THE LIBRARY
OF
THE UNIVERSITY
OF CALIFORNIA

ROBERT FULTON

AMERICAN BIOGRAPHY

EDITED BY

JARED SPARKS

DAVID RITTENHOUSE

&

ROBERT FULTON

By

JAMES RENWICK

Vol. 12

HARPER & BROTHERS

PUBLISHERS

NEW YORK AND LONDON 1902

CONTENTS

CONTENTS

CONTENTS

CHAPTER XI

CHAPTER XII

CHAPTER XIII

CHAPTER XIV

CONTENTS

CONTENTS

CHAPTER X

CHAPTER XI

CHAPTER XII

LIFE

OF

DAVID RITTENHOUSE

BY

JAMES RENWICK

DAVID RITTENHOUSE.

CHAPTER I.

Introduction.

The annals of our country are illustrated by but few names of scientific eminence. It has been well remarked, that the energies of our people have been directed by circumstances to objects demanding not less powers of mind, than those required to master the highest subjects in abstract knowledge. To plan constitutions and enact laws for a mighty nation, placed under new circumstances, and to bring, by novel applications of science, the most distant parts of an extensive continent into close and frequent intercourse, are objects as worthy of a master-spirit, as the investigation of the most subtile mathematical problems, or the research of the most recondite physical questions. Yet, as the paucity of our men of science has been urged upon us as a reproach, it behoves us to set a due value upon those whom our country has produced, and who, while their cotemporaries have been engaged in

reclaiming the wilderness, in bringing to light the hidden or dormant riches of our soil, in opening artificial, and improving natural channels of trade, and in extending our commerce to the most distant regions of the globe, have patiently devoted themselves to the less lucrative pursuit of philosophic study. Among these the subject of the present memoir holds no mean place. Were we called upon to assign him a rank among the philosophers whom America has produced, we should place him, in point of scientific merit, as second to Franklin alone. If he wanted the originality and happy talent for discovery, possessed by that highly gifted man, he has the advantage of having applied himself with success to a more elevated department of physical science.

Astronomy, to use the words of Davy, is the most ancient, as it is now the most perfect, of the sciences. Connected with the earliest events even of savage life, the phenomena of the heavenly bodies must have attracted the attention of the progenitors of our species, from the time they were doomed to eat their bread in the sweat of their brow. The waning and increase of the moon, and the connexion of her phases with the varying length of the natural day, have been studied and transmitted from father to son, among even the rudest tribes of hunters; and the wildest Indians of our own country still note them for similar

purposes. At no long interval after the deluge of Noah, the Egyptian husbandmen, who first furrowed the soil, wherein to cast the seeds of the cereal *gramina*, remarked the coincidence of the re-appearance of Sirius in the eastern horizon, with the return of the vivifying waters of the inundation; and from that time to the present, man has not forgotten the use of the heavenly bodies, as signs and as seasons. From the hands of the hunter and the husbandman, astronomy, still in a rude state, passed into those of a priesthood, which, monopolizing the traditions of its more obvious facts, found in them the surest support of its influence, and turned to the purposes of superstition, what had been preserved for general use. Twenty centuries have however elapsed since this science made its escape from the dark cells of the pagan temple, and took up its abode in the observatory of Hipparchus. From that time to the present, in the hands of the Greek, the Arab, the Tartar, and finally in those of the nations of modern Europe, astronomy has made almost annual progress, until it has become, not only the highest triumph of human genius, but the surest test of civilization It is only by advancing a knowledge of this science, that the men of future generations can hope to place their names by the side of those of a Ptolemy, a Galileo, a Kepler, a Newton, or a

La Place; and it may be almost predicted of a country in which astronomy is cultivated, that it is polished and enlightened; while we may as surely infer, that, when it is neglected, the arts of civilized life have either never made their appear ance, or are upon the decline.

In submitting to this test the claims of our country to be considered as enlightened, we might shrink from the task of comparison, or be on the point of admitting her inferiority to several of the nations of Europe, were we not aware that we even now. number among our citizens a name inferior to none in the pursuit of celestial mechanics, and may count in the generation, which has just descended to the tomb, the equal, in skill and tact of observation, of Lalande and Maskelyne in the person of the subject of this memoir.

The science of astronomy, cultivated as it has been for so many centuries, and adorned by genius and talents of the highest order, has ac cumulated to a vast amount. It has therefore demanded a division of labor, in order to admit of its being pursued in any one direction with complete success. When astronomy first became a science, a few verses might comprise all the treasured learning of former observers, and could be easily committed to memory; further progress could be insured by noting phenomena, visible to the naked eye, or measuring the length of the

shadow of a gnomon; calculation was hardly known as an aid, and instruments had not been invented. At the present day, the whole life may be devoted to the study of physical astronomy alone, in which no other instrument is to be employed than the calculus, and no theory required but the simple laws to which Newton reduced the causes of all the celestial motions. Another may find sufficient occupation in calculating in numbers the formulæ obtained by the physical astronomer, and arranging his results in tables, by which future phenomena may be predicted. A third may found upon these tables the ephemerides by which the practical astronomer is to be guided in his observations. The practical astronomer, on the other hand, need devote himself only to watch for the phenomena of the heavenly bodies, as they are successively presented to him in their varying motions, and thus furnish to the physical astronomer the practical test of his theories, and to calculators the numerical values of the quantities involved in the formulæ. Observation, however, would be beyond measure laborious, were not its proper times predicted in the calculated tables, and is now of no account, unless performed by the most perfect instruments, and aided by the most accurate arithmetic.

The construction of the instruments, which the

practical astronomer demands, forms an elevated branch of the mechanic arts, and requires no little proficiency in the physical sciences. The artists, who have improved the fabrication of the timekeeper, and increased the accuracy of circular graduation, have been proudly ranked as colleagues by the most learned societies; and their names will be intimately associated with the discoveries, for which their handiwork has furnished the indispensable materials.

In considering the character of Rittenhouse, we shall find him uniting in himself more of these varied merits than any person who has lived since a division in the labors of astronomy became necessary. If he made no attempt to extend the domain of celestial mechanics, he nevertheless mastered, under most unfavorable circumstances, all that Newton had taught; he calculated with success the difficult problem of the path of various comets; exhibited unsurpassed precision and accuracy in many important observations; and finally constructed the greater part of his instruments with his own hands. Other claims we might present for him, not only to the admiration, but to the gratitude of his countrymen. We shall not, however, anticipate what may be best gathered from the records of his useful and laborious life.

CHAPTER II.

His Birth and Parentage.

The family, whence Rittenhouse descended, was originally from that part of the Duchy of Guelders, which had become a province of the United Netherlands. This republic of confederated States had, as is well known, attempted, at one time, to occupy one of the fairest portions of this continent, and had established settlements, scattered at distances, over a wide extent of country. The advantageous position of New York had attracted the attention of its traders and soldiers, and had become the site of a strong fortress, around which a little city had collected, under the name of Amsterdam. Proceeding hence, posts had been established, on the one hand, on the Connecticut River, while, on the other, the western shore of the Delaware was occupied, after a contest with the Swedes. Both banks of the Hudson were in full possession of this colony, not only by military stations, but by flourishing agricultural settlements. The Dutch province of the New Netherlands, therefore, included, at one time, not only the ancient part of the present State of New York, but the whole of

New Jersey, and Delaware, the eastern part of Pennsylvania, and the western part of Connecticut. This wide extent they were not permitted to occupy without remonstrance on the part of the settlers of English blood. Indeed the whole of it fell within the chartered limits of companies founded by the government of England. That government, however, did not interfere directly with the progress of the Dutch, until the reign of the second Charles; nor were its colonies in a condition to assert their claims by an appeal to arms. It was not, therefore, until 1662 that an expedition was fitted out from England, for the conquest of the New Netherlands. This was successful, and the province was ceded by the Dutch, at the peace of the Breda. That peace was but of short duration; and the government of Holland, unwilling to part wholly with so valuable a colony, took advantage of the ensuing war to repossess themselves of it. It did not, however, long remain in their hands; for the final cession of the New Netherlands to England was insisted upon at the peace of Westminster, in 1664, before two years from its recovery had elapsed.

We have been thus particular, because it appears that the ancestor of Rittenhouse emigrated to the New Netherlands during the last-mentioned period, while the colony was re-occupied by the Dutch arms. This ancestor

was the great-grandfather of the subject of this memoir, and he was accompanied, or speedily followed, by his two sons. One of these, by name Nicholas, married in New York. The father, accompanied by this son, emigrated from New York to Germantown in 1690. Here they established the first manufactory of paper ever erected in America. It would appear, that this was an art, in which the elder Rittenhouse, or Rittinghousen, as the name seems to have been originally spelled, had been engaged in his native country; and it is said that his relatives continued to pursue this business at Arnheim, in Guelderland, after his departure for America. The enterprise, however, marks a union of capital, intelligence, and enterprise, at that time rare in the colonies.

Nicholas pursued the manufacture of paper after the death of his father, and brought up to it his youngest son Matthias, who succeeded to the possession of the mill, and prosecuted the business after the decease of his parent.

Here we find an illustration of the mode of inheritance originally practised among the settlers who derived their origin from Holland, and which is not wholly obliterated at the present day. The father of a family provided, to the best of his ability, for his elder sons, as they successively attained to man's estate. His youngest son re-

mained with him, even if married, until his death, when he succeeded to the occupation of the original homestead. This custom appears better founded in natural reason than the law of primogeniture, and even more just than the existing laws which regulate the descent of property. By it, a prop is secured for the declining years of parents, in the care of an affectionate son, who finds not only his duty, but his own personal interest, in the care which he takes of the property of his father.

It is a remarkable fact, which we must not pass over, that the introduction of the manufacture of paper into America by the Rittenhouses, was about as early as the time at which it took root in Great Britain.

Matthias Rittenhouse, while still resident at Germantown, and occupied in the manufacture of paper, took to wife Elizabeth Williams, the daughter of a native of Wales. This marriage took place in 1727. Shortly afterwards, he appears to have discovered, that agriculture offered greater chances of providing for a growing family, than the manufacture in which he was engaged; for we find him, in 1730, retiring from the latter business. With the funds derived from the sale of his property at Germantown, he proceeded, in that year, to the township of Norriton, where he commenced a settlement upon a small farm,

of which his means were sufficient to enable him to become the owner. His residence, however, does not appear to have been permanently fixed at Norriton, until after 1732; for his three elder children were born at Germantown. Among these was David, the subject of this memoir, who, although not the first born, was the eldest child who survived the age of infancy.

One of the former biographers of Ritten house has endeavoured to account for his abilities, by supposing that he derived them by descent from the mother's side. In this he seems to have adopted the popular opinion, which denies to persons of pure Dutch descent any claim to talents of the higher order. This opinion is, however, no more than a prejudice, which any inquiry into the annals of our country might have dissipated. It may indeed be admitted, that the settlers of the New Netherlands made a less careful and less extensive provision for the education of their children, than was done by the descendants of the Pilgrims; and to this want of foresight we may fairly ascribe any difference in the intelligence of the several masses of people. But, in comparing those classes whose wealth gave them the power of commanding the higher kind of education, Holland has no reason to blush for her descendants; and the number of intelligent and learned individuals of Dutch

extraction is only small, because the population whence they are derived is less numerous, than that with which it is thus invidiously compared. The United Netherlands were distinguished, at the time when the ancestors of Rittenhouse emigrated, for high attainments in science and the useful arts. The very business in which they had been engaged in the place of their nativity, and which they so speedily resumed in America, may almost serve as a proof, that they were devoid neither of education nor ability. Still, talent is not hereditary in families; and it often happens that we are wholly at a loss to account, by any circumstances of parentage, for the peculiar genius of individuals. So far from there being a transmission of abilities by natural descent, nothing is rarer than to find successive generations of the same family equally distinguished; and, on the other hand, it often happens that a single individual may shed lustre upon a name, which may be almost disgraced by his nearest relations.

The mother of Rittenhouse is described as a woman of uncommonly vigorous and comprehensive mind, but as almost wholly deficient in education. If, therefore, we are to seek in his genealogy for the cause of his distinction, it is rather to be found in the fact of his deriving his descent from two races of distant origin. The

effect of such a mixture of races is well illustrated in the character of the people of Great Britain; and the same cause seems to be at work in producing that peculiar activity of mind which marks our own countrymen, into whose veins blood derived from almost every nation of any intellectual eminence in the old world has been successively transfused. From such parents, and of such lineage, DAVID RITTENHOUSE derived his birth, which took place at Germantown, Pennsylvania, on the 8th of April, 1732.

CHAPTER III.

His Education. — Early Indications of Mechanical Genius. — Remarkable Progress in Mathematical Learning.

No records or traditions remain of the manner in which Rittenhouse obtained the elements of learning. His education, however, could not have been neglected; and what public instruction, in the imperfect form it must have borne in a remote district of a newly settled country, denied, seems to have been supplied by the tuition of a maternal uncle. This near relation, although exercising the humble trade of a joiner, appears to have been gifted with a taste and capacity for scientific pursuits. Circumstances made him an inmate in the family of the elder Rittenhouse, and in this abode he died. His books and papers passed thereupon into the custody of his nephew David, along with his tools of trade. Among his books were found elementary treatises on mathematics and astronomy; and in addition he left numerous manuscripts, in which were contained models of calculation and investigation.

The death of his uncle took place when Rittenhouse had attained his twelfth year. Whether

in continuation of former studies, or in consequence of the interest excited by the treasures which came by this event into his possession, he seems from that time to have devoted his whole mind, and every opportunity of leisure, to the pursuit of the studies in which he afterwards became distinguished. The son of a farmer, in comfortable, but by no means affluent circumstances, it became imperative, that he should share in the labors of agriculture; and this was the more necessary, as his father entertained a desire that he should pursue the occupation of a farmer. Even when engaged in agricultural labors, however, the bent of his genius was not to be restrained; and it was recollected by his brother, that in his fourteenth year he was in the habit of covering the fences of the farm, and the implements of husbandry, with numerical figures and diagrams, unintelligible to his rustic associates.

Mere abstract investigations did not, however, engross his whole attention. The tool-chest of his uncle supplied him with the instruments for practice in the mechanic arts; and he appears to have applied his severer studies to practical purposes, at every possible opportunity. Thus it is recorded of him, that, as early as in his eighth year, he had made a model of a water-mill, and, at no long period after the death of his uncle, he

undertook and succeeded in the construction of a clock. The material of both of these early evidences of his ingenuity and knowledge was wood. But he almost immediately after the last-mentioned instance of successful ingenuity, undertook the bolder task of framing a timekeeper in metal; and this he also successfully accomplished.

Among the books he inherited from his uncle was an English translation of the "Principia" of Newton. Such was the progress which he made in mathematical knowledge, although now destitute of any aid, that he was enabled to accomplish the perusal of this work, for the proper understanding of which so much acquaintance with geometry and algebra is necessary, before he had attained his nineteenth year. Newton, as is well known, from deference to the practice of the ancient philosophers, adopts in this work the synthetic method of demonstration, and gives no clue to the analytic process by which the truth of his propositions was first discovered by him. Unlike the English followers of this distinguished philosopher, who contented themselves, for a time, with following implicitly in the path of geometric demonstration, which he had thus pointed out, Rittenhouse applied himself to search for an instrument, which might be applied to the purpose of similar discoveries, and in his researches attained the principles of the

method of fluxions. So ignorant was he of the progress which this calculus had made, and of the discussions in relation to its invention and improvement, that he for a time considered it as a new discovery of his own. In this impression, however, he could not have long continued; as he made, in his nineteenth year, an acquaintance, who was well qualified to set him right in this important point.

In the year 1751, the Reverend Thomas Barton became an inhabitant of Norriton. This gentleman had just completed his education at Trinity College, Dublin, and been admitted as a clergyman of the Episcopal Church. Passing to America in pursuit of preferment, which want of powerful connexions denied him in Europe, he became for a time the teacher of a school at Norriton. Although Mr. Barton was principally distinguished as a classical scholar, he was also well grounded in all the elementary mathematics then considered necessary in the undergraduate course of the institution, where he received his education Exiled as he must have felt himself from literary society, the discovery of a neighbor of such intelligence as Rittenhouse was a matter of no little pleasure; nor could the latter have felt less joy in finding at last an associate with whom he could communicate on his favorite studies. The difference in their ages was but two years; and,

when we take into view the more rapid devel opement, both of body and mind, which is usual in our climate, this difference was probably insensible. A strong intimacy speedily took place, which ripened into friendship; and this friendship was farther cemented by an attachment, which Barton formed for the sister of Rittenhouse, who subsequently became his wife. This intimacy with Barton was attended with valuable consequences. Desirous to peruse his admired Newton in the original dress, Rittenhouse now applied himself to the study of the Latin language, which he speedily mastered. He also appears, under the instruction of Barton, to have acquired the elements of Greek, although he never attempted to become a proficient in the literature of that tongue. Barton also had it in his power to communicate to Rittenhouse scientific works of more modern date, than those to which his previous studies had, from circumstances, been confined, and treating of a greater variety of subjects. Setting forth from his native country with the intention of devoting himself to the profession of a teacher, the former had provided himself with a well-selected library, not only in classical literature, but also in the pure and mixed sciences. These were freely imparted to his youthful and ardent associate.

Before two years had elapsed, the success of

Barton as a teacher, attracted the attention of the government of the College of Philadelphia. He was in consequence called to fill a professor's chair in that institution. The collections of the College were therefore placed at his disposal, and he did not hesitate to use his privilege for the advantage of him, who had now become his brother-in-law. Barton had also projected a circulating library before he quitted Norriton. This project was accomplished, and Rittenhouse took an active part in its management. By this a fund was obtained for the purchase of useful works, which neither could have afforded to pro cure from his own resources.

Barton had not long filled his chair in the University, when it became necessary for him to visit Europe. He on this occasion was commissioned by Rittenhouse to purchase an additional supply of books. This commission he faithfully fulfilled.

Such was the aid which Rittenhouse derived from his brother-in-law; but this, however valuable in communicating a knowledge of the existing state of science, and in opening a channel through another language, by which to reach the thoughts and learning of the master spirits, both of antiquity and modern times, (for Latin had not ceased to be the conventional language of science,) had no effect in determining the inclinations of

Rittenhouse for mathematical and physical studies The acquaintance with Barton was therefore both useful and profitable, but exercised a far less important influence on the future life of Rittenhouse, than has been frequently ascribed to it.

The more, indeed, we contemplate the early life of Rittenhouse, the more our admiration is excited. With such elementary knowledge only as could be obtained at the school of a remote settlement; under the parental discipline of a father, who rather discouraged than aided his studies, and of an illiterate, although strong-minded mother; possessed of no books but those of an humble mechanic; he persevered, until he had, step by step, mastered all the truths of mathematical science, and had arrived at the principles of that calculus, for the honor of whose invention a Newton and a Leibnitz had contended. At the same time, with no tools but those of a country joiner, and aided by no instruction except from books, he had attained such skill in practical mechanics as to execute the delicate mechanism of a timekeeper.

CHAPTER IV.

His Agricultural Occupations. — Choice of a Profession. — Entrance into Business. — Laborious Pursuit of his Trade and Scientific Studies. — Consequent Injury to his Health. — Becomes known as an Artist and an Astronomer. — His Marriage.

The father of Rittenhouse had always intended that his eldest surviving son should pursue the same plan of life which, on his retreat from his manufactory, he had chosen for himself. He had, on leaving Germantown, become, as we have already stated, a farmer, and for this occupation he destined our philosopher. The term farmer, it may be mentioned incidentally, bears a far different signification among us, from that which its derivation would seem to warrant, or in which it is understood in Great Britain. By this word we understand, not the tenant, either at pleasure, or on some more secure tenure, of a more wealthy landlord, but most frequently the independent cultivator of his own fields. The condition of a tenant is in truth extremely rare in all parts of the United States.

In the avocations necessary in this mode of

life, Rittenhouse had been laboriously employed, from the moment his strength was sufficient to perform them; and the studies and mechanical operations of which we have spoken, were no more than the pastimes of those intervals of leisure, which so frequently occur in agricultural life in the United States. When the mind of Rittenhouse became so far matured, as to fit him for reflecting upon the plan of his future life, his reason led him to disapprove of that pointed out by his father. He had discovered in himself powers of higher character, than are necessary for the occupation of a farmer; and, encouraged by his success in the construction of a complete timekeeper, he resolved, could his father be prevailed upon to give his consent, to choose for his profession that of a clock-maker. This branch of the mechanic arts was, at that time, little practised in the colonies, and it does not appear that there were any means within his reach for obtaining instruction in it. His reasons finally satisfied his father of the propriety of this contemplated course.

The choice of Rittenhouse was directed by no little wisdom and modesty. Had his mind been tinctured with vanity, it is probable that he would rather have sought to make those studies available, in which he had, by this time, made no mean proficiency, than have undertaken an apprentice-

ship, for we might so style the practice of an art, in which his highest efforts, when compared even with the less perfect instruments of that period, were no more than the playthings of an ingenious, and perhaps precocious boy. Years of toil and patient labor must have appeared in perspective, before he could obtain a competent degree of skill; and without it the reputation, by which alone fortune, or even competence, could be secured, was inaccessible. Such thoughts, however, did not deter Rittenhouse; and, the consent of his father being finally obtained, along with funds to purchase a part of the necessary tools and instruments, he opened a shop in the year 1751. This was a small building erected for him on his father's farm; and he speedily stocked it with instruments, the work of his own hands, more perfect than any which could at that time be bought in Philadelphia.

The art of clock-making was at that time far from having reached the degree of perfection it has attained of late years, partly from the great extent to which the division of labor has since been carried in it, and partly from the valuable improvements which it has derived from the discoveries of physical science. To improve the art by introducing a division in the labor, neither entered into the views, nor was within the means of Rittenhouse. Such division can only be

carried into effect by the resources of wealth and capital, of which he had little. But the search for improvement, by the application of physical science, had already been entered into; and Rittenhouse might fairly hope, that the knowledge he had previously acquired might be advantageously applied to the profession he had chosen. The compensation pendulum of Graham, which has of late asserted its equality, if not its superiority, over all others intended to subserve the same purpose, had indeed been invented more than twenty years before. But his cotemporaries did not appreciate the merits of the discovery, and it was forgotten or neglected. Harrison and Leroy had not made public their inventions, and the field of investigation appeared to be open. The art of clock-making, therefore, not only presented a trade, interesting in itself, and capable of affording a decent livelihood, but also demanded, in order that it should be pursued with success, that he should continue the study of those physical and experimental sciences, by the progress of which the instrument could alone be perfected. His astronomical studies had taught him the value of the clock in the practical part of that science, a value so great as to render it the indispensable companion of an observer; and he was aware that he could not deliver his pieces of nicest workmanship to the purchaser, until

their rates had been ascertained by reference to the motions of the heavenly bodies. He therefore saw in his intended trade, not only an opportunity, but a necessity, for continuing the study of the sciences in which he delighted.

For the space of seven years Rittenhouse devoted himself most assiduously to his trade, and the studies he saw to be connected with it. The whole of the day was steadily employed in the former; time for the latter was stolen from his hours of repose. Up to this time his constitution, fortified by agricultural labor, and exercise in the open air, had been robust and vigorous. But such intense and unremitting exertion was not without evil effect upon his health; and this was probably aggravated by the contrast, which a wholly sedentary life presented to his former active pursuits. He finally was affected by a complaint, the prominent symptom of which was a continual and disagreeable sensation of heat in his stomach. He was, in consequence, compelled to abandon for a time the pursuits in which he had so earnestly engaged. A short period of relaxation sufficed to restore him, if not to his pristine health, at least to such a degree of it, as enabled him to resume his business. But the complaint was not wholly overcome; it continued to afflict him from time to time throughout

the rest of his life, and was finally the cause of his abandoning the exercise of his art.

Pursuing his trade with such unwearied assiduity, it is not surprising that he speedily acquired reputation for the accuracy and perfection of his workmanship. This reputation was spread abroad by the numerous highly-finished pieces of mechanism which issued from his workshop, bearing the maker's name inscribed upon their dials. His neighbors too were not slow to note the attention he paid to observations of the heavenly bodies, which he extended far beyond those absolutely essential for the rating of his time-keepers, and spread his fame throughout their limited circle as an astronomer. It was now that the good offices of his friend Barton were again exerted. Knowing well the ability of his brother-in-law, he watched with earnestness his almost daily progress in manual dexterity and scientific knowledge. In the more extended circle in which he moved, he found those who could fully appreciate all the skill and knowledge of Rittenhouse. With these he brought him in contact, to the mutual pleasure of both parties. From such associations Rittenhouse derived no little benefit, in obtaining a channel through which his merits could be made more extensively known. Among those who may be mentioned as the early friends of Rittenhouse, were Dr. Smith, the

provost of the College of Philadelphia, and John Lukens, surveyor-general of the province. Their official positions rendered them the organs of the government, when a demand for astronomic knowledge arose for public purposes; and they conferred no trifling public benefit, when they pointed out the capacity of Rittenhouse.

While thus engaged in the pursuit of his occupation, Rittenhouse long remained an inmate of his father's family. Here his labors were gradually acquiring for him provision competent to his moderate desires.

After the lapse of thirteen years from the time of his entering into business, his father made him proprietor of the paternal mansion, retiring himself to Worcester, where he had purchased another farm. Thus having attained to independence, he sought a wife, and, in the year 1764, married Eleanor Colston, the daughter of a respectable farmer of the neighborhood. This marriage appears to have been a happy one; and the loss of his consort, after several years, produced so great a depression in the spirits of the surviving husband, as to call forth the remonstrances of his friends

CHAPTER V

Boundary Line of Pennsylvania, Delaware, and Maryland. — Mason and Dixon's Line. — Boundary of Pennsylvania and New York.

Rittenhouse had hardly begun to attract the attention of the intelligent society of Philadelphia, when an occasion presented itself for applying his peculiar talent and knowledge to use in the public service. The several States, of which the American Union was first composed, held their respective territories by grants from the British crown. In the absence of a topographical knowledge of the countries granted, it had been customary to define the limits of the several charters by lines traced upon a map, and defined either by geographical terms, or even by more arbitrary methods. In the subdivision, which in some cases took place, of the original grants, similar lines were chosen to define the manner of partition. These lines were in most cases parallels of latitude, or portions of a meridian, traced in some given degree of longitude. However easy it may be to delineate such lines upon a map, to trace them upon the ground is a business of no little labor, and requires no small degree both of astronomic and geometric skill

The tenure, by which Penn and his descendants held their possessions, was defined by lines of this character. He had in the first instance purchased a territory included within a circle, drawn around a point in the town of Newcastle, as a centre, with a radius of twelve miles. This had been subsequently extended to the south by drawing a meridian line tangent to this circle. By a farther grant he had acquired all the territory extending westward from the Delaware between certain parallels of latitude, for the distance of five degrees of longitude. All these contemplated boundaries were as yet merely matters of parchment record, or geographical description; but the place where the lines existed was in some cases wholly unknown, in others, but imperfectly guessed at. The part of this boundary, which most early attracted the attention of the interested parties, was that, which separated the territory held by Penn as proprietor, from that belonging to Lord Baltimore, and particularly the limits of the present States of Delaware and Maryland. As early as 1735, this boundary had become the subject of a suit in the British court of chancery, and after fifteen years of delay a decree had been awarded. By this decree the parties were directed to enter into a formal written agreement to have the lines traced upon the ground. This agreement, how

ever, was not executed until 1760, and no joint action was had under it until 1769. But in the last-mentioned year Messrs. Mason and Dixon were sent out from England, as commissioners, for the purpose of carrying the agreement into effect.

In the proceedings before the court of chancery, the Penn family had been the complainants. Their interests were far more deeply involved in the decision, than those of the opposite party; for the wise institutions of their ancestor, and the repugnance of the settlers under them to slave labor, had rendered each acre within their proprietary jurisdiction of much greater value than in the lands held by Lord Baltimore. They were therefore unwilling to await the slow course of chancery proceedings, but determined to examine the question for themselves; knowing, that, when a boundary was defined in scientific terms, it was only necessary to cause it to be traced by men of competent attainments, and no important difference could arise in the subsequent determination by a joint action.

The governor of the province of Pennsylvania was therefore directed to seek out a competent person, to whom this important task might be intrusted. The most difficult part of the boundary was no doubt that defined by a circle, having a radius of twelve miles around the town

of Newcastle, as a centre, and the problem was entirely new in practical geometry. To this the attention of Rittenhouse was first directed by the Proprietary government, not only as the part of the division line which was involved in the greatest uncertainty, but because it passed through lands at that time more accessible and therefore more valuable than any others in dispute. The appointment to this important task bore date in 1763, and he was engaged in it for some months in the following year. It was performed so much to the satisfaction of his employers, that he was proffered, and received, more than the stipulated compensation. It does not appear, that on the subsequent arrival of the commissioners appointed by the British court of chancery, it became necessary to change the locality of any part of this line, although they were furnished with the best instruments which Europe could then produce, and one of them was already highly celebrated as an accomplished observer, while the American topographer had no instruments that were not the work of his own hands, and was as yet unknown to fame.

The British astronomers, Messrs. Mason and Dixon, seem therefore to have contented themselves with running the meridian tangent southward, and the parallel of latitude westward, until it intersected the meridian traced north

ward from the source of the north branch of the Potomac. They thus defined the boundaries of the present States of Maryland and Delaware on the one hand, and of Pennsylvania and Maryland on the other. This operation has become famous on more than one account. The tracing of the meridian line between two given latitudes, both of which required accurate astronomic determination, over a country nearly level, afforded an opportunity for actually measuring the itinerary length of the arc in question. This measure is still quoted as one of those whence the magnitude and true figure of the earth are to be deduced, and is the only case where the length of a degree of a meridian has been actually measured; for, in all other instances, the determination has been made, by measuring a base of a few miles, and calculating the whole length by means of a series of triangles. The parallel is well known in American politics, as it forms the separation between the States to which the names of Middle and Southern are applied, and is the boundary between the region in which domestic slavery is still recognised by law, and that in which it has been abolished.

The previous observations of Rittenhouse seem to have greatly facilitated these operations of Mason and Dixon; but, as the official report is made by them, and could have authority only

when so made, the connexion of our own countryman with this important question is but little known, and rarely mentioned even among ourselves.

That geographical and geometric lines should have formed the divisions of the original provinces, and thus of the States, has exercised an influence upon the destinies of our country, which is not the less evident, because it has rarely been noticed. In most of the disputes concerning land titles derived from different authorities, or concerning territorial jurisdiction, it has not been necessary to have recourse to civil violence or hostile arms. The *ultima ratio* has been not the cannon or the bayonet, but the plumb-line, the clock, and the telescope. Even courts of civil authority, where such have had jurisdiction, have been appealed to, only to cause one or other party to perform his duty, or to commission the astronomic surveyors by whom the determination was made. The habit has thus been created of referring to reason and science for the composition of all disputes; and this is so firmly established among the people, that even the folly of their rulers, as was manifested in a recent instance, cannot bring them to refer the matter to the decision of arms. That this habit has become a part of the character of our people, is in a great measure due to the confidence created

by the fidelity and accuracy with which the earliest operations of the sort were performed. From the delineation of Mason and Dixon's line to the present time, both State governments, although this portion of their sovereignty has been reserved, and individuals, who have occasionally suffered hardship, have bowed in obedience to the decision of the astronomer. Rittenhouse was the first American, who was employed in the delineation of such lines; he was also most extensively engaged in tracing them, and, with those formed under his instruction, actually defined nearly all the important division lines within the chartered limits of the thirteen original States. Most of these delicate and valuable operations were however performed at a later period of his life, and after the close of the revolutionary war. The account of them will therefore fall into a subsequent chapter of this memoir. One alone is connected by date with that of which we have just spoken.

This was the determination of the division line between New York and New Jersey, and thus of the point whence the parallel, which divides the former State from Pennsylvania, was to be traced westward. The northern limit of New Jersey upon Hudson's River is the forty-first degree of latitude. The point where this parallel intersects the shore was fixed by Rittenhouse in

the year 1769, at the request of a board of commissioners deriving their authority from the legislatures of the provinces of New York and New Jersey. The northern limit of both Pennsylvania and New Jersey, upon the Delaware, is the forty-second degree of latitude; and this parallel, continued westward, divides the former from New York. To determine the place where this parallel intersects the Delaware, Rittenhouse received the appointment of commissioner from his native province, and was met by a gentleman named on the part of the province of New York. This appointment also included the duty of running the parallel westward, but nothing farther was done at the time (1774), than to determine the point of departure upon the Delaware.

CHAPTER VI.

Experiments on Expansion. — Application of them to the Pendulum. — Metallic Thermometer. — Experiments on the Compressibility of Water. — Adaptation of Planetary Machines to Clocks. — Project of an Orrery.

For the sake of connecting with each other the geodetic operations of Rittenhouse performed previous to the revolutionary war, we have departed from the order of time. We shall now return, for the purpose of mentioning various other scientific occupations in which he was engaged, between the date at which he was first employed upon the boundary of Maryland, and that at which he became a commissioner to define the line between the States of New York and Pennsylvania.

To a person engaged in the manufacture of clocks, and occupied in determining their rates by astronomic observations, the influence of variations of temperature upon the oscillations of pendulums becomes at once apparent. That this is owing to the expansion and contraction of the materials of which the pendulums are composed, under alternations of heat and cold, was well

understood. Partial remedies, too, had been applied; but they had not yet been rendered as available as they might be, for want of a sufficient number of well-conducted experiments. If such had been made, they had not been recorded or published. At the present time, we can refer to no observations of earlier date than those of Rittenhouse, which are worthy of confidence, except a few of Muschenbroeck and of Smeaton. The latter were only made public in 1754, when we have reason to believe that Rittenhouse had already made some progress in his researches. That he entered into this investigation experimentally and pursued it with no small success, we have abundant evidence. The first volume of the "Transactions of the American Philosophical Society," published in 1770, contains a paper of his on expansion by heat; another paper on the same subject is noted by Rush as existing in their archives, and is probably that on the improvement of timekeepers, in the fourth volume. The accuracy of his experiments is demonstrated by the various astronomic clocks, which were constructed by his own hands, or under his direction, in which original forms of compensation pendulums were employed. In this respect, Rittenhouse was somewhat in advance of the applications of science in Europe. The mercurial pendulum, which is now admitted to be the best

compensation for a fixed observatory, had indeed been invented by Graham in 1726; but this important discovery had been neglected and almost forgotten. The account of the gridiron pendulum, which was the first that came into familiar use in Europe, was not published by Harrison until 1775. Rittenhouse himself, however, in a letter dated in 1768, refers to Harrison's time-keepers as having been executed in 1765. If, then, he was aware of the discoveries of Graham and Harrison at the time he commenced his own researches, he did not content himself with a servile imitation, but entered into experiments on which to found his own practice, and struck out a method of compensation different from either.

Another valuable application of a correct knowledge of the relative expansions of solid bodies also occurred to Rittenhouse, and he carried this application into successful practice. In this he forestalled, in the career of discovery, Breguet, who, within the present century, has received no small praise for the re-invention of a forgotten instrument of Rittenhouse's. We refer to the metallic thermometer. It is in evidence, that, in the year 1769, the latter constructed an instrument, in which, by the expansion of metals, a hand was made to traverse on a semicircular dial-plate, on which were marked the degrees of Fahrenheit's thermometer, and that it corre-

sponded in its indications with the mercurial instrument. Here then we have his experimental knowledge brought to a severe practical test, and applied to an important purpose.

The Florentine Academy had, by an experiment, all the circumstances of which could not be reached, inferred the incompressibility of water. The accuracy of this inference remained for a long time unquestioned. It may be doubted, whether the whole scientific world rejected the Florentine experiment until very recently, when the experiments of Oersted and Perkins have demonstrated the compressibility of water beyond all cavil. The question was at least still open in the days of Rittenhouse, and he proceeded, in 1767, to examine it for his own satisfaction. In doubting the results of the Florentine philosophers, he was not however original; the subject had already been examined by Canton in England, and by Kinnersley, at that time a professor in the College of Philadelphia. But, as the question was not yet admitted to be settled, merit is still to be attributed to one who brought the aid of his powers of research to the investigation of an important question in physical science; an investigation which he pursued by means of his own contrivance, and illustrated by experiments of great ingenuity.

The merits of Rittenhouse, not as a mechanic

only, but as a successful improver of physical science, now became apparent to his country men. His rising reputation is manifested by the compliment paid him in 1767 by the College of Philadelphia, by which the honorary degree of Master of Arts was conferred upon him at the public commencement. At a time when the distinction in points of useful knowledge, between those who had received the advantage of a public education and those who had not, was still marked, this act implied a higher degree of acknowledged merit, than would be inferred from a similar diploma at the present day. It was therefore not only a deserved compliment, but a passport to the realms of science.

In the pursuit of his mechanical vocation, Rittenhouse had complied, as was necessary, with the prevailing taste. His clocks were not only accurate as timekeepers, and furnished with the apparatus for striking the hours, but they frequently contained chimes, and other arrangements for performing pieces of music. Among other embellishments, he had adapted to one of his timekeepers a small planetary machine, in which the mean motions of the bodies of the solar system were made to keep their proper rate with the time marked by the instrument The calculations, into which it became necessary for him to enter as a preparation for this toy,

appeared as capable of application on a larger scale. He, in consequence, in 1767, projected the instrument, which, perhaps improperly, is known under the name of his Orrery.

Machines, by which the apparent motions of the heavenly bodies could be represented, are of remote origin. Among the ancients they had even been brought to such a degree of perfection, as to be capable of use in the prediction of eclipses, and of other phenomena, with an accuracy as great as that of any other known method. The great improvements made in modern astronomy had rendered them useless for any such purpose; and, confined to the representation of appearances alone, the mechanic spheres of the ancients were rejected as giving false notions of the structure of the universe. Still, planetary machines were not the less in request, and it was attempted to give, by means of them, an exhibition of the true relative motions and distances of the bodies of the solar system. The most celebrated machine of this character was constructed by Rowley for the head of the family of Boyle, a name of no little lustre in the annals of science. This nobleman bearing the title of Earl of Orrery, the instrument was introduced to the public under this name, which still continues to be applied to all those intended for similar purposes. By this name also did Rittenhouse propose to designate his projected

piece of mechanism. In his views, however, he was actuated by a much higher ambition than has ever stimulated any other person, who has attempted to exhibit the mechanism of the universe by the aid of the workmanship of human hands.

Abandoning all attempts to exhibit the imaginary celestial sphere, a mode of representing appearances, which is no more than a projection in orthographic perspective upon a surface supposed to be infinitely distant, he retained no other portion of it but the zodiac. He wisely saw the immense difference, which must result between the true geocentric places of the bodies themselves, and those which would be represented by any instrument enclosed within a skeleton sphere. His mimic planets were not made to revolve in circular orbits with uniform motion, but were caused to describe ellipses in conformity to the laws by which Kepler had completed the theory of Copernicus. So far from being content with a mere approximation to the relative motions, he conceived the design of regulating them to each other with such accuracy, that his instrument might be used in the place of tables for predicting the places and phenomena for any given epoch. Bold and novel as were these designs, Rittenhouse proposed to carry them into effect, if not in such a manner as to supersede the use of astronomic tables, yet so as to give to calculators

a valuable check upon their numerical computations. The motions of his mimic planets were to be so registered upon proper dials, as to give not the mean heliocentric places, but the true anomalies, defining the positions in elliptic orbits, both as seen from the sun and from the earth for twenty-five centuries before, and as many after, the date of its construction. If, then, we should ascribe, as some have done, to the orrery of Rittenhouse no higher place among physical instruments than that of an ingenious philosophic toy, we must admit that he exhausted in its construction all the existing knowledge of astronomy, and applied this extensive scientific information, with the most consummate practical skill.

From the time at which the orrery was pro jected, until it was actually completed, Rittenhouse was exposed to many interruptions. These, however, are so little to be regretted, that we consider them as having furnished him with the means of establishing his future fame upon a basis far more sure than any such application, even of the highest science, and the most perfect mechanical dexterity.

CHAPTER VII.

Preparations for Observing the Transit of Venus.

Up to the year 1768, we have no records of the astronomic observations of Rittenhouse. They had been limited to such as were necessary for regulating his timekeepers, or were called for in tracing the boundary lines, for the determination of which his practical and theoretic skill had been resorted to. In the practice of such observations, and in the execution of the public trusts confided to him, he had gradually acquired much dexterity in the management of instruments, and facility in calculation. The year 1769 presented an opportunity, in which his practised powers of observation and computation might be applied to an important purpose. This year is rendered memorable in the annals of astronomy, by the recurrence of that rare phenomenon, the transit of the planet Venus over the Sun's disk.

From the time that the truth of the Copernican system had been universally admitted, it was known that this planet must, at every succeeding interval of about five hundred and eighty-four days, be in inferior conjunction with the sun

Whether the planet shall be exactly interposed at this time between the body of the sun and the earth, in such manner that it may be seen, by the aid of proper instruments, passing over the disk of the former, will depend upon the inclination of the orbit of the planet. As this inclination is considerable, the phenomenon of such a passage was inferred to be at best a rare one. Before the telescope was adapted as a sight to graduated instruments, and great public observatories were established at national expense, the tables which gave the inclination of Venus' orbit were far from agreeing. An Englishman of the name of Horrox, however, placing reliance upon the Rudolphine tables of Kepler, ventured to predict a transit of this planet for the year 1639. The result verified his prediction, and he, with a friend of the name of Crabtree, was fortunate enough to see this rare and curious phenomenon, of which they alone were witnesses. The improvement in the tables of the elements of the orbits of planets, made in consequence of the establishment of the observatories of Paris and Greenwich, enabled astronomers to predict with certainty transits for the years 1761 and 1769. No other can again take place until the year 1874. The phenomenon, from its extreme rarity, is therefore one of the greatest interest in astronomy. Far greater importance had, however, been given to the

phenomenon of the transit by the remark of Halley, that observations of it, made either at a single favorable position, or in remote parts of the earth's surface, afforded the best possible data for calculating the dimensions of the solar system; for, by means of them, the horizontal parallax, both of Venus and the sun, may be determined, and thence their distances, in terms of a semi-diameter of the earth, become capable of calculation in the most easy way.

The transit of 1761 was visible in Europe, and in other parts of the eastern continent. Its approach was looked for with great anxiety, and imposing preparations were made for observing it. Not only were such measures taken at the great observatories of Europe, but observers, furnished with the best instruments which the existing state of the arts would supply, were despatched to St. Helena, to the Cape of Good Hope, to Tobolsk, to Calcutta, to Madras, and to Tranquebar. The governments of France, England, Russia, and Denmark seemed to vie with each other in zeal; and no expense was spared to make the observation complete, by which the truth of the Copernican system might be brought to ocular demonstration, the laws of Kepler reduced to experimental proof, and the vast distances and dimensions of the solar system included in a problem, as simple in form as the easiest case of trigonometry. No part of the

transit of 1761 was to be visible in the continent of America; but, in the island of Newfoundland, the sun would be seen to rise before the emergence of the planet from his disk. As this was the only spot in the western hemisphere, where an observation could be made, Professor Winthrop, of Harvard University, was sent to St. John's, in that island, furnished with the proper instruments by the liberal grant of the colonial Assembly of Massachusetts. In fine, wherever the transit was to be visible, and this was in every part of the civilized world except America, every amateur astronomer, as well as those who made that science their profession, endeavored, to the utmost of his means, to take advantage of the rare occasion.

Notwithstanding such imposing and costly preparations, the transit of 1761 ended in disappointing every hope. Some of the most practised observers, particularly those stationed at the great fixed observatories, lost the view altogether, in consequence of the weather; a very considerable discrepancy existed among the observations of others; and, upon the whole, the determination of the parallaxes was admitted to be inconclusive. It was indeed remarked, that, by throwing out four of the observations altogether, the rest might be made to agree, or that the same might be done, by supposing, what occasionally happens, that each of these four observers had noted the wrong minute, in

writing this element of time in front of the second marked by his clock. That this was the case, has now been established, beyond the possibility of doubt; but, to correct, in this apparently arbitrary manner, a large proportion of all the obser vations, which the state of the heavens permitted to be made, would hardly have been justified by any of the laws of probability.

Such an unfortunate result of the transit of 1761 served to make that of 1769 of far greater interest than had attached even to the former. The hopes of astronomers having been once frustrated, anxiety became mingled with expectation; and this anxiety was enhanced by the consideration, that but a small part of the transit of 1769 was to be visible to any of the great observatories of Europe. At Stockholm, London, Paris, Lisbon, and Madrid, the immersion might be seen just before sunset, and the emersion at Petersburg soon after sunrise on the following morning, but at no other European capital. In the northern frozen zone, beyond the latitude of sixty-seven and a half degrees, the sun was not to set on the day of the transit; the whole of the phenomenon would therefore be visible; and at Wardhuys, in Lapland, where the observation would be included between the hours of half past nine in the afternoon and three in the morning, the circumstances would be the most favorable possible

In less high northern latitudes, near the same meridian, the beginning might occur before sunset, and the end take place after sunrise. Such a position was found at Cajaneburg in Sweden.

Maskelyne, the British Astronomer Royal, seeing that advantages, such as were presented by the last-mentioned places could be secured by the comparison of observations made at two different points, one in the southern, the other in the northern hemisphere, induced his government to despatch two expeditions, the one to Hudson's Bay, the other to Otaheite. The latter was under the command of the celebrated Cook.

The French government, at the instance of Lalande, sent Chappe to California; here the immersion was to take place when the sun was on the meridian, and, at that season, not far from the zenith.

Even at Pekin, although only the last contact was to be visible, the European astronomers of the imperial observatory were aided and excited to the task. It may be here mentioned, that a great degree of jealousy, and consequent mystery, attended the preparations of the several governments. This appears to have arisen from the arrogance of Lalande, who wished to assume the direction of the whole, and expressed his expectations that the records of the observations should be sent to him for calculation. The choice of

the stations of Otaheite and Wardhuys was therefore carefully concealed from him, until it was too late for him to abandon the less favorable position of California, for another.

The position of Pennsylvania offered advantages of another description; the whole of the transit was to be visible, beginning before, and terminating after noon. It was thus to occur at hours when less disturbance was to be feared from fogs and vapors, than in the north of Europe; while the effects of the parallax, it was hoped, if less than at Cajaneburg, Otaheite, or Wardhuys, might be sufficiently marked to admit of favorable results in the subsequent calculations. At all events, it would be a subject of mortification, that so important a phenomenon, visible throughout its whole duration to the then British colonies in America, should be permitted to pass unnoticed, except by idle curiosity; while a successful observation, and the calculation of the important results, would redound to the scientific reputation of the whole of the provinces.

Such reflections did not escape Rittenhouse, and while he felt his own capacity to perform the necessary operations unaided, and had prepared with his own hands most of the more essential instruments, he showed himself unwilling to attempt to engross the whole honor, and manifested a laudable anxiety to have the means of

observation so far multiplied and distributed, that the risk of failure from unfavorable weather, or any other contingency, might be as much diminished as was possible. He therefore communicated to the Philosophical Society of Philadelphia a calculation of the anticipated times and phenomena of the transit, as likely to be visible at Norriton, and called the attention of that learned body to the important subject. It cannot be doubted that the members of that Society, who afterwards distinguished themselves by performing a part in the observation and subsequent calculations, were aware of the importance of the occasion; but the matter appears to have been first brought before them in a tangible shape by the communication of Rittenhouse; and this communication, showing them that they had in the vicinity, both many of the instruments, and an expert observer and calculator, seems to have served as a stimulus to their zeal, by exhibiting the possibility of attaining high honor, where the gratification of a laudable and enlightened curiosity had alone been thought of.

CHAPTER VIII.

Observation of the Transit of Venus. — Calculation of the Parallax of the Sun.

Previous to the year 1768, Philadelphia had not only become the seat of a highly respectable seminary of learning, which has since by gradual expansion become a thriving university; but had been chosen as the place of meeting of a scientific association, which still flourishes under the name of the American Philosophical Society Although members of this association resided in various parts of the colonies, the intelligence of the citizens of Philadelphia gave them no ill-founded claim to the choice of their city as the scientific centre of the Union, and this choice has been justified by the share which they have taken in its proceedings and published memoirs. To this learned association the communication of Rittenhouse on the subject of the transit of 1769 was addressed. The American Philosophical Society seems to have appreciated fully the interest of the subject, and to have entered zealously into measures of coöperation. In order that preparations might be made, adequate to the importance of the occasion, a large committee was, on the

7th of December, 1768, chosen from among the members. Of this committee, Rittenhouse was one. The committee lost no time in assembling, in order to plan the most expedient mode of carrying the purposes of their appointment into effect. Three places of observation were immediately selected. The first of these was the State-house Square of Philadelphia; the second, Cape Henlopen, at the mouth of the Delaware; the third was Norriton, the residence of Rittenhouse. The charge of making the observations at Cape Henlopen was intrusted to Mr. Owen Biddle; Professor Ewing of the College, and Dr. Hugh Williamson, were appointed to the Philadelphia station; while Provost Smith and Mr. Lukens were associated with Rittenhouse at Norriton.

The proprietaries of the province, the colonial legislature, and the public institutions of Philadelphia furnished aid with great liberality to the important object. The station at Cape Henlopen was provided with an excellent telescope, as well as with timekeepers, and the instruments for rating them. A complete observatory was erected in the State-house Square, to which were assigned an equal altitude and a transit instrument, with a great zenith sector, the property of the proprietaries; to these, a powerful reflecting telescope, furnished with a micrometer, was added by the

funds granted by the legislature. Rittenhouse was left to prepare and furnish his observatory from his own resources. He had, in the autumn of 1768, commenced the construction of a proper building, which was finished in April, 1769. In this he placed a transit and an equal-altitude instrument, with a clock, all the work of his own hands. He was however without an instrument for determining his latitude; this was finally obtained by the exertions of Provost Smith from the surveyor-general of New Jersey, (Lord Stirling,) in the form of an astronomical quadrant of two and a half feet. All that remained to be provided was a telescope of sufficient power, furnished with a micrometer. Two telescopes of less magnitude seem indeed to have been provided; but the micrometer was indispensable to a complete set of observations. Provost Smith had, however, sought at an early period for the means of supplying this deficiency; he had entered into correspondence on the subject with Mr. Penn, the proprietary, and with the British Astronomer Royal. In consequence of his representations, Mr. Penn purchased and sent out, for the use of the observatory at Norriton, an excellent reflecting telescope and micrometer.

The observatory at Norriton being thus at last completely provided, Rittenhouse applied himself with diligence to the necessary preparations. The

distance from Philadelphia was sufficient to make it inconvenient for his colleagues on the sub-committee to render him much assistance, and they seem to have considered it unnecessary to attempt to overcome this inconvenience. Confiding in the attention and skill of their associate, they left all the preliminary observations and calculations wholly to him. These were executed in a manner which fully justified their having intrusted the whole matter to their colleague, and, when the approach of the day of the transit called them to their posts, nothing was left for them to do, but to take their seats at the telescopes provided for them.

The labor imposed upon Rittenhouse became therefore more arduous, and the responsibility greater, than was originally intended by the Society, or than he would probably have ventured to assume. Great anxiety was also mingled with the exhaustion produced by continual labor, both by day and night; for it was within the limit of possibility, that, as on the former occasion (1761), clouds might interfere with the observation.

The morning of the expected day, however, broke without a cloud, and not even a floating wreath of vapor appeared to interfere with the observations. Exhilarated by the favorable state of the atmosphere, and stimulated by the near approach of the time when he was to reap the

fruit of his long and patient labors, excitement supplied the place of strength. But when the contact had been observed, and the planet had entered fairly upon the disk of the sun, his bodily strength was exhausted, and he sunk fainting to the ground, unable to bear the intense feelings of delight which attended the accomplishment of his wishes. He however speedily recovered, and proceeded to perform the measures of the distances between the centres of the two bodies, at proper intervals during the continuance of the transit.

When the record of the observations made at Norriton came to be collated, not only with those of the other members of the committee of the American Philosophical Society, but with those made in different parts of the world, the practical skill of Rittenhouse shone forth in the most brilliant light; and it would have been sufficient for his fame had he added no more than this record to the science of astronomy. But he was not content with having performed more than his full share of the observation, and executed the whole of the preparatory work. The planet had hardly completed its emergence, before he set himself down to the task of calculating the parallaxes. His calculation was among the earliest that were completed, and the results were forthwith communicated to Dr. Smith, who incorpo-

rated them in a paper of his own, which was laid before the Philosophical Society. This learned body did not hesitate in undertaking the costly duty of committing this paper, with some others on the same subject, to the press, and it thus happened, that the first correct determination of the solar parallax was derived from an American source. Before a transit of Venus could be observed for the purpose, astronomers had no mode of determining the dimensions of the solar system, except by the parallax of Mars. The exact determination of the parallax of this planet is far from being easy, and thus no writer before 1761 had ventured to assign to the sun a parallax of less than 10″. The calculations of the American committee did not make this parallax more than 8″.6. Some time elapsed before the record of the distant observations could reach Europe and be collated. When this was done, the calculations were made up, not by the observers themselves, but by Maskelyne in England, and Dusé-jour in France. The result of these calculations gave 8″.88 for the solar parallax. When however all the observations, with the exception of the American, are brought into the calculation, the mean derived from the whole has been found to be rather below 8″.6, than greater; and thus the results of the American observations were not

only first calculated, but gave the most accurate determination.

This very accuracy of the American observations and calculations seems to have been at first injurious to their credit. Those who had long been accustomed to estimate the distance between the sun and earth at eighty millions of miles, were not prepared to have that distance suddenly increased to ninety-six millions. The highest determination which could possibly be drawn from the observations was for a time preferred as most likely to be accurate. It hence arose, that these records of the skill and science, which our countrymen exhibited more than sixty years since, are but little appreciated even among ourselves; while in Europe they are almost forgotten. Even the learned Delambre, in his account of the manner in which the dimensions of our system were determined, neglects to quote the papers of the American Philosophical Society, although he shows by a recalculation of all the other observations, that the true result is almost identical with that, which was set forth in those very papers. Of the honor to which the American Philosophical Society is justly entitled for its labors and exertions on this occasion, no small portion is due to Rittenhouse. His relative merits were fully appreciated in Europe, and he was named with the highest praise in the congratulations, which flowed in from

all directions upon the Society. To Franklin, who, from his official station in England, became the organ of these communications, it was declared by an accomplished judge, that no learned society in Europe could at the moment boast of a member possessing the various merits of Rittenhouse, who united, in his own person, tact as an observer, theoretic skill as a calculator, and practical talent as a constructor of instruments

CHAPTER IX.

Transit of Mercury. — Longitudes of Philadelphia and Norriton. — Orrery resumed. — Comet of 1770.

The year 1769 was marked, not only by a transit of Venus over the sun's disk, but also by one of Mercury. The latter phenomenon is, however, of less interest than the former, as it is of more frequent occurrence, and could not be advantageously employed in determining the dimensions of the solar system, in consequence of the much greater distance between it and the earth. Rittenhouse observed this phenomenon also, and was assisted again by Messrs. Smith and Lukens, together with Mr. Owen Biddle, the gentleman who had observed the transit of Venus at Cape Henlopen.

This observation afforded data whence to calculate the difference of longitude between his observatory at Norriton, and the State-house Square at Philadelphia. This difference had indeed been deduced from the transit of Venus; but, as the parallaxes of the sun and planet must be assumed in the calculation of the longitude, and as the longitude again enters into the calculation

of tne parallaxes, it was important that it should be obtained by an independent method. The observation having been made, the difference of longitude was deduced by Rittenhouse and his associates. The observations of the transit of Venus appeared to Maskelyne very important in their bearing upon a true knowledge of the dimen sions of the solar system; and, as the longitudes of Norriton and the State-house Square were important elements of the calculation, that distinguished astronomer urged the members of the American Philosophical Society to ascertain the difference between these two places, not only by every practicable mode then employed in astronomy, but also in itinerary measure. The longi tudes of both, from the observatory at Greenwich, would be of course ascertained in the employment of the first of these methods. These essential operations were in consequence undertaken, and performed by Provost Smith, Lukens, and Rittenhouse.

Since that period the instruments of astronomy have been vastly improved; new methods, more easy and accurate, founded on more complete tables, have been introduced; yet, for fifty years from the date of this operation, the longitude of no part of the American continent had been determined with an accuracy equal to that attained for these two places, by the operation we have re ferred to.

The labors preceding and attending the observation of the transit of Venus diverted Rittenhouse for a time from his mechanical pursuits The orrery, projected in 1767, therefore remained unfinished upon his hands. No sooner, however, was this interesting subject completed, than he returned to his tools with increased zeal. Even before the orrery was finished, a contest commenced between the Colleges of Philadelphia and Princeton, to determine which should become the proprietor by purchase of this beautiful piece of mechanism. It would appear, that the former expected some favor would be shown it, either in price or in the terms of payment. Such favor, however, Rittenhouse, whose sole resources lay in his own labor, and who had already lost much time and ex pended much money in his attention to astronomic subjects, was not disposed to grant. It therefore became the property of the institution at Princeton, of whose cabinet it is still the pride.

We have already stated some of the important differences between this instrument and any other which bears the same name. These differences are pointed out by Rittenhouse himself in a communication to Barton, in which he imparts his original design.

"I did not," says he, "design a machine, which should give to the ignorant in astronomy a just view of the solar system; but would rather aston-

ish the skilful and curious examiner, by a most accurate correspondence between the situations and motions of our little representatives of the heavenly bodies, and the situations and motions of those bodies themselves. I would have my orrery really useful, by making it capable of informing us truly of the astronomic phenomena for any particular point of time; which I do not find that any orrery yet made can do."

The instrument, as constructed in entire conformity with these views, presents three vertical faces. That in front is four feet square. In the middle is a ball to represent the Sun, and around this others revolve to represent the planets. The latter move in elliptical orbits, having the former in their common focus, and at rates varying according to the law of Kepler. The orbits of the several planets are properly inclined; their nodes and the lines of their apsides are in just position, and have motions corresponding to those of the orbits of the planets themselves. The instrument being set in motion, three indices are caused to move, which point out, on graduated circles, the year, the month, and the day. The first of these extends to a period of five thousand years. In order to determine the heliocentric place of any one of the planets for any day within this period, the instrument is caused to revolve until this epoch is marked by the three indices; a small telescope

is then placed upon the body of the mimic Sun, and, being directed to the representative of the planet, the position of the latter may be read on a graduated circle representing the zodiac. This zodiac is not fixed, but has a motion corresponding with the precession of the equinoxes. The geocentric place is determined by affixing the same telescope to the earth, and is read off upon a circle, whose centre is the movable place of the earth in the instrument.

The two lateral faces of the orrery have the same height with the principal one, and about half the breadth. Upon one of them are represented the motions of Jupiter and his satellites, and of Saturn, his ring, and satellites. On the other the phenomena of the Moon's motion are exhibited, her phases, the exact time and duration of her eclipses, the appearances of solar eclipses for any given position of the earth, the Moon's longitude and latitude, the motions of her apogee and nodes. In addition, it exhibits the apparent motion of the Sun in declination, and the equation of time.

Were it not that the instrument actually exists to attest that all this has been successfully executed, it might have been believed that such varied, numerous, and complicated motions were incapable of being represented by mechanism.

The calculation of the longitudes of Norriton

and Philadelphia was communicated to the Amer ican Philosophical Society in August, 1770, by Provost Smith. A few days earlier than the date of this communication, Rittenhouse laid before that association a series of observations on a comet, which was visible in June and July of that year. To the observations were appended cal culations of the elements of its motion and of the figure of its orbit. In this paper he not only sustained the reputation he had acquired as a skilful observer, but showed himself capable of performing the most laborious and difficult computations of physical astronomy. The amount of labor, manual, bodily, and mental, which were thus crowded into less than three years of the life of Rittenhouse, was prodigious. Other men may have indeed accomplished as much and more, by directing their energies steadily to a single pursuit. But it is probable that there is no other instance on record of such a variety of occupation having been successfully executed by a single person within so small a space of time

CHAPTER X.

His Second Orrery. — Proposed Removal to Philadelphia. — Loan-Office Bill. — Gift of the Legislature. — Change of Residence. — Election as Secretary of the American Philosophical Society. — Second Marriage. — Proposed Public Observatory.

The cession of the orrery to Princeton College caused, at first, no little dissatisfaction in Philadelphia. But this event, coupled with the praises that were daily pouring in from Europe, redounded in the end to the advantage of Rittenhouse, and exhibited to the inhabitants of Pennsylvania the high value of the talents and acquirements of their distinguished fellow-citizen. The loss of the orrery was found to be of little moment, so long as they could command the knowledge and manual dexterity by which it had been executed; and Rittenhouse at once tendered to supply it, by making for the College of Philadelphia an exact duplicate of the original instrument. Although he offered to do this at a price inconceivably cheap, the funds of that institution were not yet adequate to the purchase. In this emergency, Provost Smith undertook to furnish what

was necessary, by delivering a course of public lectures on astronomy, the profits of which were to be applied to the purpose. This undertaking was successful, the necessary funds were raised, and a duplicate of the orrery of Princeton was placed among the apparatus of the College of Philadelphia.

A just appreciation of the merits of Rittenhouse led the citizens of Philadelphia about this time (1770) to desire to withdraw him from his retirement at Norriton, and fix his residence among themselves. This could only be properly done by supplying him with means by which the difference in the cost of supporting his family, upon a well-stocked and fertile farm, and in a city, might be compensated. Simple in his habits, and economical in his expenditure, the products of his paternal estate sufficed in a great degree for his wants, and he was enabled to afford his beautiful timekeepers at prices which gave them an extensive sale. Had he been compelled to manufacture them in the more expensive position of Philadelphia, this might not have been the case. At this moment, however, an office presented itself, which demanded a residence at the seat of government, and, calling for high integrity and much intelligence, could be performed with little labor; the emoluments would be sufficient to justify Rittenhouse in changing his abode. This post was

that of one of the commissioners of the loan office, a bill for the regulation of which was pending before the legislature of the province at their session of 1770. The commissioners were to be three in number; and, on the motion to place the name of Rittenhouse in one of the blanks left for the insertion of the names, the whole Assembly rose to vote in the affirmative. A point of etiquette was however in dispute between the Assembly and the Governor, in consequence of which it appeared probable that the bill would receive his veto. It was therefore permitted by the Assembly to sleep among their unfinished business. Yet the legislature, willing to compensate him for the disappointment which he might sustain, and anxious to testify their sense of his merits, voted him at their next session a free gift of £300 currency, and in addition appropriated £400 to defray the cost of a third orrery of double the dimensions of the two former ones. This gift, which is perhaps without either precedent or imitation in the legislative annals of the country, is glorious to the body which granted it, and honorable to the party which received it. It is expressed in the resolution to be "a testimony of the high sense which this House entertains of his mathematical genius and mechanical abilities."

Rittenhouse had, before the date of this vote,

namely, in the autumn of 1770, become a resident in the city of Philadelphia. This change of abode was speedily followed by a distressing event, the loss of his wife. The affliction consequent on this bereavement appears to have interfered for a time with the activity of his scientific and mechanical pursuits, and to have caused him to meditate an expedition to Europe, which he was advised by his friends to undertake as a means of relief. It is, nevertheless, happily ordained that time mitigates the most severe dispensations of this character, and the mind of Rittenhouse speedily resumed its tone.

In 1771, the American Philosophical Society, whose meetings his change of abode enabled him to attend regularly, elected him one of their secretaries. The palmy days of that association were however at an end; the disputes between the colonies and the mother country were rapidly approaching a crisis, and the minds of men were diverted from all pursuits, except those essential to subsistence, by the all-absorbing discussions of politics. From the time of the publication of the first volume of the Transactions of this Society, until the second was put to press, fifteen years elapsed, and an interval of ten years exists between the date of the latest communication of Rittenhouse in the former, and of his earliest in the latter. He did not however wholly neglect his

scientific studies, for in 1771 we find him to have been engaged with Kinnersley in experiments on the electric properties of the gymnotus; but the four years which succeeded his removal to Philadelphia seem to have engaged him in few other pursuits than the labors of his business, with the exception of some public tasks, a part of which have already been referred to. The completion even of these was prevented by the threatening aspect of public affairs, and they did not occupy much of his time. The only other duty, which was assigned him, was that of a commissioner for rendering the Schuylkill navigable, and this was also reduced to little importance by the state of public feeling.

During this interval, Rittenhouse recovered from affliction caused by the death of his first wife, and again married. The object of his second choice was Miss Hannah Jacobs of Philadelphia.

The year 1775 opened with a project intended to bring the abilities of Rittenhouse more effectually into the service of science. The Philosophical Society addressed the colonial legislature of Pennsylvania, praying it to establish a public observatory, and commit it to the care of Rittenhouse. Had the circumstances of the times permitted this project to be carried into effect, it would have enabled him to occupy a

great space in the history of astronomy. He had already shown himself the equal, in point of learning and skill as an observer, to any practical astronomer then living; nothing was wanting to make him rank with the Flamsteads, the Halleys, and the Maskelynes, but that he should be permitted to devote his whole mind to this pursuit, and be furnished with those instruments and accommodations, for which no private fortune will suffice. Other men might have been found as well, nay, better qualified for the political pursuits and public offices in which it became his fate to spend the rest of his life; but America has never yet produced any individual who has manifested so great a capacity for extending the domain of practical astronomy. To arrange the details of a disorganized and depreciating currency, to collect and disburse a scanty and ill-paid revenue, were thereafter to be the pursuits of our philosopher; and he was to expend upon the estimates and returns of the tax-gatherer those powers of mind which were capable of grasping, and that mechanical skill which sufficed to imitate, the vast mechanism of the universe.

From the time at which Rittenhouse removed to Philadelphia, the minds of men had been undergoing a preparation for the parts they were to take in the ensuing contest. The inhabitants of the colonies had hitherto been remarkable for

their loyalty, and, in the earlier remonstrances they presented, had appealed to a paternal sovereign from the acts of a tyrannical legislature in which they were not represented. As the crisis approached, the unanimity with which such remonstrances had been made no longer continued. Some, finding that the acts of the Parliament were guided and directed by the pleasure of the monarch, unwillingly acquiesced in his sovereign will. Others, more bold, finding redress was not to be obtained by peaceable means, sought it in resistance. Among the latter was Rittenhouse, who, in defiance of the influence of beloved relatives, enrolled himself at an early date on what became the popular side. From this period to his death, his time was principally spent in a series of public duties, some of which had reference to his favorite scientific pursuits; but others, and those the most engrossing, were wholly repugnant. If he did occasionally revert to his original profession, and the studies in which he had acquired reputation it was at distant intervals, and rather as the recreation of leisure from other pursuits, than as the absorbing occupation of his mind.

CHAPTER XI

His Election to the Legislature of Pennsylvania —First Committee of Public Safety.—Treasurer of the State.— Capture of Philadelphia, and Removal of the Treasury to Lancaster.— Second Committee of Public Safety.—Transit of Mercury and Solar Eclipses.

The residence of Rittenhouse in the city of Philadelphia, for four continuous years previous to the commencement of hostilities between the colonies and the mother country, had made him familiarly known to his townsmen. Although he did not take any active part in the public meetings and deliberative assemblies, by whose discussions the friends of the people were prepared for a resort to arms, his sentiments were not concealed; and the reputation he had acquired pointed him out as one to whom the conduct of public affairs might safely be committed in a moment of emergency. His known worth and ability speedily led to his being called to occupy a prominent position. It is a truth which all experience seems to confirm, that, if in time of profound peace the management of republics is apt to fall into the hands of such as seek office only for

their own private advantage; in the hour of war and of danger, it is most usually intrusted to those who are most capable of directing the councils and leading the armies of the nation. Our own revolution is an obvious instance, which may be cited in support of this proposition.

Franklin had been elected a member of the Provincial Assembly of Pennsylvania for the year 1775. From this station he was speedily called to the General Congress. Rittenhouse was immediately chosen to fill the vacant seat. To be installed as the successor of such a man was no small proof of the confidence reposed in him This confidence he justified by the useful, if not prominent part, which he took in the deliberations of the body of which he thus became a member, at this eventful and important period.

The ancient government being speedily dissolved by the commencement of hostilities, Rittenhouse was chosen a member of the convention called for the purpose of framing a constitution; and when, by an ordinance of that convention, the provisional government was intrusted for a time to a Committee of Public Safety, composed of twenty-four members, Rittenhouse was included in that number. On the promulgation of the constitution, and the election of the officers and functionaries, who were to execute it, the powers of this committee ceased; but the public duties

of Rittenhouse did not terminate with the expiration of this important trust. The constitution had provided for the appointment of a State treasurer by the vote of the lower House of the legislature, and he was unanimously elected to this responsible and laborious office on the 14th of January, 1776. The appointment was for no more than a single year; but Rittenhouse continued to be annually reëlected, until he declined any longer to hold the office.

Philadelphia, which had been threatened by the British forces from Jersey at the close of the year 1776, was made the object of a powerful expedition, which proceeded up the Chesapeake, in the summer of 1777. The utmost efforts of the forces of the confederation did not suffice for the protection of the city, and it fell into the hands of the enemy in the month of September. In anticipation of the possibility of this event, the public offices were removed in haste to the borough of Lancaster, at which place the legislature was speedily convened. This body, considering the emergency of the case, and the necessity of prompt and energetic measures, not only to resist the invading enemy, but to repress the disaffected, determined to constitute again a Committee of Public Safety, to which powers the most absolute and extraordinary were given. It was authorized to proceed summarily, and even to inflict

capital punishment upon all persons "inimical to the common cause of liberty and the United States of America." This committee was composed of twelve members, of whom Rittenhouse was one. It is to be recorded to the honor of this committee, that, during a time of the most highly exasperated feeling against those who were considered as Tories, no exercise of these extraordinary powers appears to have occurred, and that no individual, however obnoxious, appears to have sustained injury, either in person or property. The duties of Rittenhouse as a member of the Committee of Public Safety, and still more as presiding over a treasury of the most scanty resources, and liable to the most urgent demands, were arduous in the extreme. The pressure of these duties was aggravated by a separation from his family, and anxiety for their safety. On the approach of the enemy to Philadelphia, he had sent them to Norriton; the duties of removing the treasury from that city prevented him from joining them and making them the partners of his further flight. Even to visit them from Lancaster would have been attended with danger; for, although Norriton was without the British lines, it was not sufficiently distant to place it beyond the reach of flying parties of the enemy, and a member of the Committee of Public Safety would have been no mean prize. On the other hand,

a woman and children could not venture to travel se a country exposed to the partisans of both armies

This painful separation continued for nine months, and the evacuation of Philadelphia was, in consequence, not less a subject of rejoicing to Rittenhouse as a patriot, than as a husband and a father.

During this period, too, he was exposed to anxiety from another cause. He had built his fame as a mechanic, and perhaps as an astronomer, upon his orrery. That at Princeton was reported to have been destroyed, and apprehensions seem to have been entertained, that the duplicate at Philadelphia might have suffered from the wantonness of a licentious soldiery. It was not until his return that this anxiety was removed. It was then found that the British commanders had respected this work of art, and had taken effectual measures for its safety. This liberal act redounds highly to the honor of Sir William Howe; and it is still more to his credit, that, after appreciating as he fully did the beauty and value of the instrument, the idea of treating it as a prize of war seems never to have occurred to him. Had he been governed by the principle, which has more recently directed the commanders of European armies, the orreries of Princeton and Philadelphia might at this time have decorated the halls of Oxford and

Cambridge, for both were at different times at his disposal.

Although the anxieties of Rittenhouse in respect to his wife and children were of short duration, the war was not without painful influence upon his domestic relations. His brother-in-law, the Reverend Mr. Barton, whom we have seen as the early friend, and the assistant of the studies, of Rittenhouse, was naturally led to take an opposite side in the dissensions of the times. A native of Great Britain, and a clergyman of the established church, it is not to be wondered at, if he saw the cause of quarrel in a very different light from that in which it was viewed by his relative. Although neither his sacred profession nor his prudence permitted him to take any active part in the struggle, he felt a scruple of conscience, which prevented him from taking an oath of allegiance. He, in consequence, could not escape becoming obnoxious to the new government. It appears, that he was subjected to inconvenience, and perhaps put under restraint; at any rate it became necessary for him to leave Pennsylvania, and he was compelled to make interest for permission to retire to New York, then in the possession of the British forces. Painful as this separation must have been, it did not put an end to the personal friendship of the two relatives, who seem to have each appreciated the pureness of the other's mo-

tives. The children of Barton, who were of an age to form opinions of their own, did not partake of their father's political sentiments; their protection, therefore, devolved upon Rittenhouse. He was also the means of procuring for Barton various indulgences required by his position as an exile, from the Supreme Executive Council of the State; and these, with other good offices, were continued, until they were rendered unnecessary by the death of Barton, which took place in New York in 1780.

The astronomical pursuits of Rittenhouse were not wholly abandoned, even during this period of labor, anxiety, and danger. He found time to observe a second transit of Mercury, which took place on the 2d of November, 1776, and an eclipse of the sun, on the 7th of January, 1777. In the first of these, he was associated with his friends Smith and Lukens, and in the second with the former of these two gentlemen. On the 24th of June, 1778, the same three observers, with Mr. Owen Biddle, were engaged in the observation of an eclipse of sun, and this within a week of the evacuation of Philadelphia by the British troops. In these observations, however, it appears by the record, that the laborious preliminaries were now performed by the other parties, and there is no trace of any calculation having been founded upon them. The relation of the

parties had in fact become the reverse of what it had been at the transit of Venus; thus showing how completely his other pursuits had diverted Rittenhouse from the cultivation of astronomy, although they had not been able to conquer his taste for that interesting science.

CHAPTER XII.

Boundary Lines of Pennsylvania and Virginia. — Division Line of Pennsylvania and New York. — Demarkation of Territory reserved by Massachusetts within the State of New York.

The pressure of a public enemy, and the obvious necessity of union in opposing him, were not sufficient to prevent internal disputes in respect to territorial jurisdiction, and property in land derived from conflicting authorities. The very rejection of allegiance to a common sovereign, by removing any authority paramount to that of the State governments, seemed to aggravate the controversies; and it was even to be feared, that, in addition to acts of individual violence, States of the confederation might be arrayed against each other in open hostilities.

Among the disputes, which thus assumed a threatening aspect, was that between the States of Pennsylvania and Virginia. The line of Mason and Dixon had not been extended by them beyond the western limits of Maryland; and here another parallel became the chartered boundary in a direction from east to west while the western

limit of the grant to Penn was a line parallel to the windings of the Delaware, and was even more vague than an unexplored parallel. A wide space of country was thus covered by two conflicting claims, and settlers, holding titles under both, had entered upon the disputed territory. It so happens that within this very space are included some of the most fertile lands in the Union; and thus the pioneers of cultivation, leaping at once over the wide extent of rugged cliffs and narrow valleys of the Appalachian group of mountains, had entered upon this inviting district at a comparatively early period. Those, who held titles from the proprietaries of Pennsylvania, seem to have been the first to attempt to subdue this part of the wilderness; but they were speedily followed by those, who claimed under the land warrants of Virginia. As no common jurisdiction was acknowledged by the two parties, ejectments were attempted, and possessions were maintained by force.

In order to bring these disputes to an amicable settlement, commissioners were mutually appointed by the two States in 1779. Rittenhouse was named first on the Pennsylvania commission, and with him were associated Professor Ewing and Mr. Bryan. On the part of Virginia were nominated the Reverend Dr. Madison and Professor Andrews. The commissioners, after a short session, agreed that the boundary between the two

States should thenceforth be, an extension of Mason and Dixon's line due west to the distance of five degrees of longitude from the river Delaware, and, from the termination of this line, a meridian drawn northward to the Ohio.

The uncertainty in which the determination of a degree of longitude is necessarily involved, particularly in the absence of any astronomical investigation, was however such, that great doubt existed, even after the conclusion of this convention, as to the place where the appointed limit existed; and thus, although the space was narrowed, the disputes and acts of aggression were not the less violent. Such was the warmth with which the contest was carried on, that a civil war was apprehended, and Congress conceived it necessary to interpose its paternal advice, in order to avert the calamity.

The joint commission was however still continued; and, it being understood that it was to proceed, with as little delay as possible, to determine the limits by astronomical observation, and to trace them upon the ground, the knowledge that strict and impartial justice would thus be finally obtained had an irresistible influence in averting the threatening evil. The discussion was not, however, finally adjusted until after the close of hostilities with Great Britain. Up to the final settlement, Rittenhouse was retained, by succes

sive appointments, in his office of commissioner In this capacity, he not only directed and partly executed the observations necessary to trace the parallel, to determine the difference of longitude, and mark out the meridian; but was compelled to enter into a variety of other questions. That the adjustment was at last made in an amicable manner, is in no small degree to be ascribed to his moderation, firmness, and acknowledged superiority in astronomical knowledge.

In this, and in all other subsequent operations of this sort in which Rittenhouse was engaged, either under the authority of his own State or that of others, he was constantly first named in the commissions, of which he in consequence became the chief. It was fortunate that the high public and political stations which he occupied entitled him at once to this preëminence, while his admitted excellence as an observer gave him on all occasions the undisputed direction of the methods calculated to produce the most authentic results. It is to this that we must ascribe, in no small degree, the ease and certainty with which many of our internal territorial disputes were settled, and the fact that no appeal has ever been made from the decisions of any commission of which he formed a part. A different policy has governed Great Britain and the United States in the adjustment of the boundary

between their respective territories; and thus it has happened, that points, which might have been settled by two intelligent astronomers in the course of a few hours, and lines whose actual delineation on the ground would have occupied but a few months, have been involved by the ingenuity of professional advocates in a mist of their own crea tion, and have from year to year appeared more and more remote from any satisfactory conclusion.

The settlement of the boundaries of Pennsylvania and Virginia was the most important of all the commissions on which Rittenhouse served. The line was completed in 1784. The other operations of the sort, in which he was engaged, were, the division line between the States of New York and Pennsylvania, defined by the forty-third parallel of latitude, in the astronomi cal determination of which he spent the summer of 1786; and the demarkation of a territory the right of soil in which the State of Massachusetts had accepted, in lieu of a contested claim both to the land and the jurisdiction of a large part of the State of New York.

The last-mentioned duty was assigned him by the Congress of the confederation. This body had found it necessary to interfere in order to prevent the dangerous consequences, which at one time appeared likely to flow from the dispute.

The original grant from the crown of England

under which the State of Massachusetts claimed, was limited only by the Pacific Ocean. The occupation of both banks of the Hudson river by a colony from Holland, and the conquest of this colony, had vested the settled parts of New York in the crown, by a right derived from conquest. At the close of the revolutionary war, the State of Massachusetts claimed, that this right could only be extended to the actual settlements, and that the whole of the territory west of them reverted to the holders of the prior grant. After much discussion, this State finally agreed to renounce all claim to the sovereignty, and to accept in lieu the property of a territory divided from the rest of the State of New York by a meridian line drawn northward from a point in the northern boundary of Pennsylvania, distant eighty-two miles from the Delaware river. Out of this, however, were to be left certain townships and other reservations.

The determinations necessary to set off this territory were made by Rittenhouse, and were the last operations of the kind in which he was engaged. They occupied him during a great part of the year 1787.

We have already adverted to the influence, which the fact, that many of the territorial divisions of the United States were geographical lines, capable of being determined by astronomical

methods, calling neither for legal discussion, nor admitting of a just resort to arms, had upon the early destinies of our confederated republic. We can now see the important bearing, which the possession of an astronomer, of such acknowledged talent as Rittenhouse, had in the pacific adjustment of these questions. This was the more important, as every commission, on which he served, began and terminated its labors before the confederation had derived strength from the adoption of a federal constitution, capable of enabling it to restrain those States, which might have thought it expedient to support their pretensions by arms.

CHAPTER XIII.

His Appointment as Trustee of the Loan-Office — Retirement from Office as State Treasurer. — Private Observatory. — Commissioner to organize a Bank of the United States. — Director of the Mint of the United States — Resignation of that Office.

During the performance of his duties as commissioner for running and determining astronomically the several boundary lines of which we have spoken, Rittenhouse continued to exercise the functions of treasurer of the State. In the year 1780, the office of trustee of the loan-office was also conferred upon him. To the former of these trusts he declined a reëlection in the year 1789, after having held it by unanimous annual elections for thirteen years. The causes, which he assigns in his letter of resignation, are ill health and the inadequacy of the emoluments to the labor and responsibility he incurred in the performance of the duties. During the time in which he held the office of treasurer, it was in truth one of difficulty and danger, and he was compelled to conduct it throughout in the face of a continually depreciating currency, which finally ceased to have any ex-

changeable value. During a part of the time his emoluments, which were received in the form of a commission, did not admit of his employing a clerk, and he was indebted to the aid of his wife for the performance of such of his duties as required an amanuensis.

In addition to the duties of his office of treasurer, and his temporary appointments as commissioner of boundaries, he was placed by the legislature of Pennsylvania on several boards formed for the purpose of projecting internal improvements; and he received appointments of a similar character after he had left the treasury. The circumstances of the times were, however, little favorable to the execution of such contemplated works; and even the plans which became a matter of discussion were contracted, in consequence of the general poverty of the community. The time had not arrived when the gigantic mind of Clinton saw, in well-chosen plans of internal communication, the sure means of defraying their cost, and when the success of the New York canals demonstrated that a debt, incurred for such purposes, could never be more than a temporary burden.

His trust in the loan-office terminated in 1790 by a law, which merged that establishment in the general treasury of the State, from which he had retired, as we have stated, during the previous

year. He had, as has been mentioned before, been named in a bill introduced into the legislature of the province, at an early period of his life for a similar trust; but this bill did not then become a law, nor was a loan-office reëstablished until after the declaration of independence. The object of such offices was to supply the deficiency of a circulating medium, by granting loans to the owners of real estate, upon the security of their property, in paper money.

These bills of credit were not payable on demand, but redeemable by the payment of instalments upon the loans, and by the appropriation of the annual interest. Founded thus upon a security not readily accessible, it was a nice question, requiring the utmost skill and prudence to adjust, what amount might be safely thrown into circulation, without a risk of depreciation in the currency itself. Such depreciation did take place in many of the provinces; and it is to the varying rate of this depreciation, that we are to ascribe the original difference in the value of currencies bearing the same denominations in all the different provinces. In after times a specie currency circulated along with the bills of credit; and thus, while the paper might vary in value, no further change took place in the legal tender. The loan-office system not only required caution in the legislature to prevent its depreciation, but

a great degree of knowledge, firmness, and moderation in its trustees; as to them was committed the task of judging of the securities offered for the loans, of calling in the several instalments, and collecting the interest; while, on the other hand, they were required, in the exercise of sound discretion, to give extensions of time, when necessary to prevent the ruin of the mortgager, or the unnecessary sacrifice of his property.

Under the administration of Rittenhouse, the State of Pennsylvania issued a large amount of bills of credit, in addition to those already in circulation; but, such was the prudence with which the loans were made, and such the indulgent firmness with which the payments were enforced, that no loss accrued to the State, nor was there any failure in their regular redemption. In fact, when the loan-office system was put an end to by a clause in the constitution of the United States, that of Pennsylvania may probably be cited as that, which had been best administered, and had, without any loss to the holders, been productive of the greatest benefit to the community. This example, however favorable in its results, is not to be quoted as justifying a mode of creating a currency, which is so liable to abuse.

It appears as if Rittenhouse, in retiring from the office of treasurer, had determined to resume, with more regularity and attention than he had at any

period of his life been able to devote to it, the study of his favorite science of astronomy. For this purpose he had erected an observatory on the lot in Philadelphia, on which he also built a house for his own residence. Various circumstances and engagements, however, prevented his entering into any connected series of observations, nor was he ever able to carry his intention fully into effect. In truth, no sooner had he detached himself from the public business of the State of Pennsylvania, than he was called into the service of the general government.

Although he did not enter into such a regular course of observations as may be necessary to extend the bounds of science, he notwithstanding noted every phenomenon of interest which presented itself. Of these observations, some of the records have been published. These are, the transit of Mercury in 1789, two lunar eclipses in 1789 and 1790, and the two solar eclipses of the 8th of November, 1790, and the 3d of April, 1791. These observations are referred to by Lalande, in his great work on astronomy, and he quotes the private observatory of Rittenhouse, as the only one on the continent of America where any observations of value had been made.

The first appointment, which he held under the federal constitution, was that of commissioner for receiving subscriptions to the Bank of the United

States; and, when the law establishing a national mint was passed, he had the high honor to be named by Washington as its first director. In this capacity he found himself engaged in a most arduous task. Not only were the machinery and other fixtures to be constructed, in a country where the little of mechanical skill which had once existed had expired under the pressure of a long and devastating war; but the very persons, who were to be intrusted with the most important parts of the process, were to be formed under his auspices.

With such difficulties in his way, it is sufficient for the reputation of Rittenhouse to say, that the mint of his construction continued to be adequate, without any radical change, to all the wants of the country, until a very recent period. It would be unfair to institute a comparison between it and the establishments of the same description, which have been erected or remodelled within the present century. But, if we judge it in reference to the state of the art as it existed in 1792, the mint of the United States might rank before any other in the perfection of its workmanship, and the accuracy of its processes. The beautiful coinage which will perpetuate the name of the Emperor Napoleon as surely as his victories, and the splendid specimens of art which appeared when the bank of England resumed specie pay-

ments, had not yet been struck, nor had Bolton applied the engine of his partner to improve and facilitate the processes of the mint.

The duties thus imposed on Rittenhouse were performed with his accustomed industry and energy. Even after the organization was complete, and every part in full operation, he pursued all the processes, and superintended all the details with unremitting assiduity. So long as his health permitted, he was daily at his post, although personal attendance was no longer absolutely necessary; and, when prevented from paying his accustomed visit, he organized a system of written reports, by which every part of the work was fully exhibited to him.

Such close and unremitting attention were unfavorable to his health. The organic disease, which had been induced in his youth by excessive attention to his mechanical and scientific pursuits, but which had been resisted by a constitution, naturally vigorous and strengthened by agricultural labors, began at length to gain upon him. He in consequence resolved to retire from this laborious office, and resigned the direction of the mint in June, 1795, after having organized and brought it into successful operation.

It appears more than probable, that, considering the depressed state of the arts in the United States at this period, had not Rittenhouse pre

Philadelphia Decr 26th 1795

—I flatter myself he will be successful in his intended application to the hon.ble Board of Trustees, but I am certain this will much depend on Your Interest.

I am, Dear Sir, with the sincerest affection and esteem, your most obed.t Servant.

Dav. Rittenhouse

sented himself, possessing the united talents of a skilful mechanic, and a learned natural philosopher, the nation must have been compelled to resort to Europe for a person qualified to erect and set in motion this important institution

CHAPTER XIV.

He is elected President of the Democratic Society — Declining Health. — Death. — Character. — Literary and Scientific Honors. — Conclusion.

RITTENHOUSE lived long enough to witness the commencement of the long struggle, which divided the people of the United States into two opposing political parties. This contest began during the administration of Washington, and terminated only with the war against Great Britain. Of these two parties, the one was accused of cherishing aristocratic sentiments; the other claimed to be exclusively the friends of popular rights. It would be a needless revival of animosities, which have long since been buried, to examine into the truth of this accusation, or the justice of such an exclu sive claim. Suffice it to say, that the latter of the two parties sought to increase its strength by the organization of associations under the name of *Democratic Societies*, throughout the Union.

Rittenhouse was too important a personage, both in character and station, to escape being involved in this discussion, at least in name. The Democratic Society of Philadelphia, as soon as it

was formed, elected him its president. In the embittered contest which followed, these societies were accused, by their opponents, of the design of subverting all government, and of desiring to imitate the worst excesses of the French Jacobins, thus retorting the accusation of an attempt to establish an aristocracy, and even of favoring a monarchy.

Rittenhouse did not escape being included in the accusation, with the additional charge of entering into opposition to an administration, under which he held a situation of trust and emolument. The best defence which has been made for him is limited to the statement, that his office of president was merely nominal; that he rarely attended the meetings of the Society, and that the state of his health prevented him from being aware of its tendency. To do away such excuse, he has been charged with having permitted himself to be made the tool of designing politicians. At the present day, no such defence is necessary; the principles, which the Democratic Society was formed to promulgate, have become the acknowledged rules of both the general and State governments; and, if Rittenhouse be liable to any reproach, it may be couched in terms derived from his own trade; his timepiece only went a little faster than those of his neighbors. So much of the accusation, as relates to his having arrayed himself in opposition to the

administration of Washington, is answered by the fact, that his resignation of office under it was accepted with extreme reluctance.

It is however due to historical truth to state, that Rittenhouse did not take any active part in the operations of this Society, although he often appeared before the public as their presiding officer. He in fact continued to decline in health from the time of his resignation of the office of director of the mint, which he survived little more than a year. Rittenhouse had not only been warned by his infirmities to retire from public life, but was aware of the gradual decay of his constitution. He was sensible of the close approach of death, and prepared to meet it with philosophic firmness and Christian resignation. Although he had never united himself to any of the various sects which abound in our country, his early education had imbued him with reverence for the Christian doctrine, and his subsequent studies had impressed on his mind a conviction of the existence of a Deity. Although accused by his enemies of infidelity, he was far from being such, and sought, on the approach of his mortal disease, the consolations of religion, while his mind retained all its wonted vigor. His death took place on the 26th of June, 1796, in the sixty-fifth year of his age.

The person of Rittenhouse is described as tall

and slender, his temper as placid and good humored, although capable of strong excitement. In the capacity of a husband and a father he was exemplary, and his social virtues insured him general esteem.

It is not necessary that we should state that he was industrious and energetic in the pursuit of his mechanical business, in his scientific studies, and in the execution of the various public trusts he was called to fulfil. The sketch we have given of the principal events of his life is a sufficient evidence of these points of his character.

His published works are principally contained in the "Transactions of the American Philosophical Society," in which they occupy a prominent part. They consist chiefly of the records and calculations of the astronomical observations which we have particularized, and of papers on other subjects in physical science. We have also an oration on astronomy, delivered by him before the same learned body in 1775, and several short pieces relating to subjects of temporary interest.

Although denied in youth the advantages of a collegiate education, his reputation earned for him honorary degrees, not only from the University of Pennsylvania, but from other literary institutions in the United States. Of the University of Pennsylvania he was long a useful and active trustee, and held for a time the appointment of

professor of astronomy. He was also chosen an honorary member of the only learned association, other than the American Philosophical Society, which had been formed in the United States previous to his decease. Of the American Philosophical Society, he was in succession an active and distinguished member, secretary, vice president, and president. In the last office he succeeded Franklin, and was followed by Jefferson. More than one foreign society of the highest reputation solicited the honor of enrolling him as an associate; and towards the close of his life he received the highest mark of distinction, which the scientific world at that time acknowledged, in being chosen a foreign member of the Royal Society of London.

In order that the value of this compliment may be fully appreciated, it may be necessary to explain, that, as the Royal Society derives no direct endowment from the government, it is principally supported by the pecuniary contributions of its fellows. Among them we therefore find not only names of distinction in science, and of those who take an active part in its transactions, but of those who are qualified only by birth, station, or fortune, united to a desire to promote the interests of learning. For the same reason, this Society does not refuse to enroll among its ordinary fellows, foreigners of fair scientific reputation, who, like

the subjects of Great Britain, are required to contribute to its funds. In this capacity, a considerable number of Americans have been chosen fellows. To be permitted to use this title, and have at the same time the privilege of increasing the funds by which the publications of the society are effected, is no small honor; as such, it is eagerly sought, and highly valued. But, when the Royal Society chooses to elect a foreign member, this choice imports, that it has sought to confer honor upon itself by placing on its list, without receiving any pecuniary equivalent, a name already distinguished, and likely to be celebrated in the history of science. Such was the reputation of the Royal Society at the time this honor was conferred upon Rittenhouse, that it was the proudest distinction which a man of science could attain, and would have been the fit reward of a life spent in the pursuit of physical learning.

We have thus traced the subject of our memoir from his birth in an obscure part of a newly reclaimed wilderness, under circumstances which denied him many of the usual advantages of education, until, by the force of industry, talents, and genius, he had reached the acme of scientific honor. Our task is therefore concluded, and will have been successfully performed, if it shall only recall to his countrymen the memory of a name, which engrossing pursuits of a very different character

from those in which its celebrity was acquired, have caused them in some measure to forget, or to regard with no due reverence; and if we shal. have been able to assert for him the right of priority in scientific discoveries and researches, of which others have reaped the honors.

LIFE

OF

ROBERT FULTON

BY

JAMES RENWICK

ROBERT FULTON.

CHAPTER I.

Introduction.

The gratitude of mankind has not failed to record with honor the names of those, who have been the inventors of useful improvements in the arts. However quiet and unassuming they may have been in their lives; however strong the influence of prejudice, or interested opposition, in robbing them of all direct benefit from their discoveries; posterity has never failed to reverse the judgment of their contemporaries, and award the deserved, although perhaps tardy, meed of praise.

In the early history of our race we find, that such acknowledgments for important discoveries did not stop short of the attribution of divine honors to the shades of the illustrious benefactors, who had advanced the progress of civilization, or increased the comforts and the conven

iences of social life. Although veiled by the mist of unnumbered ages, and shrouded in the obscurities of fabulous narration, the records of authentic history disclose to us the time, when the inventors of letters and the plough were revered as divinities; and such honors did not cease to be rendered, until the influence of revealed religion put an end to all idolatrous worship among civilized nations. If there can ever be an excuse, in the absence of the divine light, by which alone the path of true piety can be directed, for ascribing to the creature honors due to the Creator alone, that idolatry is the least worthy of blame, which canonizes those who have proved themselves benefactors of our race.

In remote times, when the means of improving the faculties of the mind, which are now familiar to us, were wanting, to invent was the attribute of superior and lofty genius alone. As society made progress, and the means of education were extended, minds of a more ordinary character might be made to grasp some particular subject, to detect the deficiences of existing processes, and study the means of improving them. Hence even inventions acknowledged to be original, and attended with the most happy consequences, no longer raise the author to such preëminence among his fellow men, or entitle him to so large a portion of posthumous renown.

At the present day, the stock of mechanical and practical knowledge, handed down by tradition, or preserved by means of the press, has become so enormous, that the most brilliant discovery in the useful arts bears but a small proportion to the whole extent of human knowledge. In remote times, the aids, which modern inventors derive from the records of the reasonings, the combinations, and even the abortive attempts of others, were wholly wanting; and, if no one of the inventions of antiquity, when taken by itself, can rank in apparent importance with some of modern date, the former were in many instances far more conspicuous as steps in the progress of human improvement. In many cases, too, they must have produced an almost magical effect upon the comforts, the happiness, and even on the means of sustaining the lives, of men at the time.

While the rights of property, even of a material character, were imperfectly understood, and those of an immaterial nature unknown, he, who by his inventions had made himself a benefactor of his species, sought no other reward than public consideration and popular applause. Thus it may, and no doubt did, often happen, that the early improvers of the arts derived not only present reputation, but power and influence from their discoveries, as surely as they became entitled to the gratitude of posterity. The wants

which grow upon man at each step towards high civilization, were not yet made manifest; and it was neither necessary to keep processes in the arts secret, lest others should anticipate the due reward of their discovery, nor to seek the protection of laws for the security of an exclusive use to the inventor. Those who reaped the benefit of a new art, or enjoyed the advantages of an important discovery, were not called upon to pay in money for the use of them; and thus reaped all these benefits and advantages, without being compelled to furnish an equivalent. Honor, praise, and posthumous fame are of no cost to those who award them, and are, therefore, willingly allowed; while pecuniary compensation is often dispensed with a niggard hand, and the demand of it creates anger, or arouses opposition.

In the dawn of civilization, inventions were usually unexpected, and, although often calculated to supply the most pressing wants, excited surprise, because the wants themselves had not been perceived. At the present day, discoveries often appear as the almost inevitable result of previous improvements. Several projectors are ofttimes in pursuit of the same object, and this, one which the admitted wants of society point out as important to be attained; and he, who finally achieves success, is exposed to the envy,

the competition, and the detraction of his less fortunate rivals. Inventions often derive their highest merit from their peculiar adaptation to the circumstances of the times; the very method, which comes at a given instant into immediate and successful operation, may have floated in the minds of earlier inquirers, or even have assumed the form of a working model; and yet, for the want of some collateral improvement, or through the absence of public demand, may have fallen into neglect, and been wholly forgotten. But, no sooner has the successful step in invention been taken, and at a fitting time, than all forgotten, neglected, or abortive attempts at the same great end, are raked from the oblivion to which they had been consigned, and blazoned to the world as the types or originals of the improvement.

In addition to the annoyance and opposition, which may thus arise from rivals and detractors, inventors are subjected to inconvenience from the policy of the legislative provisions by which it is attempted to secure their due reward. In most countries, this is made to assume the odious form of a monopoly; and the public feeling is thus speedily enlisted in opposition to the chartered or patented privileges. An expensive lawsuit, determined resistance, or cunning evasion, is often the sole reward, with which the most

important inventions are attended during the life time of their authors.

The highest degree of merit is to be awarded, in the present age, to those, who, aware of the wants of a community, or of the world at large, set to themselves as a task, the discovery of the means of supplying these wants. In such pursuits, great learning and research must be united to high mechanical skill. All the attempts which have been previously made to attain the same object must be carefully studied; the causes of their failure inquired into; and whatever may exist in them of good and applicable, separated and recombined. Such inquiries often demand the united exertion of high ingenuity and profound science; yet those, who pursue them, taking for the foundation of their researches the discoveries and ineffectual attempts of others, often appear to be wholly wanting in ingenuity.

When, however, we examine to whom we are actually indebted for the practical benefits we enjoy, no possible comparison can exist between the merits of those who have thrown out the original, crude, and, in their hands. impracticable ideas, and those who, by a happy union of mechanical skill and scientific knowledge, have brought the plans to a successful application. Yet to this most valuable class of improvers of the arts it is difficult, if not impossible, to as-

sign, by legal enactment, any adequate remuneration. There are few instances in which they have not been deprived of their just meed of recompense, if they have attempted to secure it by patent. The shades, which separate the incomplete and abortive attempt from the finished and successful invention, are often almost insensible, and admit of no technical specification. A remedy has at last been found for this defect. The calling of the civil engineer has taken its just station, in point of honor and emolument, among the learned professions; and it has become almost disreputable for its members to attempt to appropriate their mental riches by patent rights. They in return reap no inadequate reward in the direct emoluments to which their advice and services are now considered as entitling them.

In the days of the subject of our memoir, this profession was hardly known by name among us; its value was not understood by the community; and the proper means of rewarding it unknown. It was, therefore, his misfortune, that he sought, although ineffectually, to secure by exclusive legislative grants, and the monopoly held out by the patent laws, that reward which in a more happy state of things would have been attained in a more efficient and less obnoxious manner.

If we consider Fulton as an inventor, it may

be difficult to say, in what exact particular his merits consist. As the blow of the mallet, by which the mighty mass of a ship of the line is caused to start upon its ways, in the act of launching, is undistinguishable among the numerous strokes by which that mass is gradually raised, so the minute particulars, in which his labors differ from former abortive attempts, may almost escape research. But, if we contemplate him in the light of a civil engineer, confidently building a finished and solid structure upon the incomplete foundation left by others, we must rank him among the first of his age, and place him, in the extent of his usefulness to mankind as second to Watt alone.

CHAPTER II.

Birth of Fulton. — He chooses the Profession of a Painter. — His early Taste for Mechanics. — He settles in Philadelphia. — Embarks for England. — Resides in the Family of West. — Removes to Devonshire.

Robert Fulton was born at Little Britain, in Lancaster County, Pennsylvania, in the year 1765. His parents were respectable, although far from affluent; his father a native of Ireland, his mother descended from an Irish family. From his name it appears probable, that his more remote ancestors were of Scottish origin, which is in some degree confirmed by their profession of the Presbyterian faith. Fulton himself attached no importance to circumstances of birth, and took pride in being the maker of his own fortune the probable founder of a family. Indeed, except so far as an elementary education is concerned, he was under little obligation to his progenitors; being left without patrimony at the death of his father, which occurred when he was but three years old.

Aware that he was to trust entirely to his own exertions, even for the means of subsist-

ence, he cultivated from an early age a taste for drawing, in the hope of qualifying himself for the profession of a painter. To these exertions he was probably stimulated by the reputation and honors acquired by West, who, with advantages of education and connexion little superior to his own, had raised himself to the first rank, not only among the painters of England, but of the civilized world.

From a familiar acquaintance with his performances as an artist, at a later date, when he applied to the easel merely as a relaxation, it may be stated, that there is little doubt, that, had he devoted himself to the profession of painting, he must have become highly distinguished as a professor of that art.

Painting, although chosen by him as a profession, had less charms for him than the pursuits of practical mechanics; and it is recorded of him, that, while yet a mere child, he spent hours, usually devoted at that age to play, in the workshops of the mechanics of Lancaster.

At the early age of seventeen he proceeded to Philadelphia, for the purpose of practising as a painter of portraits and landscapes, and was so successful, as not merely to support himself, but to lay up a small amount of money. His first savings were devoted to the comfort of his widowed mother; and, before he reached the age

of twenty-one, he had, by the joint aid of strict economy and persevering labor, acquired sufficient funds to purchase a small farm in Washington County, Pennsylvania.

The journey to that region, for the purpose of establishing his mother upon this purchase, opened new views to him for the occupation of his future life. His patrons in Philadelphia had been among the humbler classes; and, although he must have sighed for an opportunity of visiting those regions in which alone good models of taste, and specimens of excellence in painting, were then to be found, yet, friendless and alone, he could hardly have hoped that such aspirations would be realized.

On his return, however, from Washington County, in the unrestrained intercourse of a watering-place, he found acquaintances, who were both able to appreciate his promise as an artist, and to facilitate his plans of improving himself as a painter. By these he was advised to proceed immediately to England, and throw himself upon the protection of West; and the means of favorable introduction to that distinguished artist were tendered and supplied. It is to be recorded to the honor of West, that he was the zealous and efficient promoter of the interests of all his countrymen, who desired to study the art in which he himself excelled.

To Fulton even more than usual liberality was vouchsafed; he was at once invited to become an inmate of the house of the great artist, and remained his guest and pupil for several years.

The wealth and taste of the British nobility have gradually accumulated in that island many of the finest specimens of the pictorial art. Although many of these are now assembled in collections at their residences in the metropolis, a still greater number are distributed through the numerous and magnificent baronial residences, with which the agricultural regions of England abound. At the period of which we speak, the formation of collections in London had hardly been thought of; and he who wished to profit by the treasures which the superiority of British wealth had drawn from the continent, or which munificent patronage had commanded from the artists themselves, was compelled to perambulate the kingdom.

In order to avail himself of these scattered riches, Fulton, on leaving the family of West, procured introductions to the stewards and agents to whom the care of their estates and collections are committed by the nobility, and commenced a tour. We find him, in consequence, a short time after he left London, at Exeter, in the County of Devon. He was for a time domiciliated, as we have been informed at Pow-

derham Castle, the chief seat of the Courtenays. This family draws its proud lineage from the Merovingian kings, the emperors of Constantinople, and the Plantagenets. In wedding an heiress of the family, a Capet assumed the name as more distinguished than his own; and the pretensions of the English branch to the throne of that kingdom, roused the vengeful jealousy of the Tudors. The fatal consequences of such lofty claims had confined the ambition of the succeeding possessors of Powderham to the cultivation of the arts, and the castle became filled with masterpieces.

Fulton seems to have entitled himself to the patronage of the possessor of the title. He at any rate was for a time an inmate of this magnificent baronial residence, and was occupied in copying the pictures it contains. Affecting on their own domains a state little less than that of royalty, the barons of Powderham left the entertainment of guests undistinguished by rank to their steward, himself a gentleman by connexion and education. It is, therefore, no derogation to Fulton, however repugnant it may be to our notions of equality, that, in enjoying the advantages which this rich collection afforded him as an artist, he was the associate, not of the lord of the mansion, but of one whom we may consider as his upper servant. Envy has not failed to point at this period of Ful-

ton's life as a matter of reproach, and to treat him as having been at this time the companion of menials, if not actually so himself.

Whatever may have been the nature of Fulton's obligations to this noble family, he did not hesitate to express his gratitude for them, and, in the height of his subsequent reputation, he had an opportunity of repaying them. The heir of the title and the fortunes of the Courtenays became a refugee in our land, under circumstances of disgrace and humiliation, even more terrible than those which led to the assumption of the mournful motto of his race.* Suspected and accused of an infamous crime, his birth and title, which have in many other instances served as passports even for vice and frivolity to American hospitality, did not avail him, and every door was closed against him except that of Fulton. The feelings of Fulton were probably those, which lead the benevolen to minister to the comforts, and to soothe the mental anguish of the last hours of the condemned criminal; but, in the instance we allude to, it required not only the existence of such feelings, but a high degree of courage, to exercise them, in the face of a popular impression, which, whether well or ill founded, was universally entertained.

---

* Ubi lapsus, quid feci?

CHAPTER III.

His Acquaintance with the Duke of Bridgewater and Earl Stanhope. — His Removal from Devonshire, and Residence in Birmingham. — He abandons Painting for the Profession of an Engineer. — His first Idea of a Steamboat communicated to Stanhope. — He makes the Acquaintance of Watt.

FULTON remained for two years in the neighborhood of Exeter, where his intelligence and ability obtained for him many useful and interesting acquaintances. Among these, the most important were the Duke of Bridgewater and Earl Stanhope. The first of these noblemen fills a large space in the history of the internal improvements of Great Britain; and he was in fact the father of the vast system of inland navigation, which has spread its ramifications over every accessible part of that island. Born to the inheritance of an extensive estate, abounding in mineral wealth, he was, notwithstanding, comparatively poor, because that estate was unimproved; and his mines were useless, because inaccessible.

At that moment, no better mode of supplying the growing town of Manchester with coal had

been introduced, than to convey it in sacks upon pack-horses. The Duke of Bridgewater was not slow to perceive the vast advantages which might be derived from the introduction of a better and cheaper mode of carriage. English writers have not hesitated to ascribe the plans of canal navigation, which he adopted and carried into successful operation, to the unassisted native genius of his engineer, Brindley. Yet it cannot be believed that the Duke was wholly ignorant of the celebrated canal of Languedoc, in which the structure of canals and all their accessory works had attained, in the hands of Riquet, the projector, and by the improvements of Vauban, a degree of perfection, which has hardly been surpassed even at the present day. It is not within the limits of our subject to inquire, whence the ideas, which directed the Duke's operations, were derived. Suffice it to say, that, after a series of appalling difficulties, after having been brought to the verge of ruin, and after having narrowly escaped being confined as a lunatic, he succeeded in his enterprise.

At the moment that Fulton made his acquaintance, the Duke was in the full enjoyment of the vast wealth, which his success had created, a wealth at that time unexampled in annual amount, even in Great Britain; and of the high reputation, which, so often denied to talent and genius,

while struggling with difficulties, is liberally as cribed to successful projectors. His canals be came the models for similar enterprises, and himself, from his rapid accumulation of capital, the largest proprietor of many new navigation companies. It appears to have been at the instance of this distinguished man, that Fulton abandoned painting as a profession, and entered into that of a civil engineer. We at any rate next find him residing in Birmingham, and engaged in the construction of the canals then making in that vicinity, by which that great toy-shop was brought into communication with the ports of London, Liverpool, and Bristol. Fulton's name does not, however, figure upon the list of the principal engineers engaged in these important works; and he, no doubt, filled no more than a subordinate station, as might, indeed, have been anticipated, from his inexperi ence and youth.

With Earl Stanhope, Fulton's intercourse was still more intimate, and probably of an earlier date This nobleman was endowed by nature with high mechanical talent, which nad been improved by an education very different from the mere classical routine to which the youth of the higher classes in Great Britain are usually confined. Had he been impelled by th stimulus of necessity, there is little doubt, that he

might have become distinguished as a successful inventor. As it was, he exhibited practical skill as a canal engineer; but here his reputation faded before the prior claims of the Duke of Bridgewater; while his inventions remained incomplete, and few of them have been carried into effect.

Among other projects, this peer entertained the hope of being able to apply the steam engine to navigation, by the aid of a peculiar apparatus, modelled after the foot of an aquatic fowl. On communicating this plan to Fulton, the latter saw reason to doubt its feasibility; and, in consequence, addressed a letter to his Lordship, in which the very views were suggested, that were afterwards successful upon the Hudson. This letter was written in 1793, immediately before the removal of Fulton from Devonshire to Birmingham. The justice of Fulton's objections to the plans of Earl Stanhope was afterwards demonstrated in an ineffectual experiment made by the latter in the London docks. It is to be regretted, that this experiment had not been made before he received the communication of Fulton. His Lordship might then have received it with the same feelings, which Chancellor Livingston afterwards exhibited, when marked failure had attended his own plans. In this event, the important invention of a successful steamboat might have been given to the world

ten years earlier than its actual introduction Although prejudiced in favor of his own invention, Earl Stanhope did not fail to appreciate the ingenuity of Fulton, and became his warm friend on a subsequent occasion, when his influence with the British ministry enabled him to aid Fulton's views.

Fulton's residence in Birmingham brought him into communication with Watt, who had just succeeded in giving to his steam engine that perfect form, which fits it for universal application as a prime mover. That Fulton became intimately acquainted, not only with Watt himself, but with the structure of his engine, we learn from two facts in his subsequent life; for we find him entering into a confidential correspondence with that great improver of the application of steam, and actually superintending the construction of an engine, in a place where no aid was to be obtained.

To have become favorably known to such men as Bridgewater, Stanhope, and Watt, and to have received the patronage of the first of them, is no small proof of the talent and acquirements of Fulton at an early age. Those, who know the artificial structure of British society, understand the nice distinctions by which the several degrees of rank are separated from each other; and, although it is no doubt true, that those

who are possessed of the highest rank are not deterred from associating with any persons in whom they may take an interest, by the fear of losing caste, which has so powerful an influence upon those whose position in society is not firmly established, still the higher circles are fenced in by artificial barriers, which, in the case of an unfriended and humble foreigner, can be forced only by obvious merit. When, therefore, the detractors of Fulton's fame venture to characterize his productions as wanting in originality, "either of matter or manner," we may confidently appeal to this part of his early history for the refutation of their aspersions

CHAPTER IV.

His Plan of an Inclined Plane. — Work on Inland Navigation. — His Torpedo. — His Removal to France, and Residence there.

THE residence of Fulton in Birmingham is distinguished from the other parts of his early history by a number of patented inventions and several published works. The more level parts of Great Britain had now been rendered accessible by canals, and some projects were entertained for penetrating by the mode of artificial navigation into the mountainous regions.

In the primitive form of canals, of which a specimen still exists in the great canal of China, two methods of passing from one level to another had been practised, — the sluice and the inclined plane. An addition, probably growing out of an accidental circumstance, had converted the former into a lock; but the inclined plane had remained without improvement. It is, however, obvious, that, could it be rendered self-acting, as the lock is, it was susceptible of far more extended application. The lock is necessarily limited to small changes of level, while the inclined plane will adapt itself to every possible

variation in the surface of the ground. If, then, locks be taken as the basis of a plan of inland navigation, it will necessarily be confined to countries of little elevation; while one based upon the inclined plane may overcome consid erable elevations.

Impressed with the advantages which would attend the introduction of the inclined plane in inland navigation, Fulton applied his fertile ingenuity to plan one. For this he took out a patent, in the year 1793, and in 1796 embodied it with other projects of a similar nature in a work on Inland Navigation. At the time when he wrote, the engineers of England were engaged in reducing their canals to the smallest practicable dimensions; for it had been ascertained, that the capacity for business of the large canals far exceeded any trade, which had yet made its appearance upon them. The object of Fulton's work appears to have been to show, that canals, of dimensions below the smallest which had yet been proposed, were capable of being successfully applied, and that such canals were not necessarily limited to countries of small differences of level. Considered in reference to this object, the work is a masterly one; but, if we test it by inquiring, whether canals of such small dimensions are adapted to general purposes, we shall find, that his argument rests upon an in-

sufficient foundation. This work is, therefore, to be quoted as exhibiting a high degree of originality, ingenuity, and talent, but as inapplicable to any useful purpose.

The war of the French revolution had broken out a short time before Fulton's removal to Birmingham. In him, as a native of a republican country, and deriving his earliest impressions from the events of the struggle between America and the mother country, there is little doubt that the cause of the French democracy must have excited a powerful sympathy. Such sympathy was felt not only by a majority of the American people, but by a large portion of the population of Great Britain. The crimes and excesses, with which that revolution was stained, speedily excited the indignation of Britons; and Pitt was enabled to apply that indignant feeling to the support of the war in which the two rival nations were speedily engaged.

It is probable that a similar revulsion of feeling took place in the breast of Fulton. But, in the year 1796, the excesses of the French revolution had ceased, while, at the same moment, a system of aggression and insolent exertion of her power upon the ocean, had been manifested by Great Britain. By this system, the United States were the greatest sufferers. Our flag afforded but little protection for prop-

erty, and none for personal liberty, against the license of British naval commanders. Fulton shared deeply in the resentment which this conduct excited in every American breast; a resentment which finally led to the war of 1812. The power of Great Britain resting to so great an extent upon her naval supremacy, the thoughts of Fulton were turned to the discovery of a method, by which the boasted skill of her seamen might be set at nought, and her numerous vessels rendered inefficient in maintaining her maritime superiority. Fulton was old enough to have heard of the abortive attempt of Bushnell upon the British fleet in the harbor of Philadelphia; and, although this had failed, from being planned upon erroneous principles, enough of alarm had been excited, and such a degree of confusion caused, as to encourage him to attempt to improve upon it. It was obvious, that no encouragement was to be hoped from the government of Great Britain towards experiments upon a mode of warfare whose success would destroy her principal arm; nor could Fulton with any propriety have asked aid from it. It was otherwise with France. The insolence, with which she also invaded the rights of neutrals, had not yet been clearly manifested; and Fulton, with many others, saw in her Directory the champions of the liberty of the seas. As such, he

felt justified in offering the fruits of his ingenuity to that government. Abandoning, therefore, his pursuits as a civil engineer, he proceeded to Paris, for the purpose of completing the detail of his plan, and of seeking assistance to bring it to the test of experiment.

To his instrument for destroying vessels of war, he gave the name of the *Torpedo*. It consisted of an oval copper case, charged with gun powder. To this he proposed to attach a lock, regulated by clock-work, which, after any required time, might cause the lock to spring, and thus communicate fire to the charge.

It would be painful to follow Fulton through that period of life in which he appeared under the character of a projector, soliciting the patronage, first of the government of France, and subsequently, when he had been dismissed with contumely by Napoleon, from that of England. Without venturing to give an opinion on the influence that his Torpedo might have had upon warfare, it may be safely stated, that, in the hands of bold and determined men, it might be applied in a position where it would certainly act, and in acting insure the destruction of the stoutest vessel. As he himself well argues, "its use is attended with risks as great, but not exceeding those to which the crew of a fire-ship are exposed; and there are innumerable instances where

these dangers have been boldly confronted." His plan has the advantage over the fire-ship of being less expensive; but, like that, is attended with such uncertainty, that it cannot be surely relied upon, and thus cannot be trusted to as the only means of offence.

His subsequent attempts to bring the Torpedo into use, during the war with Great Britain, and for the defence of his native country, although entertained with greater courtesy, were equally fruitless; and, in the opposition of our own naval officers, he met with obstacles as great, as had stood in his way in the *bureaux* of France, and the public offices in England. It must, therefore, be admitted, that we cannot cite this invention as one which has been brought into successful action. Still, if the fears of an enemy may be received in proof of the value of the Torpedo, it would be easy to cite the sleepless nights and anxious days of many British commanders, who felt, that the vicinity of Fulton's operations was attended with dangers which could only be prevented by unremitting diligence and attention.

CHAPTER V.

His Inventions while residing in Birmingham. — His Letters to Washington, and the Governor of Pennsylvania. — His Submarine Vessel. — Experiment with it at the Mouth of the Seine. — He aids in introducing the Panorama into France.

Before we proceed to the history of the more important of the subjects, which attracted the attention of Fulton, and of which his residence in France was the epoch, we have to mention some other fruits of his ingenuity. While residing in Birmingham, he took out patents for a mill for sawing marble; a method of spinning flax and making ropes; and of excavators for digging canals. If none of these was introduced into extensive use at the time, and if the latter object still remains a desideratum in practical mechanics, the two former at least served as steps in the career of improvement, and have been guides and landmarks to subsequent inventors. These patents bear date in 1794.

Anxious that his views in respect to small canals might be productive of benefit to his native country, a copy of his work on Inland Navi

gation was transmitted to General Washington, who still held the reins of the government of the United States. This was accompanied by a letter, explanatory of the advantages by which the introduction of his system into America might be attended. With the work itself was published a letter to the Governor of Pennsylvania, in which the same views were enforced, and a comparison drawn between the relative advantages of canals and turnpike roads.

Although the letter to Washington was honored with a reply, in which the merit of Fulton's inventions was admitted, no action followed; for the general government was at that time confined by the necessity of economy to a system of non-interference with local improvements; and it is useless to speculate upon what might have been done by so enlightened an administration, had it possessed the overflowing treasury, which the churlish policy of one of his successors locked up from public use. The letter to the Governor of Pennsylvania produced even less effect That State adhered pertinaciously to its plan of turnpike roads; a plan, which, if it did create a better mode of communication than had before been enjoyed, was not less expensive than canals on Fulton's plan would have been, and far less beneficial.

Pennsylvania, after a lapse of more than forty

years, has at last seen the mistake which was then committed, and is now engaged in the creation of a system of internal improvement adapted to the great increase which has taken place in its wealth in the interim. But, by this very change, the whole of the capital invested in turnpike roads will be at once rendered unproductive; while, had small canals formed the original scheme, their gradual enlargement to meet the growing wants of the community might have been defrayed out of the income, and the whole capital preserved. It is not probable, indeed, that Fulton's own inventions, or canals of so small a size as he proposed, would have effected the desired object. They in fact could have been useful only in a few limited cases; but that the investment of the funds, which were expended upon turnpikes, in canal navigation, would have been more conducive to the prosperity of the country, is a fact, which will not now be questioned. Fulton, also, during his residence in Birmingham, wrote several tracts on subjects of a general political nature; but, as these do not appear to have been published, or, if published, to have attracted no more than an ephemeral notice, it is unnecessary that we should cite them by name.

In such occupations the time of Fulton was spent until he determined to proceed to France, for the purpose of laying his system of Torpedo

warfare before the government of that country. The investigations, into which he entered for the purpose of completing this system, led him to undertake the construction of a vessel, which might be capable of moving either at or beneath the surface of the water. So far as the power of easily rising to the surface, and descending at pleasure to any required depth, is a valuable object, this attempt was attended with complete success. But the difficulty of governing a submarine vessel, and of giving to it such velocity as will enable it to move rapidly from place to place, or even to stem a rapid current, is insuperable by the aid of any prime mover which has hitherto been applied. This difficulty is of the same character as that which opposes the management of balloons; and, if any mode of directing the one should be discovered, the power, which will be efficient in the one case, will probably be applicable to the other.

In a boat of this construction, the passage over the wide and stormy estuary of the Seine was safely and easily accomplished, and Fulton with his assistants remained several hours under water. In this position they were supplied with a sufficient quantity of wholesome air, not only for their own respiration, but for lights also. But the actual passage may be said to have been performed wholly on the surface of the water.

for the progress, after the whole vessel was immersed, was so slow as to have no material effect upon the passage. This experiment, then, confirmed the truth of the received opinion, that a body wholly immersed in a single fluid cannot carry the machinery necessary for its own propulsion, and that the valuable properties of ships are due to the circumstances of their position, partly supported upon one fluid, and having the greater part of their bulk buoyed up into a fluid of a different character, and less density. In this position they are easily guided, and the prime movers act with great energy in their propulsion.

The account, which Fulton occasionally gave his friends of his experiments at the mouth of the Seine, was full of thrilling interest. Those, who, in calm weather and in a land-locked harbour, have descended for the first time in a common diving-bell, have not failed to experience the sensations of sublimity which such an enterprise is calculated to awaken. But in this, assured of a supply of air by a perfect and efficient machinery, supported by strong chains, and confident in the watchful attention of an active crew, trained to obey a set of preconcerted signals, the danger is trifling, or rather can hardly be said to exist. How far such sensations must have been increased, may be imagined, when it

is considered, that, in the experiment of Fulton, all the means of safety, and even of insuring respiration, were shut up with him in a narrow space, and that any failure in the action of his machinery would have been followed by speedy suffocation, or by the loss of the power of ever again revisiting the light of day.

Fulton, on leaving England for the continent, carried with him some of the improvements in the arts which had appeared in that country after all commercial intercourse with France had ceased. A short time before, a wealthy American had become the purchaser of a part of the national domain, consisting of a large piece of ground in a central position in the city of Paris. Upon this he was in the act of erecting a number of shops, arranged along the sides of covered pas sages. In addition, at the suggestion, it is believ ed, of Fulton, two lofty circular buildings were constructed for the exhibition of Panoramas. These still exist and are applied to their original purpose. It has also been stated, that, in the first exhibitions with which they were opened, much of the attraction was due to the good taste and graphic skill of the subject of our memoir

CHAPTER VI.

Steam Navigation. — Watt. — Evans. — Fitch. — Rumsey. — Miller, of Dalswinton. — Symington.

THE art with which Fulton's name is inseparably connected, as the principal agent in its creation, is that of navigation by steam. That this subject had attracted his attention at an early period, we have already seen; it now remains for us to inquire in what state he found it, and to what extent he carried it.*

* In the first volume of Navarrete's *Coleccion de los Viages y Descubrimientos*, &c., published at Madrid, in 1825, there is a remarkable statement, in which the invention of the steamboat is ascribed to a Spaniard, three hundred years ago. The particulars were derived from the public archives at Simáncas. The following is a translation of a part of this statement.

"Blasco de Garay, a sea captain, exhibited to the emperor and king, Charles the Fifth, in the year 1543, an engine by which ships and vessels of the larger size could be propelled, even in a calm, without the aid of oars or sails. Notwithstanding the opposition, which this project encountered, the emperor resolved, that an experiment should be made, as in fact it was with success, in the harbor of Barcelona, on the 17th of June, 1543.

"Garay never publicly exposed the construction of

Until Watt had completed the structure of the double-acting condensing engine, the application of steam to any but the single object of pumping water, had been almost impracticable. It was not enough, in order to render it applicable to general purposes, that the condensation of the water should take place in a separate vessel, and that steam should itself be used, instead of atmospheric pressure, as the moving power; but it was also necessary, that the steam

---

his engine; but it was observed at the time of the experiment, that it consisted of a large caldron or vessel of boiling water, and a movable wheel attached to each side of the ship. The experiment was made on a ship of two hundred tons, arrived from Colibre to discharge a cargo of wheat at Barcelona; it was called the *Trinity*, and the captain's name was Peter de Scarza.

"By order of Charles the Fifth, and the prince, Philip the Second, his son, there were present at the time, Henry de Toledo, the governor Peter Cardona, the treasurer Ravago, the vice-chancellor Francis Gralla, and many other persons of rank, both Castilians and Catalonians; and, among others, several sea captains witnessed the operation, some in the vessel, and others on the shore. The emperor and prince, and others with them, applauded the engine, and especially the expertness with which the ship could be tacked. The treasurer, Ravago, an enemy to the project, said it would move two leagues in three hours. It was very complicated and expensive, and exposed to the constant danger of bursting the boiler. The other commission-

should act as well during the ascent, as during the descent, of the piston. Before the method of paddle wheels could be successfully introduced, it was in addition necessary, that a ready and convenient mode of changing the motion of the piston, into one continuous and rotary, should be discovered. All these improvements upon the original form of the steam engine are due to Watt, and he did not complete their perfect combination before the year 1786.

Evans, who, in this country, saw the possi-

---

ers affirmed that the vessel could be tacked twice as quick as a galley, served by the common method, and that, at its slowest rate, it would move a league in an hour. The exhibition being finished, Garay took from the ship his engine, and, having deposited the wood work in the arsenal of Barcelona, kept the rest himself.

"Notwithstanding the difficulties and opposition thrown in the way by Ravago, the invention was approved; and, if the expedition, in which Charles the Fifth was then engaged, had not failed, it would undoubtedly have been favored by him. As it was, he raised Garay to a higher station, gave him a sum of money (200,000 maravedies) as a present, ordered all the expenses of the experiment to be paid out of the general treasury, and conferred upon him other rewards.

"Such are the facts collected from the original registers, preserved in the royal archives at Simancas, among the public papers of Catalonia, and those of the secretary of war for the year 1543."—See *North American Review*, Vol. XXIII. p. 488.

bility of constructing a double-acting engine, even before Watt, and had made a model of his machine, did not succeed in obtaining funds to make an experiment upon a large scale before 1801. We conceive, therefore, that all those who projected the application of steam to vessels before 1786, may be excluded, without ceremony, from the list of those entitled to compete with Fulton for the honors of invention. No one, indeed, could have seen the powerful action of a pumping engine, without being convinced, that the energy, which was applied so successfully to that single purpose, might be made applicable to many others; but those, who entertained a belief, that the original atmospheric engine, or even the single-acting engine of Watt, could be applied to propel boats by paddle wheels, showed a total ignorance of mechanical principles. This is more particularly the case with all those whose projects bore the strongest resemblance to the plan, which Fulton afterwards carried successfully into effect. Those, who approached most nearly to the attainment of success, were they, who were farthest removed from the plan of Fulton. His application was founded on the properties of Watt's double-acting engine, and could not have been used at all, until that instrument of universal application had received the last finish of its inventor.

In this list of failures, from proposing to do what the instrument they employed was incapable of performing, we do not hesitate to include Savary, Papin, Jonathan Hulls, Perier, the Marquis de Jouffroy, and all the other names of earlier date than 1786, whom the jealousy of the French and English nations have drawn from oblivion, for the purpose of contesting the priority of Fulton's claims. The only competitor, whom they might have brought forward, with some shadow of plausibility, is Watt himself. No sooner had that illustrious inventor completed his double-acting engine, than he saw, at a glance, the vast field of its application. Navigation and locomotion were not omitted; but, living in an inland town, and in a country possessing no rivers of importance, his views were limited to canals alone. In this direction, he saw an immediate objection to the use of any apparatus, of which so powerful an agent as his engine should be the mover; for it was clear, that the injury, which would be done to the banks of the canal, would prevent the possibility of its introduction. Watt, therefore, after having conceived the idea of a steamboat, laid it aside, as unlikely to be of any practical value.

The idea of applying steam to navigation was not confined to Europe. Numerous Americans entertained hopes of attaining the same object;

but, before 1786, with the same want of any reasonable hopes of success. Their fruitless projects were, however, rebuked by Franklin; who, reasoning upon the capabilities of the engine in its original form, did not hesitate to declare all their schemes impracticable; and the correctness of his judgment is at present unquestionable.

Among those, who, before the completion of Watt's invention, attempted the structure of steam boats, must be named with praise Fitch and Rumsey. They, unlike those whose names have been cited, were well aware of the real difficulties, which they were to overcome; and both were the authors of plans, which, if the engine had been incapable of farther improvement, might have had a partial and limited success. Fitch's trial was made in 1783, and Rumsey's in 1787. The latter date is subsequent to Watt's double-acting engine; but, as the project consisted merely in pumping in water, to be afterwards forced out at the stern, the single-acting engine was probably employed. Evans, whose engine might have answered the purpose, was employed in the daily business of a mill-wright; and, although he might, at any time, have driven these competitors from the field, took no steps to apply his dormant invention.

Fitch, who had watched the graceful and rapid way of the Indian pirogue, saw in the oscillating

motion of the old pumping engine the means of impelling paddles, in a manner similar to that given them by the human arm. This idea is extremely ingenious, and was applied in a simple and beautiful manner; but the engine was yet too feeble and cumbrous to yield an adequate force; and, when it received its great improvement from Watt, a more efficient mode of propulsion became practicable, and must have superseded Fitch's paddles, had they even come into general use.*

* Fitch had sanguine expectations of success; and it appears by the following extract from a letter to Dr. Franklin, dated October 12th, 1785, that he anticipated some of the important advantages of steam navigation, which have since been realized. He says, in writing to Dr. Franklin;

"The subscriber begs leave to trouble you with something further on the subject of a steamboat. His sanguine opinion in favor of its answering the purpose, to his utmost wishes, emboldens him to presume this letter will not give offence. And, if his opinion carries him to excess, he doubts not but your Excellency will make proper allowance.

"It is a matter, in his opinion, of the first magnitude, not only to the United States, but to every maritime power in the world; and he is full in the belief, that it will answer for sea voyages, as well as for inland navigation, in particular for packets, where there may be a great number of passengers. He is also of opinion, that fuel for a short voyage would not exceed the weight of water for a long one, and it would pro

In the latter stages of Fitch's investigations, he became aware of the value of Watt's double-acting engine, and refers to it as a valuable addition to his means of success; but it does not appear to have occurred to him, that, with this

---

duce a constant supply of fresh water. He also believes, that the boat would make head against the most violent tempests, and thereby escape the danger of a lee shore; and that the same force may be applied to a pump, to free a leaky ship of her water. What emboldens him to be thus presuming, as to the good effects of the machine, is, the almost omnipotent force by which it is actuated, and the very simple, easy, and natural way by which the screws or paddles are turned to answer the purpose of oars."

Rittenhouse, after seeing repeated experiments, entertained a favorable opinion of Fitch's machine, as is proved by the following certificate to that effect, given more than two years after the above letter was written.

"*Philadelphia*, 12 *December*, 1787.

"These may certify, that the subscriber has frequently seen Mr. Fitch's steamboat, which, with great labor and perseverance, he has at length completed; and has likewise been on board when the boat was worked against both wind and tide, with a very considerable degree of velocity, by the force of steam only. Mr. Fitch's merit, in constructing a good steam engine, and applying it to so useful a purpose, will, no doubt, meet with the encouragement he so justly deserves from the generosity of his countrymen, especially those who wish to promote every improvement of the useful arts in America.

"DAVID RITTENHOUSE."

improved power, methods of far greater efficiency, than those to which he had been limited before this invention was completed, had now become practicable.

When the properties of Watt's double-acting engine became known to the public, an immediate attempt was made to apply it to navigation. This was done by Miller, of Dalswinton, who employed Symington as his engineer. Miller seems to have been the real author; for, as early as 1787, he published his belief, that boats might be propelled by employing a steam engine to turn paddle wheels. It was not until 1791, that Symington completed a model for him, of a size sufficient for a satisfactory experiment. If we may credit the evidence, which has since been adduced, the experiment was as successful as the first attempts of Fulton; but it did not give to the inventor that degree of confidence, which was necessary to induce him to embark his fortune in the enterprise. The experiment of Miller was, therefore, ranked by the public among unsuccessful enterprises, and was rather calculated to deter from imitation, than to encourage others to pursue the same path.

Symington, at a subsequent period, resumed the plans of Miller, and, by the aid of funds furnished by Lord Dundas, put a boat in motion on the Forth and Clyde canal in 1801.

There can be little doubt that Symington was

a mechanic of great practical skill, and consid erable ingenuity; but he can have no claim to be considered as an original inventor; for he was, in the first instance, no more than the workman, who carried into effect the ideas of Miller, and his second boat was a mere copy of the first. It is with pain, too, that we are compelled to notice a most disingenuous attempt, on his part, to defraud the memory of Fulton of its due honor.

In a narrative which he drew up, after Fulton's death, he states, that, while his first boat was in existence, probably in 1802, he received a visit from Fulton, and, at his request, put the boat in motion. Now it appears to be established, beyond all question, that Fulton was not in Great Britain between 1796 and 1804, when he returned to that country on the invitation of Mr. Pitt, who held out hopes that his torpedoes would be experimented upon by that govern ment. At all events, we know, that Fulton could not have made the copious notes, which Symington says he took, and we have reason to believe, that he had never seen the boat of that artist; for the author of this memoir, long after the successful enterprise of Fulton, actually furnished him, for the purpose of reference, with a work containing a draft of Symington's boat, of which he could have had no need, had the assertions of the latter been true.

CHAPTER VII.

Farther Attempts at Steam Navigation in the United States. — Stevens. — Livingston — Roosevelt. — Livingston goes as Minister to France. — Becomes acquainted with Fulton. — Their Contract. — Experiments at Plombières. — Experimental Boat on the Seine. — Engine ordered from Watt. — Its Peculiarities.

The experiments of Fitch and Rumsey in the United States, although generally considered as unsuccessful, did not deter others from similar attempts. The great rivers and arms of the sea, which intersect the Atlantic coast, and still more, the innumerable navigable arms of the Father of Waters, appeared to call upon the ingenious machinist to contrive means for their more convenient navigation.

The improvement of the engine by Watt was now familiarly known; and it was evident, that it possessed sufficient powers for the purpose. The only difficulty which existed, was in the mode of applying it. The first person who entered into the inquiry was John Stevens, of Hoboken, who commenced his researches in 1791. In these he

was steadily engaged for nine years, when he became the associate of Chancellor Livingston and Nicholas Roosevelt. Among the persons employed by this association was Brunel, who has since become distinguished in Europe, as the inventor of the block machinery used in the British navy yards, and as the engineer of the tunnel beneath the Thames.

Even with the aid of such talent, the efforts of this association were unsuccessful, as we now know, from no error in principle, but from defects in the boat to which it was applied. The appointment of Livingston as ambassador to France broke up this joint effort; and, like all previous schemes, it was considered as abortive, and contributed to throw discredit upon all undertakings of the kind. A grant of exclusive privileges on the waters of the State of New York was made to this association without any difficulty, it being believed that the scheme was little short of madness.

Livingston, on his arrival in France, found Ful ton domiciliated with Joel Barlow. The cor formity in their pursuits led to intimacy, and Fulton speedily communicated to Livingston the scheme, which he had laid before Earl Stanhope in 1793. Livingston was so well pleased with it, that he at once offered to provide the funds necessary for an experiment, and to enter into

a contract for Fulton's aid in introducing the method into the United States, provided the experiment were successful.

Fulton had, in his early discussion with Lord Stanhope, repudiated the idea of an apparatus acting on the principle of the foot of an aquatic bird, and had proposed paddle wheels in its stead. On resuming his inquiries, after his arrangements with Livingston, it occurred to him to compose wheels with a set of paddles revolving upon an endless chain, extending from the stem to the stern of the boat. It is probable, that the apparent want of success, which had attended the experiments of Symington, led him to doubt the correctness of his own original views.

That such doubt should be entirely removed, he had recourse to a series of experiments upon a small scale. These were performed at Plombières, a French watering place, where he spent the summer of 1802. In these experiments, the superiority of the paddle wheel over every other method of propulsion, that had yet been proposed, was fully established. His original impressions being thus confirmed, he proceeded, late in the year 1803, to construct a working model of his intended boat, which model was deposited with a commission of French *savans* He at the same time commenced building a vessel sixty-six feet in length and eight feet in width. To this

an engine was adapted; and the experiment made with it was so satisfactory, as to leave little doubt of final success.

Measures were therefore immediately taken, preparatory to constructing a steamboat on a large scale in the United States. For this purpose, as the workshops of neither France nor America could at that time furnish an engine of good quality, it became necessary to resort to England for the purpose. Fulton had already experienced the difficulty of being compelled to employ artists unacquainted with the subject. It is indeed more than probable, that, had he not, during his residence in Birmingham, made himself familiar, not only with the general features, but with the most minute details of the engine of Watt, the experiment on the Seine could not have been made. In this experiment, and in the previous investigations, it became obvious, that the engine of Watt required important modifications in order to adapt it to navigation. These modifications had been planned by Fulton; but it now became important, that they should be more fully tested. An engine was therefore ordered from Watt and Bolton, without any specification of the object to which it was to be applied; and its form was directed to be varied from their usual models, in conformity to sketches furnished by Fulton As this engine was in fact the type of many of

those used in the steam navigation of both Europe and America, it may not be uninteresting to inquire into its original form.

The cylinder having the usual proportions, the capacity of the condenser was increased, from one eighth of that of the cylinder, to one half. By this fourfold increase of capacity, the necessity of a cold water cistern was done away with. The water of injection was supplied by a pipe intended to be passed through the bottom of the boat. Instead of the parallel motion of Watt, the piston rod had a cross head, and worked in guides. From the cross head was suspended, by connecting rods, two lever beams, whose centres were no more elevated above the floor timbers of the vessel than was sufficient for their free oscillation. As these would lie in an unfavorable position to work the wheels, the beam was made nearly in the form of an inverted L; and, from the upper end of the stem, a connecting rod proceeded to a crank formed upon the axle of each wheel. This connecting rod lay, while passing the centre, in a horizontal position. On the same axle with the cranks were toothed wheels, which gave motion to pinions, and to the axles of these pinions was adjusted a heavy fly wheel. Provision was made for throwing either wheel out of gear, and it was even proposed to cause the two wheels to revolve

at pleasure in opposite directions. These two adjustments were intended to aid in turning the vessel.

In his subsequent experience, Fulton soon discovered that this engine was unnecessarily complicated; he therefore suppressed the working beam in his next vessel, making the connecting rods apply themselves to the cranks of the wheels without any intervening machinery. The possibility of backing either wheel, while the other continued its motion was thus dispensed with; but the fly wheel, and the gear for driving it, were retained. A small lever was used to supply that office of the working beam, which consists in giving motion to the bucket of the air pump. This last construction, with the omission of the fly wheel, is still the most usual form of boat engines in the United States; but the proportions of the cylinder have been changed, and the length of stroke much increased. By the latter change, the crank is made to act much more favorably in giving motion to the wheel.

Among the workmen sent out from Soho for the purpose of putting up the engine purchased from Watt and Bolton, was one of the name of Bell. This person, after performing his task, returned to Europe. The success of Fulton's experiment being known, Bell was employed to build a steamboat This he did not do until

the year 1812, four years after Fulton's boats had been in active operation upon the Hudson.

The vessel built by Bell, it may be stated from actual inspection, is obviously a copy of that of Fulton. The engines subsequently constructed in England have, with little variation, followed the original model. The lever beam is still placed near the keelson of the vessels, but is usually suspended by a parallel motion; the wheels are moved by cranks attached to the beam by connecting rods, which in passing the centre are vertical. But, while the American engineers have sought to obtain a more favorable position for the impelled point of the crank, by increasing the stroke of the piston, the English have worked for an advantage of another description, namely, that of greater stability, in the opposite practice of diminishing the height of the cylinder, until it may work wholly beneath the deck.

The advantage gained in the latter way is at best problematical; for it by no means follows, that a vessel is rendered safer by every increase of stability; and, as a suppression of a part at least of the masts and sails, increases the stability also, it appears more than probable, that vessels, whose lading is thus purposely lowered, must labor much more in heavy seas, than those in which the centre of gravity is higher. By lessening the stroke of the piston, the action of

the crank is rendered unfavorable; and it is no doubt owing to this structure of the engine, that, with equal power, and more accurate workmanship in the engine, the steamboats of Great Britain fall far short of the speed attained by those of America.

CHAPTER VIII.

Application of Livingston to the State of New York for exclusive Privileges. — Fulton revisits England. — Returns to the United States. — First Steamboat built and tried. — First Voyage to Albany. — Transactions of the Summer of 1807.

The order for an engine, intended to propel a vessel of large size, was transmitted to Watt and Bolton in 1803. Much about the same time, Chancellor Livingston, having full confidence in the success of the enterprise, caused an application to be made to the legislature of New York, for an exclusive privilege of navigating the waters of that State by steam, that granted on a former occasion having expired.

This was granted with little opposition. Indeed, those who might have been inclined to object, saw so much of the impracticable and even of the ridiculous in the project, that they conceived the application unworthy of serious debate The condition attached to the grant was, that a vessel should be propelled by steam at the rate of four miles an hour, within a prescribed space of time. This reliance upon the reserved rights

of the States proved a fruitful source of vexation to Livingston and Fulton, embittered the close of the life of the latter, and reduced his family to penury. It can hardly be doubted, that, had an expectation been entertained, that the grant of a State was ineffectual, and that the jurisdiction was vested in the general government, a similar grant might have been obtained from Congress. The influence of Livingston with the administration was deservedly high, and that administration was supported by a powerful majority; nor would it have been consistent with the principles of the opposition to vote against any act of liberality to the introducer of a valuable application of science. Livingston, however, confiding in his skill as a lawyer, preferred the application to the State, and was thus, by his own act, restricted to a limited field.

Before the engine ordered from Watt and Bolton was completed, Fulton visited England. Disgusted by the delays and want of consideration exhibited by the French government, he had listened to an overture from that of England. This was made to him at the instance of Earl Stanhope, who urged upon the administration the dangers to be apprehended by the navy of Great Britain, in case the invention of Fulton fell into the possession of France. After a long negotiation, protracted by the difficulty of communicating

on such a subject between two hostile countries, he at last revisited England. Here, for a time, he was flattered with hopes of being employed for the purpose of using his invention. Experiments were made with such success, as to induce a serious effort to destroy the flotilla lying in the harbor of Boulogne by means of torpedoes. This effort, however, did not produce much effect; and finally, when the British government demanded a pledge that the invention should be communicated to no other nation, Fulton, whose views had always been directed to the application of these new military engines to the service of his native country, refused to comply with the demand.

In these experiments, Earl Stanhope took a strong interest, which was shared by his daughter, Lady Hester; whose talents and singularity have since excited so much attention, and who now almost reigns as a queen among the tribes of the Libanus.

Although the visit of Fulton to England was ineffectual, so far as his project of torpedoes was concerned, it gave him the opportunity of visiting Birmingham, and directing, in person, the construction of the engine ordered from Watt and Bolton. It could only have been at this time, if ever, that he saw the boat of Symington; but a view of it could have produced no effect upon his own

plans, which had been matured in France, and carried, so far as the engine was concerned, to such an extent as to admit of no alteration.

The engine was at last completed, and reached New York in 1806. Fulton, who returned to his native country about the same period, immediately undertook the construction of a boat in which to place it. In the ordering of this engine, and in planning the boat, Fulton exhibited plainly, how far his scientific researches and practical experiments had placed him before all his competitors. He had evidently ascertained, what each successive year's experience proves more fully, the great advantages possessed by large steamboats over those of smaller size; and thus, while all previous attempts were made in small vessels, he alone resolved to make his final experiment in one of great dimensions. That a vessel, intended to be propelled by steam, ought to have very different proportions, and lines of a character wholly distinct from those of vessels intended to be navigated by sails, was evident to him. No other theory, however, of the resistance of fluids was admitted at the time, than that of Bossut, and there were no published experiments except those of the British Society of Arts. Judged in reference to these, the model chosen by Fulton was faultless, although it will not stand the test of an examination founded upon a better theory and more accurate experiments.

The vessel was finished and fitted with her machinery in August, 1807. An experimental excursion was forthwith made, at which a number of gentlemen of science and intelligence were present. Many of these were either skeptical, or absolute unbelievers. But a few minutes served to convert the whole party, and satisfy the most obstinate doubters, that the long-desired object was at last accomplished. Only a few weeks before, the cost of constructing and finishing the vessel threatening to exceed the funds with which he had been provided by Livingston, he had attempted to obtain a supply by the sale of one third of the exclusive right granted by the State of New York. No person was found possessed of the faith requisite to induce him to embark in the project. Those, who had rejected this opportunity of investment, were now the witnesses of the completion of the scheme, which they had considered as an inadequate security for the desired funds.

Within a few days from the time of the first experiment with the steamboat, a voyage was undertaken in it to Albany. This city, situated at the natural head of the navigation of the Hudson, is distant, by the line of the channel of the river, rather less than one hundred and fifty miles from New York. By the old post road, the distance is one hundred and sixty miles, at which

that by water is usually estimated. Although the greater part of the channel of the Hudson is both deep and wide, yet, for about fourteen miles below Albany, this character is not preserved, and the stream, confined within comparatively small limits, is obstructed by bars of sand, or spreads itself over shallows. In a few remarkable instances, the sloops, which then exclusively navigated the Hudson, had effected a passage in about sixteen hours, but a whole week was not unfrequently employed in this voyage, and the average time of passage was not less than four entire days. In Fulton's first attempt to navigate this stream, the passage to Albany was performed in thirty-two hours, and the return in thirty.

Up to this time, although the exclusive grant had been sought and obtained from the State of New York, it does not appear, that either he or his associate had been fully aware of the vast opening which the navigation of the Hudson presented for the use of steam. They looked to the rapid Mississippi and its branches, as the place where their triumph was to be achieved; and the original boat, modelled for shallow waters, was announced as intended for the navigation of that river. But, even in the very first attempt, numbers, called by business or pleasure to the northern or western parts of the State of New York, crowded into the yet untried vessel, and,

when the success of the attempt was beyond question, no little anxiety was manifested, that the steamboat should be established as a regular packet between New York and Albany.

With these indications of public feeling, Fulton immediately complied, and regular voyages were made at stated times until the end of the season. These voyages were not, however, unattended with inconvenience. The boat, designed for a mere experiment, was incommodious, and many of the minor arrangements by which facility of working, and safety from accident to the machinery, were to be insured, were yet wanting. Fulton continued a close and attentive observer of the performance of the vessel; every difficulty, as it manifested itself, was met and removed by the most masterly as well as simple contrivances. Some of these were at once adopted, while others remained to be applied while the boat should be laid up for the winter. He thus gradually formed in his mind the idea of a complete and perfect vessel; and, in his plan, no one part, which has since been found to be essential to ease of manœuvre or security, was omitted. But the eyes of the whole community were now fixed upon the steamboat; and, as all, of competent mechanical knowledge, were as alive to the defects of the original vessel as Fulton himself, his right to priority of invention of various important accessories has been disputed.

CHAPTER IX.

Steamboat rebuilt. — Occupations of the Summer of 1808. — *Causes of Opposition to Fulton's Rights. — Rival Boats upon the Hudson.*

THE winter of 1807 – 8, was occupied in remodelling and rebuilding the vessel, to which the name of the *Clermont* was now given. The guards and housings for the wheels, which had been but temporary structures, applied as their value was pointed out by experience, became solid and essential parts of the boat. For a rudder of the ordinary form, one of surface much more extended in its horizontal dimensions was substituted. This, instead of being moved by a tiller, was acted upon by ropes applied to its extremity, and these ropes were adapted to a steering wheel, which was raised aloft towards the bow of the vessel.

It had been shown by the numbers, who were transported during the first summer, that, at the same price for passage, many were willing to undergo all the inconveniences of the original rude accommodations, in preference to encountering the delays and uncertainty to which the

passage in sloops was exposed. Fulton did not however take advantage of his monopoly, but, with the most liberal spirit, provided such accommodations for passengers, as, in convenience and even splendor, had not before been approached in vessels intended for the transportation of travèlers. This was, on his part, an exercise of almost improvident liberality. By his contract with Chancellor Livingston, the latter undertook to defray the whole cost of the engine and vessel, until the experiment should result in success; but, from that hour, each was to furnish an equal share of all subsequent investments. Fulton had no patrimonial fortune, and what little he had saved from the product of his ingenuity was now exhausted. But the success of the experiment had inspired the banks and capitalists with confidence, and he now found no difficulty in obtaining, in the way of loan, all that was needed. Still, however, a debt was thus contracted, which the continued demands made upon him for new investments never permitted him to discharge. The *Clermont*, thus converted into a floating palace, gay with ornamental painting, gilding, and polished woods, commenced her course of passages for the second year in the month of April.

The first voyage of this year was of the most discouraging character. Chancellor Livingston,

who had, by his own experiments, approached as near to success as any other person, who, before Fulton, had endeavoured to navigate by steam, and who had furnished all the capital necessary for the experiment, had plans and projects of his own. These he urged into execution in spite of the opposition of Fulton. The boiler furnished by Watt and Bolton, was not adapted to the object. Copied from those used on the land, it required that its fireplace and flues should be constructed of masonry. These added so much weight to the apparatus, that the rebuilt boat would hardly have floated had they been retained. In order to replace this boiler, Livingston had planned a compound structure of wood and copper, which he insisted should be tried.

It is only necessary for us to say, that this boiler proved a complete failure. Steam began to issue from its joints a few hours after the *Clermont* left New York. It then became impossible to keep up a proper degree of tension, and the passage was thus prolonged to forty-eight hours. These defects increased after leaving Albany on the return, and the boiler finally gave way altogether within a few miles of New York. The time of the downward passage was thus extended to fifty-six hours. Fulton was, however, thus relieved from all further interference;

this fruitless experiment was decisive as to his superiority over his colleague in mechanical skill. He therefore immediately planned and directed the execution of a new boiler, which answered the purpose perfectly; and, although there are many reasons why boilers of a totally different form, and of subsequent invention, should be preferred, it is for its many good properties extensively used, with little alteration, up to the present day. But a few weeks sufficed to build and set this boiler, and in the month of June the regular passages of the *Clermont* were renewed.

In observing the hour appointed for departure, both from New York and Albany, Fulton determined to insist upon the utmost regularity. It required no little perseverance and resolution to carry this system of punctuality into effect. Persons, accustomed to be waited for by packet boats and stages, assented with great reluctance to what they conceived to be a useless adherence to precision of time. The benefits of this punctuality were speedily perceptible; the whole system of internal communication of the State of New York was soon regulated by the hours of arrival and departure of Fulton's steamboats; and the same system of precision was copied in all other steamboat lines. The certainty of conveyance at stated times being thus secured, the number of travellers was instantly augmented; and, before the end of

the second summer, the boat became far too small for the passengers, who crowded to avail themselves of this novel, punctual, and unprecedently rapid method of transport.

Such success, however, was not without its alloy. The citizens of Albany and the River towns saw, as they thought, in the steamboat, the means of enticing their customers from their ancient marts, to the more extensive market of the chief city; the skippers of the river mourned the inevitable loss of a valuable part of their business; and innumerable projectors beheld with envy the successful enterprise of Fulton.

Among the latter class was one, who, misled by false notions of mechanical principles, fancied that in the mere oscillations of a pendulum lay a power sufficient for any purpose whatever. Availing himself of a well constructed model, he exhibited to the inhabitants of Albany a pendulum, which continued its motions for a considerable time, without requiring any new impulse, and at the same time propelled a pair of wheels. These wheels, however, did not work in water. Those persons, who felt themselves aggrieved by the introduction of steamboats, quickly embraced this project, prompted by an enmity to Fulton; and determined, if they could not defeat his object, at least to share in the profits of its success.

It soon appeared from preliminary experiments, made in a sloop purchased for the purpose, that a steam engine would be required to give motion to the pendulum; and it was observed, that the water wheels, when in connexion with the pendulum, had a very irregular motion. A fly wheel was therefore added, and the pendulum was now found to be a useless incumbrance. Enlightened by these experiments, the association proceeded to build two boats; and these were exact copies, not only of the hull and all the accessories of the *Clermont*, but the engine turned out to be identical in form and structure with one, which Fulton was at the very time engaged in fitting to his second boat, *The Car of Neptune*.

The pretence of bringing into use a new description of prime mover was of course necessarily abandoned, and the owners of the new steamboats determined boldly to test the constitutionality of the exclusive grant to Fulton. Fulton and Livingston, in consequence, applied to the Court of Chancery of the State of New York for an injunction, which was refused. On an appeal to the Court of Errors this decision of the chancellor was reversed, but the whole of the profits which might have been derived from the business of the year, were prevented from accruing to Livingston and Fulton, who, compelled to contend in price with an opposition supported by popular feeling

in Albany, were losers rather than gainers by the operations of the season.

As no appeal was taken from this last decision, the waters of the State of New York remained in the exclusive possession of Fulton and his partner, until the death of the former. This exclusive possession was not, however, attended with all the advantages, that might have been anticipated. The immense increase of travel, which the facilities of communication created, rendered it imperative upon the holders of the monopoly to provide new facilities by the construction of new vessels. The cost of these could not be defrayed out of the profits. Hence new and heavy debts were necessarily contracted by Fulton, while Livingston, possessed of an ample fortune, required no pecuniary aid, beyond what he was able to meet from his own resources.

CHAPTER X.

Fulton's Marriage. — His Success speedily clouded by Opposition. — Nature and Sources of the Opposition. — Claims derived from Fitch. — Fulton's two Patents. — Simplicity of his Methods.

The success of Fulton's first experiment, was speedily followed by his marriage. On his arrival in the United States, his connexion in business with Chancellor Livingston brought him in contact with the relatives and friends of that gentleman. Of this circle Miss Harriet Livingston, the niece of the Chancellor, was, at that time, the ornament. Preëminent in beauty, grace, and accomplishments, she speedily attracted the ardent admiration of Fulton; and this was returned by an estimate of his talent and genius, amounting almost to enthusiasm.

The epoch of their nuptials, the spring of 1808, was that of Fulton's greatest glory. Every thing, in fact, appeared to concur in enhancing the advantages of his position. Leaving out of view all questions of romance, his bride was such as the most impartial judgment would have selected; young, lovely, highly educated, intelligent,

possessed of what, in those days, was accounted wealth. His long labors in adapting the steam-engine to the purposes of navigation, had been followed by complete success; and that very success had opened to him, through the exclusive grant of the navigation of the Hudson, the prospect of vast riches. Esteemed and honored, even by those who had been most incredulous while his scheme was in embryo, he felt himself placed on the highest step of the social scale. Nothing, in short, seemed wanting to complete the blessings of his lot.

We have seen, in a former chapter, how speedily his apparently well-grounded hopes of immediate profit from his invention, were frustrated by the opposition steamboats constructed in Albany, and how slow was his legal remedy for the damage he thus incurred. This opposition was, as we have stated, supported by those who anticipated injury from his success. When it was clearly to be seen, that any such anticipation was groundless, and that Albany, so far from being injured, was to be largely benefited by the steam navigation of the Hudson, other causes of discontent and opposition speedily arose; and, however important were the services conferred upon travellers, and the community in general, by the introduction of steamboats,

those of Fulton and Livingston speedily ceased to enjoy popularity.

In the early part of the enterprise, before its rapidity and certainty had actually created a traffic beyond the capacity of the vessels to accommodate, nothing could be imagined more agreeable than a summer passage to Albany in the steamboats. Gliding along, at a steady, but by no means rapid rate, the passenger had leisure to dwell upon the beauties of a scenery almost unrivalled in beauty, and to view it in all its aspects and under every variety of light. The time had not yet arrived when prudence would require a separation of one's self from all unknown persons; for the very fact of being a steamboat passenger, was, for a time, almost a guaranty of respectability. A society, therefore, existed on board, of the most easy and polished character. Rudeness and vulgarity, if accidentally present, were controlled by a preponderating force of good manners and refinement.

Such happy influences, however, continued but a few months, and the steamboats were speedily crowded by persons of every description, in such numbers as to defy all attempts on the part of the owners to render them comfortable. Most of the additions to the number, were of that class, who, from calculation, found that the saving of time in the steamboat was

more than equivalent to its additional cost. These nice calculators also speedily found, that the cost of the provisions they consumed, and of the fuel which conveyed them, was far less than the sum they paid; and, leaving out of account the vast cost and labor expended on the preliminary experiments, they not only grumbled at the inconveniences arising from their own unexpected numbers, but complained of the extortions of which they conceived themselves the victims.

Of such impressions, each passenger became in his turn the vehicle; and those, to whom the steamboats were known only by name, were speedily aware of all their discomforts. The crowded sleeping-rooms, the decks strewed with couches, the confined and offensive air, meals scrambled for, food ravenously swallowed, were all laid to the charge of the exclusive privileges of the owners. These feelings it was attempted to counteract by the most liberal, nay, profuse, expenditure; but this liberality produced no other good effect than to enrich the stewards and purveyors; in the hands of some of whom, the wealth gained in his service, was made the most efficient means of depriving his family of the rights Fulton bequeathed them. Thus, while with the intelligent, the educated, and the high-minded, the name of Fulton was regarded with esteem and reverence, it became hateful to the ignorant and

selfish, of whom, even in our more enlightened times, the majority is made up.

It is, however, to be admitted, that the opposition to Fulton's monopoly was not wholly confined to persons of the latter description. In the legal disputes which arose out of the attempts to set aside the exclusive privileges granted to Fulton, and in the debates which arose in the legislatures of several of the States, there were men enlisted on the side of the opposition, who were not mere professional advocates, but had the firmest reliance upon the justice of the cause they espoused. They believed, conscientiously, that Fulton had arrogated to himself the merit of discoveries, which had been made by others. To these pure and disinterested gentlemen we must allow the praise of proper and patriotic motives.

The most formidable opposition which was made to the privileges of Fulton, was founded upon the discoveries of Fitch. We have seen, that he had constructed a boat, which made some passages between Trenton and Philadelphia; but the method, which he used, was that of paddles, which are far inferior to the paddle-wheel. Of the inferiority of the method of paddles, had any doubt remained, positive evidence was afforded in the progress of this dispute; for, in order to bring the question to the test of a

legal decision, a boat propelled by them was brought into the waters of the State of New York. The result of the experiment was so decisive, that, when the parties engaged in the enterprise had succeeded in their designs, they made no attempt to propel their boats by any other method than that of wheels.

Fulton, assailed in his exclusive privileges derived from State grants, took, for his further protection, a patent from the general government. This is dated in 1809, and was followed by another, for improvements upon it, in 1811. It now appeared, that the very circumstance in which the greatest merit of his method consists, was to be the obstacle to his maintaining an exclusive privilege. Discarding all complexity, he had limited himself to the simple means of adapting paddle-wheels to the axle of the crank of Watt's engine; and, under the patent laws, it seems hardly possible that such a simple, yet effectual method, could be guarded by a specification. As has been the case with many other important discoveries, the most ignorant conceived that they might themselves have discovered it; and those acquainted with the history of the attempts at navigation by steam were compelled to wonder, that it had been left for Fulton to bring into successful operation.

CHAPTER XI.

Conflicting Claims of the States of New York and New Jersey. — Attempt to obtain a Repeal of the Grant from the State of New York. — Fulton's Steam Ferryboats. — Boat for the Navigation of the Sound. — Boats planned by Fulton, and left unfinished at the Time of his Death.

In considering the history of the remaining years of Fulton's life, it is impossible not to be struck with the obvious fact, that he had made a false step in forming a partnership with Livingston, and in looking to exclusive legislative grants for his remuneration. Had he acted simply as Livingston's engineer, and kept aloof from all more intimate connexion, he would have been consulted, as a matter of course, by all those who embarked in the enterprise of extending steam navigation.

From such professional service, fortune and popularity could not fail to have followed. But becoming, as he did, the partner in a monopoly, every new extension of the method he had brought into successful use, and every improvement made in it, was hostile to his interests, and

those, who, under other circumstances, would have been his firmest supporters became his opponents and enemies.

The State of New York, at the time when its grant to Fulton and Livingston was in force, claimed jurisdiction over the whole of the waters lying between its own shores and those of New Jersey. The latter State resisted this claim; but, in the intercourse by ferries between the two States, the influence of individual interests had prevented any inconvenience arising from the con flicting jurisdictions.

It is probable, that, had Fulton himself been the sole proprietor of the grant from the State of New York, a spirit of compromise with the citizens of New Jersey would have governed him. But the partnership, instead of treating on fair terms with the parties holding ferry rights in that State, transferred the whole of the rights they held under the State of New York to a near relation of Chancellor Livingston. The boat constructed under this grant, on commencing its passages, came into immediate competition with the ferry owners in New Jersey, and left them no option except between the total abandonment of their property in the ferries and a competition by means of steamboats.

For this latter object, grants made to Fitch by the State of New Jersey, which, although

never acted upon, were still in force, were resorted to. Not content with an opposition upon the debatable waters, the parties engaged in this attempt resolved to try the validity of the grant to Livingston within the acknowledged jurisdiction of the State of New York. With this view an application was made in the winter of 1808–9 for a repeal of the law. This application, being referred to a committee of the Legislature, was favorably received, and a bill for the repeal was reported. Fulton and Livingston, however, having obtained permission to be heard by counsel at the bar of the House of Assembly, succeeded in preventing this bill from becoming a law.

The action of the State of New Jersey was effectual in causing the steamboat, constructed by virtue of the grant from Fulton and Livingston, to suspend her passages; and, in retaliation, her proprietors, in opposition, as is believed, to the wishes of Fulton, brought the law of the State of New York to bear upon a ferryboat belonging to John Stevens, of Hoboken, which was in consequence prevented from plying.

It thus happened, that the persons, who were entitled to all the merit of introducing steam successfully into the service of navigation, were the greatest sufferers by the contest. Fulton lost the income for which he had stipulated out of the profits of the steamboats plying to New Jersey;

while Stevens, who had constructed and set in motion a steamboat of unobjectionable construction, within a few weeks after Fulton's successful experiment, was prevented from using it.

We may here pause to remark, on what small circumstances the claim to original invention may rest. Stevens had now been engaged for seventeen years in attempts to apply the steam engine to the purposes of navigation, and was on the very eve of success, when forestalled by Fulton, while the latter was entitled to his right of priority by no more than a few weeks. It is, however, to be remarked, that the engine, with which Fulton's successful experiment was made, had been planned and constructed several years before; and it appears probable, that the exertions of Stevens, and of his son, who had now come forward as his father's engineer, were stimulated by the knowledge of Fulton's confidence in a successful issue of his experiments. If, however, it were necessary for us to decide to whom, of all the rivals of Fulton, any share of the honors of success were due, there could be no hesitation in awarding them to Stevens.

This controversy with the State of New Jersey, which embarrassed, and often interrupted wholly, the communication by steam between Philadelphia and New York, was not adjusted during the life of Fulton, and may indeed be said

to have continued until the grant of the State of New York was finally decided to be unconstitutional by the Supreme Court of the United States.

Although thus harassed by litigation, Fulton did not permit his mind to be wholly diverted from mechanical pursuits. The insular position of the City of New York, however favorable to commerce, both domestic and inland, subjected it to great difficulty in its communications with the adjacent country, and diminished materially the value of the lands situated on the opposite shores of its rivers and bay. From the magnitude of these masses of water, row-boats were an unsafe mode of communication, which, if attempted by them, was subject to continual interruptions; and large sail-boats, although more safe, were, in consequence of the rapidity of the tides and the irregularity of the winds, liable to great uncertainty in their passage. That these difficulties might be overcome by steam was now obvious, and Fulton tasked himself to contrive the most appropriate means of applying that mover to the object.

It appeared necessary that the vessels should be so constructed, that carriages might be driven into them without difficulty. He was in consequence led to adopt the plan of twin boats, having the paddle-wheels between them, and connected by a deck, sufficiently strong to bear the feet of

horses and the weight of loaded carriages. It is probable, that he now, for the first time, availed himself of the experiment of Symington, whose boat was of similar structure; and it was at this period, that he consulted the work which contains a drawing of that vessel. The assistance he derived from an inspection of this draft was however but small; for there is not the slightest resemblance in the arrangement and distribution of the two inventions, with the exception of both being twin boats, and both moved by a single paddle-wheel set in motion by a steam engine Fulton had found no difficulty in the navigation of rivers, in the direction of their length, by a single boat with wheels on each side; but the circumstances of the case were far different, when a movable road, bearing both foot passengers and carriages, was to be employed to cross a stream. So far as the theory then received of the resistance of fluids could be a guide, the form selected by Fulton was a good one; but it is now determined, by observations upon the ferryboats constructed by him and others, that twin boats are retarded by a resistance of a more powerful character than single ones.

This increase of resistance, to an amount far greater than is pointed out by theory, appears to be due to a wedge of water which lies between the two conjoined boats, and which must be removed

as the vessel advances. Of this Fulton could not have been aware, as no observations or experiments existed by which it could have been determined. With this exception, the ferryboat of Fulton is to be classed with the very few machines, which come perfect, on the first trial, from the hands of the inventor; and, with the substitution of a single hull for the twin boat, it has in its arrangement and distribution undergone little or no change.

Steam ferryboats were first established upon the ferry between New York and Brooklyn, and a short time afterwards, between the former city and Paulus Hook. The latter were completed shortly after the breaking out of the war between Great Britain and the United States. An immediate opportunity was afforded to prove the importance of the invention. It became necessary to transport a troop of flying artillery, with its battery of guns and other carriages. The whole were conveyed across this ferry, whose breadth is about a mile, in less than an hour, by a single boat, although comprising upwards of a hundred mounted men, and more than twenty carriages, each drawn by four horses.

A difficulty existed, on account of the ebb and flow of the tide, in making his ferryboats answer the purpose of a movable road, into and from which carriages might be driven without delay

or danger. This was obviated, in a simple and ingenious way, by means of a floating bridge; and the danger to the wharves and the vessel itself arising from the shock attending their contact, was prevented by an apparatus governed by a floating counterpoise. These exhibited much skill in practical mechanics, and knowledge of the laws of hydrostatics. The latter part of his invention has, however, been rendered useless by the dexterity, which the ferrymen have attained in the management of the boats, but was at first of the utmost importance to prevent injury, not only to the machines themselves, but to the passengers.

The steamboats on the Hudson River were increased in number, before the death of Fulton, to five. A sixth was built under his direction for the navigation of the Sound; and, this water being rendered unsafe by the presence of an enemy's squadron, the boat plied for a time upon the Hudson. In the construction of this boat, he had, in his own opinion, exhausted the power of steam in navigation, having given it a speed of nine miles an hour; and it is a remarkable fact, which manifests his acquaintance with theory and skill in calculation, that he in all cases predicted, with almost absolute accuracy, the velocity of the vessels he caused to be constructed. The engineers of Great Britain came long after to a similar conclusion in respect to the maximum of speed

It is now, however, well known, that with a proper construction of prows, the resistance to vessels moving at higher velocities than nine miles an hour, increases in a much less ratio than had been inferred from experiments made upon wedge-shaped bodies; and that the velocity of the pistons of steam engines may be conveniently increased beyond the limit fixed by the practice of Watt.

For these important discoveries, the world is indebted principally to Robert L. Stevens. That Fulton must have reached them in the course of his own practice can hardly be doubted, had his valuable life been spared to watch the performances of the vessels he was engaged in building at the time of his premature death. These were, a large boat, intended for the navigation of the Hudson, to which the name of his partner, Chancellor Livingston, was given, and one planned for the navigation of the ocean. The latter was constructed with the intention of making a passage to St. Petersburgh; but this scheme was interrupted by his death, which took place at the moment he was about to add to his glory, as the first constructor of a successful steamboat, that of being the first navigator of the ocean by this new and mighty agent.

CHAPTER XII.

Fulton's Torpedoes. — His Submarine Guns. — Steam Frigate. — Submarine Vessel. — He is called before the Legislature of New Jersey as a Witness. — Is detained on the Hudson by the Ice. — His Illness. — Death and Character.

The prime of Fulton's life had been spent in ineffectual attempts to introduce a novel mode of warfare. In these efforts, he was encouraged by the hope, that, were its efficacy once established, his native country would be safe from the aggressions of European powers. The war of 1812 promised an opportunity of applying his carefully matured schemes to the purpose for which they were originally intended, and of realizing his long-cherished hopes. He had, almost immediately after his return to the United States, instituted a set of experiments with his torpedo; these were successful in destroying a vessel anchored in the bay of New York. The attention of the general government being thus awakened, he had received instructions to perform another set of experiments, in which he was to receive the aid of officers of the navy;

or, rather, was to attempt the application of his torpedoes to a vessel, which they were to defend.

It is no dishonor to Fulton, that, in the course of these experiments, he was foiled. The officers of the navy, fully aware of the manner of his approach, took such measures as prevented all access to the vessel to be attacked. It is, however, obvious, that the very necessity of taking such precautions as they found indispensable, was a proof of the greatness of the danger; and it was evident, that, had they not had weeks for preparation, and all the means, both in men and material, furnished by a large navy yard at their disposal, some one or other of the means proposed by Fulton must have been successful.

In spite, then, of the advantage which the highest degree of naval skill, and the command of means, that could not be within the reach of an enemy's vessel upon our shores, gained over Fulton's embryo scheme, we must conclude, that it would have been a powerful and efficient means of annoyance against an enemy anchoring in our waters. It was viewed in this light by the government, not as a substitute for the ordinary modes of warfare, but as a useful and powerful addition to the means of harbor defence

When, therefore, the entrances of our harbors

were blockaded, Fulton's talents were called into the service of the government; but, as his enterprises were conducted with the most profound secrecy, little was said of them at the time. It is now, however, well known, that, although no actual injury was done to the British fleet, yet the motions of the squadron in Long Island Sound, were paralyzed, although commanded by the favorite captain of Nelson, and its crews kept in a state of continual alarm, by a fear of the invention of Fulton.

It is not to be wondered, that his motions were watched by spies, and regularly reported to the British commander; who, on one occasion, landed a strong party, which invested the house at which Fulton had intended to sleep. By a lucky accident, he was prevented reaching his intended quarters, or he would certainly have been made prisoner.

In the course of his experiments upon the mode of attaching the Torpedo, he had planned an instrument, by which a cable was to be cut. This consisted of an arrow, projected beneath the surface of the water, by a small piece of ordnance. A trial of this instrument showed the practicability of firing artillery beneath the surface of the water, and doing execution with it, at moderate distances. Upon this observation, he founded a method of arming vessels

with submarine guns; by the use of which, they would, in close action, have acquired a vast superiority over those armed in the usual man ner.

His attention was next directed to the construction of a vessel of war, to be propelled by steam; and he succeeded in producing perhaps the most formidable engine of naval war, which has ever been planned. Viewed in the light of a floating battery, intended solely for the defence of harbors, this vessel left little to be desired; but he had no intention of fitting it for the general purposes of navigation; and hence we have no right, in estimating its value, in comparison with that of subsequent constructions of the same sort, to take its fitness for any other object into account.

When death arrested the career of Fulton, he was busily engaged in constructing an improved form of the submarine vessel, which he had used in France. Aware, by experience, of the difficulty of moving a vessel when wholly submerged, he limited his views, in this case, to bringing the deck to a level with the surface of the water. This deck was to be rendered ball-proof. In this position, a large wheel, intended as the propelling apparatus, would have worked partly in air and partly in water. Such were the obvious features of the plan; but, of

many accessory parts, the idea was confined to his own breast; and thus, upon his demise, no person was to be found able or willing to undertake the completion of the unfinished invention. The object of this vessel was to furnish a safe and convenient mode of using his torpedoes and submarine guns.

The energies of Fulton's mind were arrested by death, in the midst of these active and interesting pursuits. The controversy, in which the parties holding under him were engaged with the owners of the monopoly granted by the State of New Jersey, had never been closed. A favorable opportunity seemed to present itself for obtaining a repeal of the law of that State, which was seized by the former party. Fulton, having no direct interest in the question, was a competent witness, and was summoned, as such, to attend the legislature of New Jersey, in January, 1815. On his return, the Hudson River was found to be filled with floating ice, which put a stop to the usual means of passage. Fulton, anxious to rejoin his family, attempted the passage in an open row-boat and was thus exposed for several hours to the inclemency of the weather. The consequence was a severe attack of illness.

Before he had wholly recovered, his anxiety in relation to the steam frigate and his subma

rine vessel was such as to induce him, in defiance of the suggestions of prudence, to visit the Navy Yard at Brooklyn, and expose himself for some hours upon the decks of the former. The result of this imprudence was a relapse of such violence, that his constitution, enfeebled by constant labors and anxieties, was unable to resist it. His death took place on the 24th of February, 1815.

Rarely has it happened, that the natural death of any citizen excited so general mourning as that of Fulton. Cut off in the very height of his usefulness, and in the zenith of his reputation, his countrymen felt it as a loss almost irreparable.

Fulton was in person considerably above the middle height; his countenance bore marks of intelligence and talent. Natural refinement, and long intercourse with the most polished societies both of Europe and America, had given him grace and elegance of manners. His great success, and the belief that his invention had secured the certainty of great wealth, however unfounded this belief was proved to be after his death, never, for a moment, rendered him arrogant or assuming. Fond of society, he was the soul of the intelligent circle in which he moved, and of which his hospitable mansion was the centre. The fine arts, once his chosen profes

sion, were his recreation and delight in after life; and he not only practised them himself, but bountifully encouraged the efforts of others.

Our memoir has exhibited the extent of his mechanical knowledge and ingenuity; and, in the midst of the most prolific creations of American industry, the services rendered by Fulton are at length admitted to be superior to those of any other inventor, with the sole exception of Whitney. This rank is now awarded him, not only by the tardy justice of his own countrymen, but by the almost universal suffrage of the whole civilized world, the bonds of whose union are daily drawn closer and closer, by an invention which, however long sought and nearly attained by others, was at last introduced into use by his talent and perseverance.

In forming this estimate of his services, it is not necessary that we should undervalue the efforts of those, who preceded him in the attempt to apply steam to navigation. It is very probable, indeed, that, had it not been for the experiments of Fitch, Fulton might never have applied his attention to steam navigation. But it is not less certain, that, had he not been successful, the merits of Fitch would have been forgotten, and unknown to the present generation. It may even be questioned, whether the public would have believed in the success of

Stevens, and afforded him the encouragement necessary to carry on his enterprise, had not conviction been forced upon it, by the more brilliant and conspicuous experiment of Fulton. Compared with these two names, the superiority of reputation, which the future historian will not fail to ascribe to Fulton, may be as much due to good fortune as to actual merit; but, with this exception, he has no competitor for the glory of having introduced one of the most useful applications of mechanics, with which the civilized world has yet been favored.

THE END