

6. If the committee should take the view (as they probably will) that there should be but one organization for geological and geographical work under the Department of the Interior, I beg the Secretary to call their attention to a letter addressed to the Secretary of the Interior on that subject, dated November 15, 1877, a copy of which is on file in the Secretary's office. With reference to a third survey, now conducted by the War Department, if it should be decided that the parties remain as they are, under the Department of the Interior and War Department respectively, the areas to be assigned to each could be readily determined by conference of the Secretaries of the Interior and War Departments, as was done the past season, in accordance with a recommendation of the Committee on Public Lands of the House of Representatives, in an extended report on "Geographical and geological surveys west of the Mississippi" (43d Congress, 1st session, report No. 612, page 18), herewith (marked I). In either case, duplication is prevented.

7. Should there be an effort made to divorce topography from geology, placing the former under the War Department and the latter under the Interior Department, I would urge that experience shows it to be impracticable as well as unwise. The union of both these branches in the same organization improves the quality as well as the quantity of the work, and greatly diminishes the expense. When a party is organized for any special kind of work, as topography, for example, with a very little additional expense geologists and naturalists may be added. The topographer and geologist, when working harmoniously, are of great mutual aid. The topographer locates with precision on his map the geology, while the geologist's additional knowledge gives form and completeness to the work of the topographer. Geology deals with the skeleton, so to speak, while topography clothes that skeleton with its natural form.

Again, the department having the topography could, in our new country, where so little good work has been done as yet, easily control the geologist, and throw so many obstructions in the way of his work that geology would shortly follow topography under the same department.

In comparatively small European countries, as England or Germany, the topography was worked up in detail many years before geology became a science; but in this country our topography and geology west of the 94th meridian are mostly new.

Although there are many minor or collateral points upon which I do not touch in this communication, yet the foregoing considerations are submitted as the result of many years' experience.

It would be a matter of great satisfaction to the members of the survey if the com-

mittee of the academy would make a careful examination of its workings as shown by the material in the office.

Very respectfully, your obedient servant,

F. V. HAYDEN,
United States Geologist.

Hon. C. SCHURZ,
Secretary of the Interior.

A.

Sir Joseph D. Hooker, a distinguished botanist, director of the Gardens of Kew and president of the Royal Society, London, Eng., says:

"I can hardly tell you how great the interest is which your survey work excites here in England. Taken in all its bearings, it is no doubt the most interesting and important now being undertaken anywhere on the globe, India, perhaps, only excepted, and you certainly beat India in the admirable completeness of your work and the illustrations of the physical as well as geological features of the country."

B.

Lieut. Gen. Richard Strachey, of the royal engineers, London, Eng., says:

"I wish you every success in the completion of the great work you have hitherto so well carried on. As I have before said to you, I think it is an undertaking in all respects most honorable to your government and to the men of science who have been their agents in carrying it out. In truth it is, I believe, the only really scientific survey of a great country ever entered upon."

C.

DEPARTMENT OF THE INTERIOR,
Washington, D. C., July 1, 1874.

Instructions for the government of the geological and geographical survey of the Territories of the United States (authorized by act of Congress to be made under the direction of the Secretary of the Interior) in the preparation of suitable maps for the construction of an atlas of said Territories.

The following plan for the construction of an atlas of the territory of the United States west of the meridian of 99° 30' has been adopted by this department:

As the area mentioned embraces the greater part of the arid region of the United States, and has within its limits the greater number of mining districts therein, it is necessary that the maps composing the atlas contemplated shall be on a scale of sufficient magnitude to exhibit all the important geographical and geological features of the country; and in order that the several parties working under the direction of this department may properly connect their work, that the progress made in their surveys may at all times be understood, and that the several surveys may be conducted on a uniform system, this plan has been adopted:

1. There shall be two classes of maps—one known as "general," the other as "special" maps—and the "general" maps shall be subdivided into two classes, viz: "topographical" and "geological."

2. The general maps shall be on a scale of four miles to an inch, or $\frac{1}{253440}$. The sheets thereof shall be 26 inches long by 37 inches wide, including the border, and to be folded once. The area to be represented on each sheet shall be two and one-half degrees in longitude, and one and one-fourth degrees in latitude. The one hundred and twelfth meridian shall be taken as the standard from which the maps are to be projected in an easterly and westerly direction, and the thirty-eighth parallel as the standard from which they shall be projected in a northerly and southerly direction, these lines forming the division lines between the atlas-sheets adjacent thereunto.

3. Maps or charts of the second or "special" class may be constructed on other scales and embracing other areas, wherever it shall be found necessary, for the purpose of properly representing mining districts, mineral, agricultural, pasture, or timber lands, or other special purposes.

C. DELANO,
Secretary of the Interior.

II.

DEPARTMENT OF THE INTERIOR,
U. S. GEOGRAPHICAL AND GEOLOGICAL SURVEY
OF THE ROCKY MOUNTAIN REGION,
[J. W. POWELL, IN CHARGE,]
Washington, D. C., November 1, 1878.

SIR: I have the honor to acknowledge the receipt of your communication of October 3, as follows:

"DEPARTMENT OF THE INTERIOR,
"Washington, October 3, 1878.

"Maj. J. W. POWELL,
"Geologist in charge of the U. S. Geographical
"and Geological Survey of the Rocky Mountain Region :

"SIR: I transmit herewith a copy of a letter from Prof. O. C. Marsh, acting president of the National Academy of Sciences, relative to that provision of the act making appropriation for sundry civil expenses of the government for the year ending June 30, 1879, which requires the academy to take into consideration certain matters relating to the surveys of a scientific character under the War or the Interior Department, and the surveys of the Land Office.

"I will thank you to furnish to this department a report upon the subject of said letter, giving such information as you may think will be of value to the committee of the academy.

"Very respectfully;

"C. SCHURZ,
"Secretary."

And also the letter from Prof. O. C. Marsh, transmitted with the above, as follows:

"YALE COLLEGE, NEW HAVEN, CONN.,
"September 28, 1878.

"To the Hon. SECRETARY OF THE INTERIOR:

"SIR: Referring to 'An act making appropriation for sundry civil expenses,' &c. (H. R. 5130), Forty-fifth Congress, second session, relative to the consideration by the National Academy of Sciences, of 'all surveys of a scientific character under the War or Interior Department and the surveys of the Land Office,' I have the honor to say that a committee of the academy has been appointed and is now ready to consider the subject.

"I respectfully ask, therefore, that a communication may be addressed to me from your office conveying any information in regard to the plans and wishes of your department as to the above surveys you may think proper to lay before the academy.

"The next meeting of the academy will begin November 5, 1878, and an early reply, therefore, is desirable.

"Very respectfully, your obedient servant,

"O. C. MARSH,
"Acting President of the National Academy of Sciences."

The letter was forwarded from my office and reached me in Utah, where I was engaged in field work, on the 14th of October. I immediately returned to Washington for the purpose of making reply.

The clause of the appropriation bill, referred to in the letter of Professor Marsh, is as follows:

"And the National Academy of Sciences is hereby required, at their next meeting, to take into consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Department, and the surveys of the Land Office, and to report to Congress, as soon thereafter as may be practicable, a plan for surveying and mapping the Territories of the United States on such general system as will, in their judgment, secure the best results at the least possible cost, and also to recommend to Congress a suitable plan for the publication and distribution of the reports, maps, and documents, and other results of said surveys."

In reply to the above request, I beg leave to make the following statement:

The methods of conducting the surveys carried on under my direction, and the expense thereof, are set forth in the accompanying documents, marked A and B, as succinctly as I am able to present them. I beg leave, therefore, to refer the committee to the same, as my answer to the first part of the inquiry. Should the committee, however, desire a more elaborate and detailed reply, I shall be pleased to furnish it; or should it be deemed wise to ask specific questions relating to any portion

of the work under my direction, I shall consider it an honor to reply as thoroughly and explicitly as I am able. I should consider it a privilege to explain to the committee, with the fullest detail, the methods of research pursued in my work, and should be pleased to lay before its members for examination the system employed in the geographical work, with instruments, systematic records, field sketches, &c., embracing the methods of measuring base lines, extending the triangulation therefrom, determination of altitudes, sketching the topography, construction of charts, &c., and the geological methods of research, embracing the succession and geographical distribution of the sedimentary groups, the character and distribution of the crystalline schists, the characteristics, classification, and distribution of the extravasated rocks, the methods of research and representation employed in the study of structural geology, &c.; and also the researches in North American ethnology, embracing linguistics, sociology, mythology, arts, &c., together with the geographical distribution of the tribes; and, finally, the limited studies made in natural history. The greater part of the work is yet unpublished, and for a proper understanding of what has been done it would be necessary to thoroughly examine the materials in my office.

In relation to the next part of the inquiry, *i. e.*, as to "a plan for surveying and mapping the Territories of the United States on such general system as will * * * secure the best results at the least possible cost," I beg to submit the following suggestions:

For the past ten or twelve years different parties have been engaged in this work, pursuing diverse methods and producing diverse results. Four distinct autonomous geographical and geological surveys have been carried on simultaneously. In my answer to the resolution of inquiry from the House of Representatives, made on motion of the Hon. J. D. C. Atkins, chairman of the Committee on Appropriations, relating to the same subject, I made certain statements in my final remarks to which I beg to call attention. (*Vide* accompanying document marked B, being House of Representatives Ex. Doc., 80, Forty-fifth Congress, second session.)

The closing paragraph is as follows:

"In view of all these facts, it is manifest that the work should be unified and a common system adopted. This may be accomplished either by act of Congress, by executive direction, or by placing the work under one management."

I am still of the opinion that the unification which I advocated at that time would be wise; and desire to present additional reasons for the opinion then expressed.

I. The geographical work should be based on a transcontinental triangulation on a comprehensive plan, and carried on with proper refinement. With the work divided as it has been for the past ten years this is practically impossible. No one organization with its small appropriation can make the necessary outlay of money for this work without swallowing up the whole or greater part of its funds, and thus it would be prevented from doing other work. All of the scientific surveys which have been carried on for the past ten years are practically "in the air," because this fundamental condition of accuracy has been neglected.

II. For the hypsometric work transcontinental lines of levels should be established to which all the base stations in the field should be related by connecting lines. With the multiplicity of surveys and the small appropriations for each, it is impossible to have this work done, as it is impossible to have the transcontinental triangulation made.

III. All that portion of hypsometric work which is done by means of the barometer is to a greater or less extent inaccurate, from the fact that the barometric constants for North America have not been properly determined. The tables now in use are based on observations made at Saint Bernard and Geneva under climate conditions widely differing from those that obtain in this country. (*Vide* Williamson "On the Use of the Barometer," p. 220, *et seq.*; Pettie and Whitney, "Contributions to Barometric Hypsometry," in Report of the Geological Survey of California, and Lieut. Wm. L. Marshall, "Meteorology and Hypsometry," Appendix G 1, p. 370 of Report of the Chief of Engineers, 1876-'77, vol. II, part 3, and "Results in Barometric Hypsometry," p. 515 of Report of the United States Geographical and Geological Surveys West of the 100th Meridian, vol. II. A large amount of material on this subject has been collected by the survey under the direction of the writer, but remains unpublished.)

Series of observations must be made at suitable longitudes, latitudes, and altitudes within the territory to be surveyed, and from the data thus collected the tables must be prepared. As each survey is financially weak, and has but an uncertain tenure of existence, it is practically impossible to have these observations made.

The economic importance of hypsometric work is very great because of its relation to the agricultural industries of the country. In more than four-tenths of the United States agriculture is dependent upon irrigation, and in all of this region the hypsometric relations or relative levels of the land to adjacent streams by which they are to be fertilized must be determined. In all that vast area not a single farm can be cultivated or a site for an agricultural field selected without first determining by leveling the practicability of reaching it with water. While the government will not

be expected to run lines of levels for individual farmers, yet in the selection of lands to be surveyed and sold these facts cannot be neglected.

The hypsometric methods now in use by the several surveys are entirely inadequate to meet these practical demands.

IV. The area to be mapped is very great. The expense of cartography is an important part of the total expense of the work. Each party being desirous of exhibiting the greatest results for the appropriations made, has endeavored to curtail the expense of cartography as far as possible. For this reason the maps have been reproduced by cheap methods to serve temporary purposes, and the future needs of the country have been ignored. To some extent, especially by Clarence King and by myself, the subject of cartography has been investigated and experiments made for the purpose of determining methods best adapted to the wants of the country, considering the magnitude of the work and the facts to be represented. But because each survey has been financially weak these experiments have not been carried to the extent which the importance of the subject demands, and we are thus adopting cartographic methods imperfect and ephemeral.

A system of cartography should be used that will best represent the characteristics of the topography and convey the greatest amount of practical information, limited only by considerations of cost. The maps thus constructed should be placed upon materials that are enduring, as all the natural topographic features are themselves enduring, so that thereafter the plates could be used by the government to meet all wants that may arise from time to time.

Finally the prosecution of the work by a number of autonomous organizations is illogical, unscientific, and in violation of the fundamental law of political economy, namely, the law of the division of labor. The work should be unified or integrated by placing it under one general management, and the division of labor should have a scientific basis; that is, it should be differentiated so that there shall be a division for geographical work embracing all methods of mensuration in latitudes, longitudes and altitudes, absolute and relative; and the representation of the results in appropriate charts. There should be a department of geology embracing all purely scientific subjects relating to geological structure and distribution, and practical subjects relating to mining and agricultural industries. If ethnology, botany, and zoology are to be embraced in the general scientific survey, each subject should have but a single organization, with a single head subordinated to the general plan. In such a way only can a proper integrated and differentiated organization be made. The present multiplication of organizations for all of these purposes is unscientific, excessively expensive, and altogether vicious; preventing comprehensive, thorough, and honest research, stimulating unhealthy rivalry, and leading to the production of sensational and briefly popular rather than solid and enduring results.

By the act of Congress the National Academy of Sciences is instructed to consider also the surveys of the public lands. These surveys have been carried on for nearly a century; primarily, for the purpose of *parceling* the lands in such a manner that titles to definite portions may be conveyed from the government to individuals; secondarily, that the value and characteristics of the lands may be determined. During the time in which these surveys have been in progress about 1,138,000 square miles have been surveyed, at a cost of a little more than \$23,000,000, or at an average cost of a little more than \$20 per square mile. In the prosecution of these surveys an attempt has been made to establish the boundaries of legal subdivisions, and maps have been constructed of every township surveyed, representing with greater or less accuracy the topographic features of the same, and each surveyor was required to note the character of the timber and certain facts relating to economic geology. For this work surveyors have been paid by contract for work done, instead of by salary for time employed. In pursuing this work the geography and geology of the country has been studied to some extent, but not with sufficient accuracy and thoroughness for scientific or general economic purposes. The only substantial result accruing therefrom has been the parceling of the lands by establishing boundaries, and even this has been imperfectly done by reason of certain faulty methods inherent in a system adopted nearly a century ago. Corners have been marked by planting wooden stakes where these were conveniently found, and in other regions, as the prairies, great plains, and naked valleys of the Rocky Mountain region, they have been marked by small heaps of earth, which could be easily raked together at the corners of subdivisions. But wooden stakes soon decay and heaps of earth are soon washed away by storms. In timber districts the lines are further marked by blazing the trees adjacent thereto, and the plats made by the surveyors were supposed to be additional means of identifying the boundary-lines. To a large extent, however, these added securities have proved unavailing. Marked trees are soon destroyed, and as no thorough topographic system was adopted the charts were practically valueless; hence the surveys of the public lands made for the purpose of parceling the same have been of such a character that a heritage of litigation relating to boundary-lines has been bequeathed to posterity, ever increasing with the enhancing value of lands. For scientific purposes the

geographic results exhibited on the charts made by the surveyors have been valueless for the following reasons:

Latitudes, longitudes, and altitudes have never been determined. The surveys have been proceeded from a number of initial points by north and south, and east and west lines. The geographic co-ordinates of these initial points were never determined, and no scientific checks were made in extending the lines therefrom.

The running of a straight line is an engineering feat of the greatest difficulty, and no proper precautions were taken to secure even approximately straight lines. In this manner, as the surveys proceeded from the several initial points, until they met, it was found that no two systems could be made to agree, and it became necessary to make connections by irregular fractional subdivisions, thus entailing on the land system a new set of difficulties. And, finally, in the topography and cartography no general system was adopted; the work has been given out by contract to deputy surveyors and even sublet; thus a large number of persons have been engaged annually in the work, each person adopting a system of his own, it being necessary only to comply with certain general regulations established by law.

Latitudes, longitudes, altitudes, and topographic positions were neither established absolutely nor relatively with accuracy, and the cartographic methods have been so diverse and imperfect that no general maps of value can be constructed from the vast number of township maps on file in the Land Office. For further information on this subject I refer to a little volume published by the Land Office, entitled "Instructions to Surveyors-General," and the "Report of the Hon. S. S. Burdett, Commissioner of the General Land Office, for the fiscal year ending June 30, 1875," and also to the "Report of the Hon. J. A. Williamson, Commissioner of the General Land Office, for the fiscal year ending June 30, 1877," copies of which are transmitted herewith, and in which the statements pertinent to the subjects in hand are marked.

The system of land surveys as originally adopted was, in many respects, wise, but it was never faithfully executed, from the fact that after its first inception it never had proper scientific supervision. From an early date, instead of having a single head it has a multiplicity of heads; that is, there has been a number of surveyors-general (at present there are sixteen) working independently of each other, and practically autonomous. These surveyors-general do not directly conduct the surveys, but are law officers, intermediate between the General Land Office and the deputy surveyors who do the work, and hence are not chosen as experts, for their scientific qualifications, but are selected for their legal acquirements and administrative talents. For this reason it has happened that the system of surveys has not kept pace with modern science, and has scarcely been improved during the time (the greater part of a century) in which it has been in operation. It has failed to meet the economic and scientific wants of the country from the fact that it has lacked intelligent supervision on the one hand, and, on the other, that it has been carried out by a great number of deputy surveyors whose personal interests were opposed to accurate and scientific work, as they performed their labors under contract. A list of the initial points from which surveys have been made will be found in the accompanying document, marked "C."

There yet remains to be surveyed an area of about 1,704,000 square miles, exclusive of Alaska, and it is of paramount importance that the surveys of the public lands shall hereafter be conducted in such a manner as to avoid the evils above referred to.

There are on file in the General Land Office more than 35,000 manuscript maps, elaborately constructed on a scale of two miles to the inch, and representing the topographic features of more than 1,000,000 square miles of territory. Accompanying these maps is an equal number of manuscript reports relating to the geological and physical characteristics of the areas surveyed, the whole costing the government more than \$23,000,000; and they are all of imperfect value in the parceling of the lands, of little or no value in the consideration of economic questions relating to the public lands, and absolutely valueless for scientific purposes.

These records of the Land Office furnish a gigantic illustration of the evils of badly-directed scientific work. A large corps of surveyors has been employed for nearly a century. Forests, prairies, plains, and mountains have been traversed in many directions; millions of miles have been run with compass and chain; chart after chart has been constructed with great labor; folio on folio has been placed among the national archives, containing facts incoherent and worthless; and the record has been made that here are trees, there swamps, and yonder glades; that the lands surveyed are level, hilly, or rolling; that sandstones are found here, limestones there, or granite elsewhere; and so the records of useless facts have been piled up from year to year until they are buried in their own mass. That all of this labor and expense has been lost to science, may well challenge the attention of the learned men of America, and when properly understood, they will not be slow in demanding a reform.

It is scarcely necessary to indicate to a scientific body a method by which these evils can be corrected in the future. There is one, and but one, adequate and inexpensive method. The initial points should be connected by a triangulation with a system of short base-lines accurately measured, the latter having their latitudes, longitudes, al-

titudes, and azimuths properly determined, and from the geodetic points established in this triangulation all the lines of the parceling surveys should be checked, and the datum points in the parceling surveys should be marked with imperishable monuments of stone or metal. By such a plan the boundary lines of parcels could be accurately and permanently fixed and easily identified. The corner-posts would not be immediately destroyed by natural agencies, and if lost by accident or removed by design, they could be easily and accurately replaced, and the whole basis of the system, in its geodetic points and triangles, would remain while hills and mountains stand and the stars shine. In this manner a proper parceling of the public lands would be made, and at the same time all other scientific purposes of a survey would be subserved.

It is quite unnecessary to represent to a learned body the importance of a good trigonometric survey for scientific purposes. It is rather of its utilitarian purposes that I would here speak, and especially of its importance to our system of surveys of the public lands. Not only would the use of a primary triangulation as the basis of land-surveying remedy the principal defects of that system, but it would be a means of great economy in the final cost, and would have the immense advantage of rendering much of those surveys both unnecessary and inexcusable, and would distribute the cost over the coming years in a manner least burdensome upon the revenue.

The relatively small proportion of the land remaining in the possession of the government which is useful for industrial purposes has had, in the last few years, the effect of locating the incoming population of the far West upon scattered districts where water can be found, and these settlements are separated from each other by mountains or by broad expanses of barren plains which, for many years to come, will not be sold nor turned to any economic use except in very rare instances. And yet a survey is as essential to the title of the homesteader of Wyoming and Idaho as to the old settlers of Ohio and Illinois. To make that survey by present methods, and in conformity with existing statutes, it is necessary to run lines from standard meridians and parallels or from established township corners, and these lines must be "marked and measured" before the contractor can receive his payment. Connections of isolated districts must thus be made through a series of township corners. The futility of marking such corners wherever they may chance to fall in the mountains and deserts, by such perishable devices as are authorized by law, needs no remark. The inaccuracy of such measurements in a difficult country is a consequence equally obvious. The whole system is one which from the peculiar character of the western region renders necessary a very large amount of surveying which serves no useful purpose except to connect isolated districts and such connections are from the nature of the case grossly inaccurate. To such a method the trigonometric method stands in the strongest possible contrast. By a judicious selection of natural and conspicuous geodetic stations scattered over the land, all superfluous surveying may be entirely avoided. The latitudes and longitudes of such stations being once determined, they may become the datum-points or origins of local surveys of all districts which lie in their vicinity. But while a trigonometric survey, if conducted with proper accuracy, is in one sense an expensive undertaking, there may be danger of overestimating its relative cost. It could not be more expensive than the present land surveys which yield such poor and perishable results. But even here it is well to remember that a triangulation, with a secondary and tertiary system of triangles, need not be at once extended over the entire domain, nor even over a very large proportion of it. Population in the far West has shown a tendency to cluster around a number of localities of relatively small extent, while the greater portion of the region is unoccupied. The primary points once determined in a few narrow belts, it will be practicable to expand a net of inferior triangles over those localities which need surveys while the barren wastes may be left until a survey is needed for them. It will always be practicable to regulate the extent of the triangulation, and to adapt it to wants as they arise.

The greatest economy of this method would arise from the fact that it would dispense with the unnecessary work of the present land surveys. Recalling here the fact that under the present method the work is done by contract, it obviously becomes the pecuniary interest of the deputy to survey as much land as practicable provided it will yield him a profit. To a considerable extent he has discretion in the selection of the districts which he has to survey, and being governed solely by considerations of profit, naturally, and quite lawfully, selects such lands as can be surveyed at least cost to himself without regard to their present or even probable occupation by settlers. Many millions of acres have thus been parceled without the slightest necessity, the lands being worthless, and the land marks have been allowed to perish, and all useful results have perished with them. We have but to contrast this prodigal and wasteful method with the permanent and ever-useful results of a triangulation in order to recognize the immense advantage of the latter.

Throughout the Rocky Mountain region, a great portion of the values of the public domain subsist in the mines of gold, silver, cinnabar, lead, &c. The surveys of these mining lands are carried on by methods even more poorly adapted to reasonable re-

quirements than those of the agricultural lands. The tracts of mineral lands containing ores of precious metals, titles to which are conveyed from the general government to individuals, are surveyed by methods so inaccurate that the surveys themselves are of little value in identifying parcels, and in the courts the records of such surveys are of no value, parol evidence being necessarily substituted; for in general the values of the mines exist within narrow horizontal limits and should resurveys be made following original records it would always be probable that sites thus obtained would not coincide with the original one but would be in part or in whole established on other grounds. Under the law the surveys of mineral claims are connected either with the corner posts of the land surveys or with "mineral monuments," and this connection is made by lines run with compass and chain, and it should be remembered that the mines are in the mountains where the use of these instruments involves the greatest expense and secures the least accuracy. To this primitive and almost barbaric system of surveying the mineral lands may be attributed a large part of the disastrous litigation in which the mines of the Rocky Mountain region are involved.

I need scarcely say to a scientific body that such surveys are so inaccurate as to be of no value whatever in determining the position of the claims themselves. It thus happens that when in a mineral district many claims have been surveyed, an attempt is made in the surveyor-general's office, or in the General Land Office in Washington, to plot a number of such claims on a common chart, the several surveys are found to be inconsistent with each other, and overlap or fail to connect. The claims themselves should be plotted on properly constructed topographic charts and be connected with each other by triangulation, and the whole connected with the general system of triangulation which must be carried over the country.

Every mineral district should have a thorough topographic survey, and at convenient points throughout the district monuments should be erected and their absolute and relative positions determined by fixing their angular relations to each other and to the geodetic points of the general triangulation, and thus every miner would have an accurate, simple, and inexpensive method by which the position of his claim could be fixed. But such properly constructed charts necessary for the identification of mineral claims and the proper recording of conveyances would meet all other wants. It would be a sufficient guide to the engineer, for all general purposes, in the location of highways and hydraulic works, and a sufficient map for all scientific purposes. If the work were properly done in the first instance, so as to be sufficient for all reasonable requirements, no duplication of the work would be necessary for any other purpose.

In the administration of the Land Office, there are important facts that should here be considered. The following classes of lands are recognized under the laws:

1. Agricultural lands or lands valuable for agriculture without irrigation or drainage.
2. Swamp lands.
3. Irrigable lands; lands valuable for agriculture only with irrigation and designated in the law as "desert lands."
4. Timber lands.
5. Live-oak and cedar lands.
6. Mineral-vein lands, or lands containing veins or lodes of gold, cinnabar, copper, lead, &c.
7. Placer lands, or lands containing placer mines of the precious metals.
8. Coal lands.

(*Vide* Revised Statutes of the United States, 1878, title 32, chap. 6; title 32, chap. 10, secs. 2458-2468, inclusive; and title 32, chap. 11, secs. 2478-2490, inclusive.

United States Statutes at Large, vol. 19, chap. 407.

*Statutes of the United States passed at the second session of the Forty-fifth Congress, chap. 151.)

An examination of the laws thus cited will show that the classes of lands mentioned above are therein recognized, and in the administration of the laws relating to these lands those belonging to each specific class must be determined; but no adequate provision is made for securing an accurate classification, and to a large extent the laws are inoperative, or practically void; for example, coal lands should be sold at ten or twenty dollars per acre, but the department having no means of determining what lands belong to this class, titles to coal lands are usually obtained under the provision of statutes that relate to lands of other classes; that is, by purchasing at \$1.25 per acre, or by homestead or pre-emption entry. An examination of the laws will exhibit this fact, that for the classification contemplated therein a thorough survey is necessary, embracing the geological and physical characteristics of the entire public domain. The only provision under the General Land Office for such a survey is contained in the "Instructions to the surveyors-general" (*vide* p. 18, and paragraphs under the head of "Summary of objects and data to be noted.") In the performance of those duties the deputy surveyors, who do the work under contract, fail entirely to provide the facts necessary to the proper administration of the laws, and, in practice, the facts upon

which transactions in the department are based are obtained not from experts employed as government officers and competent to perform the task, but on affidavits made by the parties interested, or by persons selected by them, and the history of the Land Office abundantly exhibits the fact that States and individuals have to a large extent obtained titles to lands from the general government under fraudulent representations.

From the above statement, it will be apparent that a thorough survey of the geology and physical classification of the entire domain is necessary to the administration of the laws relating thereto.

The importance of such a survey in the industrial interests of the country requires brief mention. The greater part of the lands yet remaining in the possession of the general government either needs protection on the one hand from overflow, because of excessive humidity, or irrigation on the other, because of excessive aridity. The utilization of all such lands depends upon the correct solution of great engineering problems. Large portions of the public domain on the Gulf coast are swamp lands; the great river valleys of the South are flood-plains, which must be protected from the waters which periodically flow over them; vast areas of swamp and lakelet lands exist in the region of the great lakes that must be redeemed by drainage; the western half of the United States is comparatively arid; in more than four-tenths of our national area, exclusive of Alaska, agriculture is dependent upon irrigation, and here the lands are to be used only by the utilization of rivers and minor streams that are chiefly fed by the snow-fields of the Rocky Mountains. The rapid migration, which has been greater during the past ten years than in any similar portion of the history of the United States, is pushing, in middle latitudes, quite to the verge of possible agriculture without irrigation, and soon all the lands in the humid and subhumid region belonging to the general government will be exhausted, and future settlers on public domain will be compelled to resort to the lands to be drained or to the lands to be irrigated. On the Floridian peninsula, millions of acres, valuable for the growth of sea-island cotton or sugar, can be redeemed by the drainage of Okechobee Lake; on the Gulf coast, millions of acres of swamp-land can be redeemed by protecting them from tide-water; in the great flood-plains of the South, millions of acres of the richest land of the continent can be redeemed by protecting them from periodic river floods; in the region of the great lakes, millions of acres can be redeemed by the drainage of the swamp and small lakes; and in the Rocky Mountain region, very many millions of acres of land can be redeemed by spreading the rivers over the plains and valleys. Some of the engineering problems thus indicated have important mutual relations. The time must soon come when all the waters of the Missouri will be spread over the great plains, and the bed of the river will be dry. A large part of the Arkansas must also be taken out to fertilize the lands adjacent to its upper course, and still farther south the waters of the upper ramifications of the Red River must be used. The utilization of these waters flowing during the season of irrigation, and the storage of the surplus, will have an important effect upon the Mississippi River, and will, to some extent at least, relieve the great valley plains of the Mississippi, extending from the mouth of the Ohio to the Gulf of Mexico, from the devastating floods to which it is periodically subject. It has been pointed out, and it is well known to the scientific men of the country, that the present system of protecting these lands by levees is not only excessively expensive but entirely inadequate, and it has been further shown that it is practicable to redeem these lands by the storage of the waters. (*Vide* Ellet: Physical Geography Mississippi Valley. Smithsonian Contributions to Knowledge, Vol. II.) But if the excess of waters can be used for irrigation a double purpose will be accomplished, and if the relief thus obtained is quantitatively insufficient, a thorough investigation of the subject should be made, for the purpose of determining what additional measures can be adopted that will be efficient and economic.

Again, in the arid region of the United States, which is more than four-tenths of the whole area, as had been stated, but a comparatively small portion can be redeemed by irrigation, and what remains is not of much value. It is, considering the wants of the country, in the main bountifully supplied with timber, but the timber is not distributed on or adjacent to the agricultural lands; it is found on the high plateaus and mountains where climatic conditions make agriculture impossible. Between the elevated timber regions and the irrigable lands adjacent to the streams are broad stretches of plain, valley, hill, and mountain-lands valuable to some extent for grazing purposes. These physical characteristics of the country demand further investigation, and the classification of the lands of the public domain now involved in the laws relating thereto must necessarily in the immediate future be somewhat enlarged. For a more thorough exposition of this subject, I beg leave to refer you to my report on the "Lands of the Arid Region of the United States," copies of which I transmitted to the vice-president of the National Academy of Sciences September 24, with the request that the same be distributed among the members of the committee.

The greater part of the remaining public domain is in the far West. The immediate incentives to its settlement are the mines of precious metals found in its mountains.

It is a region of vast and inexhaustible wealth, and gold, silver, cinnabar, copper, lead, iron, and coal abound. In the State of Arkansas and the Gulf States east of the Mississippi River, where important portions of the public domain are found, the mountains are great repositories of mineral wealth. In all of these regions a geological survey is necessary not alone to the proper administration of the Land Office, but it is of vast importance and of great value, to the general government and to the people of the United States by properly exhibiting the character and extent of our mineral resources.

In the statements thus briefly made, I have attempted to indicate by a few illustrations the character of the scientific problems involved in the question submitted by Congress to the Academy of Sciences, and the more important economic considerations that inhere in the subject.

From the statement above, though briefly and imperfectly made, it will be clear that a proper scientific survey embracing the geography of the public domain with the parceling of the lands, and the geology with all the physical characteristics connected therewith, is necessary for the following reasons:

First, to secure an accurate parceling of the public lands and enduring boundary lines.

Second, for the proper administration of the laws relating to the public lands.

Third, for a correct and full knowledge of the agricultural and mineral resources of the lands;

And fourth, for all purposes of abstract science.

These considerations are ample to secure from the National Legislature all necessary financial endowments for the prosecution of the surveys. It should be remembered that the statesmen of America who compose and have composed our National Legislature have been not averse to the endowment of scientific research when such research is properly related to the industries of the people. The verity of this statement will be more apparent by the consideration of the following facts:

For scientific work carried on under the direction of the War Department, the following appropriations have been made:

River and harbor improvements:

For the fiscal year ending June 30, 1876.....	\$5,900,000
For the fiscal year ending June 30, 1877.....	4,550,000
For the fiscal year ending June 30, 1879.....	8,200,000

Signal-service:

For the fiscal year ending June 30, 1876.....	507,000
For the fiscal year ending June 30, 1877.....	349,000
For the fiscal year ending June 30, 1878.....	326,000
For the fiscal year ending June 30, 1879.....	404,000

Lake surveys:

For the fiscal year ending June 30, 1876.....	150,000
For the fiscal year ending June 30, 1877.....	100,000
For the fiscal year ending June 30, 1878.....	110,000
For the fiscal year ending June 30, 1879.....	99,000

In addition to the direct appropriations mentioned above, large indirect appropriations were made in the bills providing for the support of the Army. In some cases the indirect appropriations were even larger than the direct.

For scientific work carried on under the direction of the Treasury Department, the following appropriations have been made:

Coast Survey:

For the fiscal year ending June 30, 1876.....	\$717,000
For the fiscal year ending June 30, 1877, (including deficiency).....	626,000
For the fiscal year ending June 30, 1878.....	468,000
For the fiscal year ending June 30, 1879.....	547,000

Weights and Measures:

For the fiscal year ending June 30, 1876.....	7,600
For the fiscal year ending June 30, 1877.....	9,700
For the fiscal year ending June 30, 1878.....	4,700
For the fiscal year ending June 30, 1879.....	5,000

Light-House Board:

For the fiscal year ending June 30, 1876.....	2,750,000
For the fiscal year ending June 30, 1877.....	2,470,000
For the fiscal year ending June 30, 1878.....	2,130,000
For the fiscal year ending June 30, 1879.....	1,970,000

For scientific work carried on under the direction of the Navy Department, the following appropriations have been made:

Naval Observatory:

For the fiscal year ending June 30, 1876	\$20,500
For the fiscal year ending June 30, 1877	21,300
For the fiscal year ending June 30, 1878	28,000
For the fiscal year ending June 30, 1879	23,100

Nautical Almanac:

For the fiscal year ending June 30, 1876	24,500
For the fiscal year ending June 30, 1877	19,500
For the fiscal year ending June 30, 1878	19,500
For the fiscal year ending June 30, 1879	22,500

For scientific work carried on under the direction of the Interior Department the following appropriations have been made:

General Land Office:

For the fiscal year ending June 30, 1869	\$535,000
For the fiscal year ending June 30, 1870, (including deficiency)	575,000
For the fiscal year ending June 30, 1871	790,000
For the fiscal year ending June 30, 1872, (including deficiency)	790,000
For the fiscal year ending June 30, 1873	1,248,000
For the fiscal year ending June 30, 1874	1,365,000
For the fiscal year ending June 30, 1875	1,238,000
For the fiscal year ending June 30, 1876	1,097,000
For the fiscal year ending June 30, 1877, (including deficiency)	550,000
For the fiscal year ending June 30, 1878	474,000
For the fiscal year ending June 30, 1879	535,000

The expenditures under the Land Office have been given for ten years, from the fact that for the past two or three years the appropriations made under this head have been greatly diminished. This diminution was due to the fact that it had come to be recognized by Congress that the surveys were carried on by faulty and wasteful methods.

The items mentioned above are only approximations, as the writer is not able to state exactly what proportion of the office expenditures of the General Land Office should be included under this head. One-fifth of the general expense of maintaining the office has been included.

For scientific work carried on under the direction of the United States Commission Fish and Fisheries, the following appropriations have been made:

For the fiscal year ending June 30, 1876	\$53,500
For the fiscal year ending June 30, 1877	36,000
For the fiscal year ending June 30, 1878	51,000
For the fiscal year ending June 30, 1879	51,000

From the several reports made in answer to the resolution of the Hon. J. D. C. Atkins, it appears that the following has been the total cost of the different geographical and geological surveys that have been in progress of late years, up to June 30, 1878, to which is added the appropriation for the fiscal year ending June 30, 1879:

United States Geological Exploration of the 40th Parallel, under Clarence King:

Amount expended up to June 30, 1878 (1868-1872)..... \$386,711

United States Surveys and Explorations west of the 100th Meridian, under Lieut. Geo. M. Wheeler:

Amount expended up to June 30, 1878 (1869-1878)..... \$499,316
 Appropriation for the fiscal year ending June 30, 1879..... 50,000

United States Geographical and Geological Survey of the Territories, under Prof. F. V. Hayden:

Amount expended up to June 30, 1878 (1867-1878)..... \$615,000
 Appropriation for the fiscal year ending June 30, 1879..... 75,000

United States Geographical and Geological Survey of the Rocky Mountain Region, under J. W. Powell:

Amount expended up to June 30, 1878 (1871-1878)..... \$209,000
 Appropriation for the fiscal year ending June 30, 1879..... 50,000

The above statement of appropriations does not include those made for the Agricultural Department, where scientific investigations are pursued to some extent, nor the many temporary appropriations such as those made for the Polaris expedition, and for investigations relating to steel and iron. It will appear from the above that the direct appropriations made for great national work involving scientific research amount to more than eight and one-half millions of dollars annually; and should we include the indirect appropriations, the amount would be considerably more than ten millions of dollars.

Much of this great amount has not been given directly for scientific research, but all the work performed under these expenditures has involved scientific investigation, and there have resulted therefrom many valuable contributions to knowledge; thus scientific research in many fields has had munificent endowment.

These amounts have been appropriated directly for the purpose of making many of the great industries of the people at large more remunerative and secure, but the history of the legislation connected therewith and the preliminary discussions in the National Legislature abundantly show that the statesmen of the country have not been unmindful of the scientific results which might accrue therefrom, but, on the contrary, such results have received due consideration and have been potent in securing the advocacy of many wise and able men. In submitting a plan to Congress for the organization of a geographical and geological survey, these facts should not be ignored. The survey should be allied to the great industrial interests of the country, those relating to agriculture and mining being of greatest magnitude, and affecting the largest number of people.

A survey organized for the purposes which I have indicated will always receive ample support because the results of its work will increase the national wealth, and beneficially affect the largest proportion of the people. But a geographical and geological survey divorced from these economic considerations, and devoted to research valuable chiefly for abstract science, must always be weak and have an uncertain tenure of existence; for in the efforts made to reduce the expenses of administration and drainage on national revenue such expenditures would be the first to be cut off. *A geographical and geological survey, to be permanent, vigorous, and efficient, should include the survey of the public lands and be subsidiary thereto.*

In the execution of the trust imposed by law on the National Academy of Sciences, two important facts, not having direct mention in the statement above, merit attention.

First. Under the Coast Survey a transcontinental triangulation is now in progress, and much has already been accomplished, as the Coast Survey has a very large number of persons trained as experts in geographical science. Two such systems of triangulation are unnecessary; the one now in progress should be made the basis of all future geographical work in the United States.

Second. The Signal Service Office has already established many stations throughout the country for barometric observations, and these, to a large extent, can be utilized, both in the preparation of hypsometric tables and in the general work, and the results of the data collected by that office are of prime importance in considering many of the questions relating to land economics; hence there should be hearty co-operation between the Signal Service and the geological surveys.

COST OF A GEOGRAPHICAL AND GEOLOGICAL SURVEY.

The average cost of the land surveys, from the time they were instituted to the present, has been something more than twenty dollars per square mile. In the earlier years it was much less; in later much more, for obvious reasons. The mountainous region of the West presents many more difficulties than the plains, prairies, and level lands of the East. At present, these surveys cost from twenty-five to thirty dollars per square mile, and if the present system continues the cost must steadily increase because of increasing difficulties. After a careful consideration of this subject, and some familiarity with the methods and cost of the land surveys and of the geographical and geological surveys of this country, and, to some extent, of those in Europe, I am of the opinion that all necessary geographic surveys, including the parceling of the lands, could be made within the expense now incurred for the land surveys. Throughout the western half of the United States all geographic work can be performed at a slight comparative cost, on account of certain physical conditions existing therein. Because of aridity the country is largely destitute of timber, and the presence of timber greatly increases the cost of this work; it is also a mountainous country, where salient points for triangulation are abundant, and from its numerous elevations the intervening valleys are readily commanded.

For the same reason, viz, excessive aridity, and the destitution of vegetation resulting therefrom, a geological survey can be carried on at a comparatively slight cost. Not covered by soils and vegetation, the whole country is an open book, where geological structure and distribution are plainly revealed, and the geologist is often able

to discover at a single glance from some eminence what in regions favored with a greater humidity would be found out only after weeks or even months of patient toil.

In comparing the cost of the surveys which should be made in this country with those made in Europe, the diverse purposes for which these surveys are made should receive attention. In Europe the areas to be surveyed, in comparison with extent of population and national wealth, are small; in America the areas to be surveyed, in comparison with the population and wealth, are great; in Europe, large standing armies are supported, and the several governments stand ever prepared for war; by those nations which have or are executing the most elaborate surveys, the object is to prepare detailed charts of every possible battle-field within their dominion, which, in fact, embraces the whole area of their territory. The relation of the United States to adjacent nations on the continent is such that our statesmen do not think it necessary to support a large standing army, and in the organization of a survey of the United States it is not necessary to consider this military purpose. We need not construct maps on a scale so elaborate as we should were we compelled to consider the whole area of the country as a succession of battle-fields; but general charts, sufficiently elaborate for economic and scientific purposes, would serve all purposes of military strategy or the planning of campaigns.

In discussing geographic surveys, we may divide the subject-matter into two parts: first, the survey and representation of the natural features, which we may call the *nature* portion of the work; and, second, the survey and delineation of the more prominent works of man upon the surface of the earth; this we may call the *culture* portion. In the surveys made for military purposes this culture part receives relatively enormous attention.

Again, in those countries of Europe where the most elaborate and expensive surveys are executed, the lands are in great part included in large estates which belong to the landed gentry; the few owners are all-powerful in the administration of the several governments, and it is considered by them that the culture of every estate, its forests, its fields, its orchards, its walls, its hedges, its ditches, its buildings, &c., should be a matter of public record; that the extent, characteristics, and appurtenances of every estate should be thoroughly understood, in order that the position and importance of every great family in the social fabric may be clearly set forth. These reasons for an elaborate survey do not exist in this country, and in such a work, carried on by authority of the general government, should receive but slight attention. The position of towns, highways, &c., should be determined and marked, but the vast details of culture should be omitted. The nature part of the survey is permanent; the culture portion in this country is rapidly changing, and if municipalities, townships, counties, or States should desire to prosecute detailed culture-surveys, the proper charts representing the nature portion would be furnished ready to their hands. In fact, these smaller units of our political organization do engage in these enterprises, and many districts, townships, and counties have prepared elaborate charts of their areas; usually, however, neglecting the nature portion of the work.

In the immediate future it is probable that the farm unit in the western portion of our country will be changed, so that it will not be necessary to parcel the public lands into tracts so small as we are now doing under existing laws. This matter I have set forth more fully in my "Report on the Arid Lands of the United States," to which I again beg to call the attention of the committee. Should this change be made, the expense of the land surveys will be materially diminished, and the saving therefrom will probably defray the cost of the geological portion of the work. In this paper, however, I have based my statements wholly on the facts and laws as they now stand.

ZOOLOGY AND BOTANY.

In considering the broad question of what should be the attitude of a government toward scientific surveys, it is not apparent why the problem should present in this country any greater difficulties than those presented in Europe. It has there been discussed alike by statesmen and by men of science with no difference of opinion as to general conclusions, and among the leading minds very little as to details. It will probably be universally admitted that the endowment of science by governments should be very limited and scrupulously confined to those objects of research which under ordinary circumstances could not or would not be undertaken by individuals. This conclusion does not arise so much from considerations as to what may be the duty of the government as from the fact that the efforts and energies of individuals acting from no other stimulus than the love of science are productive of better results than when acting under the stimulus of government patronage. There can, however, be little doubt that a topographic survey and a general geologic survey are works which fall fully within the class which may and ought to be sustained by the government. It is because of the great magnitude and expense of such undertakings, which place them far beyond the reach of individual enterprise.

But a government which patronizes and sustains such investigations has the unques-

tioned right to demand in return results which shall be not merely for the benefit of the scientific, the learned, and the cultured, but for the immediate use and wants of all classes. It has the right to demand not only results of general value, but those of utilitarian value. In a popular government like ours these considerations are even more forcible than in those governments where the dominant classes belong to the middle and higher orders. A survey in this country, sustained by the government, which does not closely ally itself to those utilitarian demands cannot be strong or permanent; nor can it face the public with demands for subsidies, as if they were things of right. These surveys should be both ostensibly and really so closely related to the practical wants of the people and of the government itself that no question could ever be reasonably raised against their utility or even necessity. They should fill in the public scheme a position analogous to those which are filled by the Coast Survey, Signal Service, Naval Observatory, Agricultural Department, and the Light-House establishment. Nor is there the slightest danger that in an organization upon such a basis and for such purposes the interests of science would suffer. No objection could be raised even by the most captious against the prosecution of any branch of scientific research properly co-ordinated with such a work, on the ground of its being too thorough or too exhaustive. Objections could commence only when such a survey should venture beyond the strict limits of its proper purview, and it must be admitted that objections then could not be commenced too quickly or be made too strong.

The liberality which has always been manifested in Congress and in the executive departments towards scientific research is a full guarantee for the present at least, and doubtless also for the future, that a survey restricting its action to its proper field, but prosecuting it to the utmost within that field, will be most liberally provided for and abundantly sustained.

It would, in my opinion, be unadvisable for government to sustain and endow research in the various branches of zoölogy and botany except in a very limited way and for very narrow and special purposes. It may, indeed, often happen that special inquiries in zoölogy and botany may suddenly acquire the importance of questions affecting intimately the national welfare, like the ravages of locusts and the cotton-worm, or subjects relating to the growth and production of forests, and these inquiries may require immediate prosecution at great expense. Such exceptions can always be taken into consideration as they arise. They do not appear to invalidate the general rule here suggested, that zoölogy and botany as branches of general science are not proper subjects of governmental patronage. Perhaps it is safe to take the ground that those sciences are injured rather than benefited by such patronage, unless it is extended in the most cautious and sparing manner, for assured patronage cannot be needed to stimulate such researches. The workers in these fields already number thousands, may it not be safely said tens of thousands, who neither ask nor want the slightest assistance from the government. It is by the numberless tributaries of this great throng of seekers after knowledge that the great mass of facts constituting the body of those sciences is accumulated. It is by the master minds in that throng that the broad and philosophic generalizations are evoked, and of these leaders of thought every generation furnishes its modicum. Surely no one will urge that it is the duty of government to add half a dozen workers to the great army of independent investigators, and no one will pretend that any amount of subsidizing can create a single philosopher. The largest amount which Congress could be asked to appropriate would bear but a trifling ratio to the aggregate sum expended by individuals and institutions of learning, either directly or indirectly, in the prosecution of zoölogic and botanic research.

Nor does it seem wise that the government should assume the responsibility and expense of the publication of such works. Magazines, the proceedings and transactions of learned bodies, and books published on the same basis as ordinary literature will afford ample means for making known all discoveries and all generalizations in those branches. Scientific magazines and proceedings will never refuse the publication of contributions, however small, provided they possess real value, and it will hardly be denied that if they do not possess that value they ought not to incur the literature of science. Nor will means be wanting for the publication of larger and more comprehensive works when their value bears a due proportion to their volume and expense of edition. It may be laid down as a safe rule that works upon zoölogy and botany which are of sufficient value to warrant their publication will ordinarily find the means through existing channels, and those which are of inferior value the government would not be justified in publishing.

The enormous bulk and chaotic character of the literature of these branches is universally felt by naturalists to be a serious evil. Those sciences are heavily encumbered and clogged by the very magnitude of their publications. It will not be supposed for a moment that the entry of the government into the field as a miscellaneous publisher will in any manner affect existing channels of publication, but would merely open another flood-gate. Nor is there any guarantee that its zoölogic and botanic works would be more valuable in matter or more concentrated in intellectual nourish-

ment than those which are culled and sifted by scientific periodicals and the commercial publishing-houses.

For such reasons, I do not think it would be wise to include zoology and botany in the plan to be recommended to Congress.

ETHNOLOGY.

Unlike the subjects last mentioned, there are reasons why ethnologic researches, or investigations relating to the North American Indians, should be fostered by the general government. The work is of great magnitude; more than four hundred languages belong to about sixty different stocks having been found within the territory of the United States. Little of value can be accomplished in making investigations in other branches of the field without a thorough knowledge of the languages. Their sociology, mythology, arts, &c., are not properly known until the people themselves are understood, with their own conceptions, opinions, and motives. The subjects of study are remote from the centers of civilization and culture, and thus inaccessible to the great body of American scholars. The field of research is speedily narrowing because of the rapid change in the Indian population now in progress; all habits, customs, and opinions are fading away; even languages are disappearing; and in a very few years it will be impossible to study our North American Indians in their primitive condition except from recorded history. For this reason ethnologic studies in America should be pushed with the utmost vigor.

But there are other cogent reasons leading to the same conclusion. In the whole area of the United States, not including Alaska, there is not an important valley unoccupied by white men. The rapid spread of civilization since 1849 has placed the white man and the Indian in direct conflict throughout the whole area, and the "Indian problem" is thus forced upon us, and it *must* be solved, wisely or unwisely. Many of the difficulties are inherent and cannot be avoided, but an equal number are unnecessary and are caused by the lack of our knowledge relating to the Indians themselves. Savagery is not inchoate civilization; it is a distinct status of society, with its own institutions, customs, philosophy, and religion; and all these must necessarily be overthrown before new institutions, customs, philosophy, and religion can be introduced. The failure to recognize this fact has wrought inconceivable mischief in our management of the Indians. For the proper elucidation of this statement a volume is necessary, but I shall have to content myself with some brief illustrations.

Among all the North American Indians, when in a primitive condition, personal property was almost unknown; ornaments and clothing only were recognized as the property of the individual, and these only to a limited extent. The right to the soil as landed property, the right to the products of the chase, &c., was inherent in the gens, or clan, a body of consanguinity, a group of relatives, in some cases on the male side, in others on the female. Inheritance was never to the children of the deceased but always to the gens. No other crime was so great, no other vice so abhorrent, as the attempt of an individual to use for himself that which belonged to his gens in common; hence the personal rights to property recognized in civilization are intensely obnoxious to the Indian. He looks upon our whole system of property rights as an enormous evil and an unpardonable sin, for which the gods will eventually punish the wicked and blasphemous white man.

From these opinions, inherent alike in their social institutions and religion, arises the difficulty which the government has always met in obtaining the consent of the Indians to the distribution of lands among them in severalty. Tribes have been willing to receive lands and distribute them themselves among their gens. Among those Indians who have been longest in contact with the white man, as the tribes in Indian Territory and Minnesota, much property has been accumulated, and with the increase of their wealth the question of inheritance and individual ownership has at last spontaneously sprung up, and at the present time these tribes are intensely agitated on the subject; the parties holding radical sentiments are rapidly increasing, and it is probable that soon, among these tribes, the customs of civilization in this respect will be adopted. Among all other tribes the ancient customs are still adhered to with tenacity. In this matter, and many others of a similar character relating to their customs and belief, we must either deal with the Indian as he is, looking to the slow but irresistible influence of civilization with which he is in contact to effect a change, or we must reduce him to abject slavery.

The attempt to transform a savage into a civilized man by a law, a policy, an administration, through a great conversion, "as in the twinkling of an eye," or in months, or in a few years, is an impossibility clearly appreciated by scientific ethnologists who understand the institutions and social condition of the Indians. This great fact has not in general been properly recognized in the administration of Indian affairs. A few of the wiser missionaries, and a few officers of the Indian Bureau have recognized some of the more important facts, but in general they have been ignored.

Again, we have usually attempted to treat with tribes through their chiefs, as if

they wielded absolute power; but an Indian tribe is a pure democracy; their chieftaincy is not hereditary, and the chief is but the representative, the speaker of the tribe, and can do no act by which his tribe is bound without being instructed thus to act in due and established form. The blunders we have made and the wrongs we have inflicted upon the Indians because of a failure to recognize this fact have been cruel and inexorable, except on the ground of our ignorance.

Within the United States there are about sixty radically distinct stocks of Indians. The history of the country shows that no coalition between tribes of different stocks has ever been successful; a few have been attempted, but these have been failures. A knowledge of this fact, and the further knowledge of the extent of the several stocks as they can be classed by linguistic affinities, would be of great value in our administration of Indian affairs. In the late Nez Percé war much fear was entertained lest the Shoshones and Pai Utes of Utah and Nevada would join with the Nez Percés in their revolt, and the officers of the Army, as well as those of the Indian Office, were exceedingly anxious in regard to this matter; and the papers were filled with rumors that such a coalition had been made; the result proved, what had been confidently predicted, that no such alliance could be formed, and the Shoshones and Pai Utes were enlisted to fight against the Nez Percés.

I might continue to illustrate the subject in many ways did time permit, but the foregoing must suffice.

I think it will be apparent from what I have said that a thorough investigation of North American ethnology would be of great value in our Indian Office. The reasons which I have briefly set forth as influencing my opinion that the general government should provide for researches in this field have for many years, to a greater or less extent, been recognized by Congress. Twice in the history of legislation in this country we find that provision has been made, by appropriations, for this work, and it has been discontinued each time only because the character of the researches made failed to obtain the confidence and respect alike of statesmen and scientists. I therefore submit the opinion to the committee that it would be wise to recommend to Congress the continuation of researches in this field, and consider in so doing under what supervision it should be placed to secure wisdom and efficiency in the prosecution. Looking to this end, I would suggest that the Smithsonian Institution has accomplished, in this direction, more than any or all other agencies.

With respect to the last part of the inquiry, relating to the distribution of publications, permit me to express the opinion that, in addition to the number of reports usually ordered by Congress for the use of its members, which experience has shown are in the main wisely distributed, an additional number should be published to be distributed among institutions of learning and public libraries of the United States and to scientific bodies throughout the world for exchange, and a suitable number of extra copies to be sold at cost of paper, press-work, and binding to persons who desire them. This would make the publication of the surveys accessible to the scholars of the country at reasonable rates without detriment to the public revenues. Permit me to point out the fact that the present provision having the same end in view is practically inoperative, because the work must be ordered before publication, and hence before the facts in relation to it are known.

In the above statement I have attempted to recommend no specific plan of organization or specific method of survey, but have attempted simply to set forth some of the more important economic considerations which should receive attention, believing that all scientific aspects will receive due consideration and that mention of the same by myself would be unnecessary.

It is a matter of profound gratification to me that Congress has submitted this important question to the consideration of the body of learned and wise men who compose the National Academy of Sciences, and I am deeply impressed with the honor which has been conferred in calling upon me for this statement of my views.

I am, with great respect, your obedient servant,

J. W. POWELL.

Hon. CARL SCHURZ,
Secretary of the Interior.