

Philadelphia Dec^r 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

David Rittenhouse

DAVID RITTENHOUSE
OF
DAVID RITTENHOUSE;

BY
JAMES RENWICK, LL. D.

LIFE
OF
DAVID HILL TENNOR
BY
JAMES HENNING, LL.D.

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 appearance, 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 accumulated 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 Rittenhouse 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 development, 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 procure 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 countrymen. 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 projected, 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 parallax 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 observations, 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 Duséjour 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 the 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 dimensions 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 longitudes 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 referred 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 expended 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 American 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 calculations 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 Flamsteeds, the Halleys, and the Maskelynes, but that he should be permitted to devote his whole mind to this pursuit, and be furnished with these 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 traverse 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 the 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 creation, 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-second degree of latitude, in the astronomical 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-

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 exclusive 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 shall have been able to assert for him the right of priority in scientific discoveries and researches, of which others have reaped the honors.



