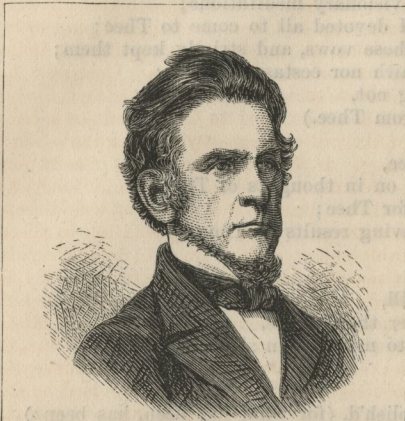


## OBSERVATORIES IN THE UNITED STATES.



ORMSBY M'KNIGHT MITCHELL.

## I.—THE NEW OBSERVATORY AT CINCINNATI.

**L**ITTLE more than thirty years ago it could not be said that there was one astronomical observatory in the United States. To-day it is safe to place the number of all classes, public and private, beyond fifty.

The first of these statements may strike many of our readers with surprise. The authority of John Quincy Adams will confirm its truth. "Is there," he asked, at the close of a magnificent oration at Cincinnati in 1843—"is there one tower erected to enable the keen-eyed observer of the heavenly vault to watch from night to night, through the circling year, the movements of the starry heavens and their unnumbered worlds? Look around you, look from the St. John to the Sabine, look from the mouth of the Never-sink to the mouth of the Columbia, and you will find not one! or if one, not of our erection."

Mr. Adams had made astronomy a favorite pursuit. He was too well informed as to its progress in our country not to know the existence of some additions to our colleges in the form of astronomical buildings and their instruments—designed almost exclusively for instructing students in their use. He appreciated them; for he was one of the first to urge their procuring by his own Harvard.

But his just conceptions of a true observatory involved yet higher character and aims in it. It must steadily labor for *discovery*. It must be fully equipped for this, and be provided with a *personnel* who could give their whole energies to that series of observations running through many years, which alone can secure valuable additions to astronomical knowledge and insure its

benefits to men. For the establishment of such an institution he had made his well-known appeal to Congress in 1825. He was ridiculed; but he remained as strenuous an advocate as ever for the establishment of observatories of the first class both at Washington and at Cambridge. In the very year before this address at Cincinnati, he had urged, in his place in Congress, the perpetual appropriation of the whole interest of the then unappropriated Smithsonian fund for an observatory for the people.

"The express object of observatories," said he, "is the increase of knowledge by new discovery. It is to the successive discoveries of persevering astronomical observations through a period of fifty centuries that we are indebted for a permanent standard of time and for the measurement of space." In 1843, he was clearly justified in saying that no observatory existed in this country capable of holding aims exalted as these. Comparatively few individuals appreciated or desired such. Most persons were content to look to Greenwich only. They agreed with some of our old officers who, in 1830, "were not sensible of any inconvenience resulting to our navy by relying on British nautical almanacs, though it might be desirable to establish an American almanac as a matter of pride and national independence."

The year 1843 was, however, an era in the history of our observatories, and Cincinnati was their birth-place. Her institution, and those of Cambridge and Washington, sprang up, and the enthusiasm of the era started others, whose equipment has been secured largely by their success. We do not forget the earlier and valued work of Professor Leomis at Hudson, the efforts at Yale and Cambridge, or at the High School in Philadelphia, the observatory of which became afterward so noted by its introduction into this country of the Munich instruments, and their brilliant use by Walker and Kendall. Yet the honor of first establishing a separate institution, with the aims characterizing a true observatory, belongs to the Queen City. We are led up to her beautiful hills, to the genius, the enthusiasm, and the persevering labors there of her master-spirit in this work, ORMSBY M'KNIGHT MITCHELL.

Our advance in astronomy to-day is nothing short of the marvelous. As in other branches, so in this, "the noblest of the sciences," progress is being made, as the Astronomer Royal at Greenwich has said, "by enormous strides." The brilliant discoveries during the solar eclipses of 1868, 1869, and 1870, and the revelations of the physical constitution of the sun and stars by the spectroscope and by the photograph sun pictures during the year close behind us, are in proof.



It is to the honor of our own land—an honor now freely awarded from abroad—that in this she takes her full share. The work done by Winlock of Cambridge, and Young of Dartmouth, and Rutherford of New York, and Watson and Peters of Ann Arbor and Clinton, besides that which is steadily secured at our government observatory at Washington (now thrice doubly armed by the possession of her twenty-six-inch refractor), is daily aiding in the establishing for us as high a position in science as we had attained in the practical arts with their inventions. A few sketches, therefore, of our chief working observatories at this day can hardly fail to profit and interest the general reader. From what has been already written, he will not be surprised that we put the Cincinnati Observatory first upon our list, especially if he has noticed that it has received a new consecration by the founding of a new edifice.

As early, indeed, as 1805, Cincinnati may be said to have had a practical working observatory. In that year the first Surveyor-General of the United States, Colonel Jared Mansfield, received, after a delay of at least three years in their construction and transportation from London, astronomical instruments ordered by Albert Gallatin, Secretary of the Treasury, and paid for by President Jefferson out of his *own contingent fund*, "since no appropriation for them had been made by law." The invoice ran thus in part:

LONDON, April 3, 1805.

Alexander Baring, Esq.,

Bought of E. Troughton—	
One 3-feet reflecting telescope mounted in the best manner.....	£47 5 0
One 30-inch portable transit instrument....	78 15 0
One astronomical pendulum clock.....	68 0 0

These instruments were said to be excellent of their kind. Years afterward, they were placed in the Philosophical Department of the Military Academy at West Point. In the house of the Surveyor-General, at Cincinnati, they were used in making numerous and interesting astronomical observations. The orbit of the comet of 1807 was calculated, eclipses of different kinds were observed, the longitude of the observatory determined, and other observations of importance made from 1807 to 1813, all of them outside of the usual duties of the mere surveyor.

The key to this is to be found in the na-

ture of Colonel Mansfield's duties at that time. Looking back to the act of 1785, introductory to the famous ordinance of 1787 for the then named "Northwestern Territory," we find that the original plan of laying out the public lands required standard astronomical observations. Congress had determined that plan by requiring the whole of the great West to be laid out in sections of six miles square by rectangular co-ordinates. It was necessary to call in astronomy to determine for these the standard meridian and base lines. Our surveyor was directed additionally, or rather in relation to the establishment of these lines, to determine also, if possible, the southern extremity of Lake Michigan, the western extremity of Lake Erie, the confluence of the Ohio and Mississippi, and the western boundary of the Reserve. The plan of astronomical surveying, adhered to this day, was devised by Colonel Mansfield. His head-quarters were his observatory at Cincinnati, from which are dated some of his observations and astronomical discussions to be found in that now rare volume, *Transactions of the Connecticut Academy*, Part I. Mansfield was a surveyor whose astronomical work would long be quoted—like Ellicott's, quoted from the time of his laying out the Federal City to this day.

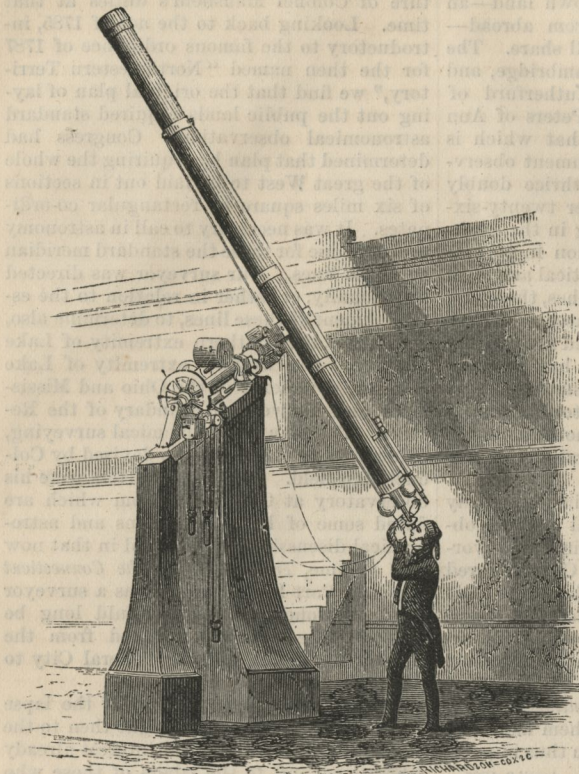
Our next date is at the end of the lapse of forty years. We are brought then to the marked era in astronomical interest already referred to, and to the labors of those who awakened that interest.

Mitchell was a native of Kentucky. He graduated with honor at West Point in 1829. Resigning from the army, and practicing law in Cincinnati, he was made professor in the City College. He was an enthusiast in astronomy. He gave a series of lectures to the citizens in 1842, which created their Astronomical Society. The preamble to their



OLD CINCINNATI OBSERVATORY.





EQUATORIAL—CINCINNATI OBSERVATORY.

constitution holds in it the expression of ideas elevated as those so often breathed by Adams. It looks as though there were a close link revealed in it between him and Mitchell.

As the astronomer of the society engaged for a ten years' work, Professor Mitchell sailed for Europe to purchase a telescope superior to any then in this country. With letters from Mr. Adams, he was received with open arms by Airy at Greenwich, Arago at Paris, and Lamont at Munich. In the optical institute of Merz and Mähler, successors of the great Fraunhofer, at Munich, he found an object-glass of twelve-inch aperture, which, after Lamont's test in his own tube (since they fitted each other), was pronounced superior to that of the Munich telescope. It was mounted, purchased for about \$9400, and arrived in Cincinnati in 1845.

The Astronomical Society meanwhile had secured from their fellow-citizen, N. Longworth, the gift of four acres of ground on one of the beautiful and commanding hills on the east of the city, and a fund of \$11,000 in shares of \$25 each.

Professor Mitchell, on his return, devoted his whole energies to the erection of an observatory. Its corner-stone was laid Novem-

ber 10, 1843, on the site given by Longworth, on Mount Adams, at the close of the oration quoted at the beginning of this article. The discourse has been called "An Outline of Astronomy."<sup>2</sup>

The observatory presented a front eighty feet, ornamented with a Grecian Doric portico, and a depth of thirty, showing a basement and two stories, with a central dome, covering an equatorial room twenty-five feet square, the roof being capable of entire removal when observations were to be made. The object-glass of the telescope had an aperture of twelve inches, and a focal length of seventeen feet. The telescope had five common eye-pieces and nine micrometers, the highest power being 1400, and was furnished with the usual clock-work by which a star is steadily kept in the field of view.

The equatorial room received the Munich instruments in March, 1845. Professor Mitchell began his labors with the enthusiasm of hope. Three thousand visitors, some of them from homes far distant, witnessed, during the first year, the satisfactory performance of his equatorial. Other necessary instruments were received: a five-foot Troughton transit, loaned by the Coast Survey, an astronomical clock, donated by Mr. McGrew, of Cincinnati, and a chronometer, loaned by Messrs. Blunt, of New York. At the request of Professor Bache, the telegraph company connected the observatory with their stations for the determination of longitude, Cincinnati being then a central point in such work. The Astronomer Royal, under whose instruction Mitchell had passed three months in 1842, urged, in an encoura-

\* It seems remarkable that in this oration when Mr. Adams asks the question, "What have we been doing for astronomy?" he makes no reference to the passage by Congress in the previous year of a bill which was in reality to found the present United States Naval Observatory, although the purpose was disguised under another name for the institution. Was he not justly disgusted with the mode and the name under which had been thus yielded to the agency of others that which had been denied him since 1825? It is an incident of interest at the laying of this corner-stone that the venerable Judge Burnet, a pioneer of Cincinnati, introduced the orator by an address historic of the West and of the care of its rightful boundary by the elder Adams, commissioner in 1783.



ging letter, that "the first application of his meridional instruments should be for the exact determination of his geographical latitude and longitude, and that his observing energies should be given to the large equatorial." With this advice, he directed his attention largely to the remeasurement of Struve's double stars south of the equator. The great astronomer of Pulkova had furnished his full catalogue of these, numbering more than three thousand. Mitchell began his work upon them. He tells in glowing language of the gratification experienced in beholding for the first time—and he, in this, the first observer in this country—the *double stars* brought into view by a powerful instrument.

Airy and Lamont had invited him to make minute observations of the satellites of Saturn, since in the latitude of Cincinnati the planet is observed at a more favorable altitude than at Pulkova, twenty degrees further north. To these, and chiefly "to the physical association of the double, triple, and multiple suns," he gave his close attention. He made interesting discoveries in the course of this review. "Stars which Struve had marked as oblong, were divided and measured; others marked double were found to be triple." He proposed a new method for observing, and new machinery for recording north polar distances or declinations. Professor Peirce reported favorably on this method at the meeting of the American Association in 1851, and Professor Bache, as Superintendent of the Coast Survey, indorsed their approval in his report for that year, presenting also a full account of work done by the new method, in observations made by the enthusiastic astronomer and his patient wife, who assisted him through all. It was claimed that the results rivaled the best work done at Pulkova. Mitchell was the first "to prepare a circuit interrupter with an eight-day clock, and to use it to graduate the running fillet of paper;" and to invent and use the revolving-disk chronograph, for recording the dates of star signals. Professors Bache and Walker had declined to adopt the first of these improvements in astronomical appliances, through an apprehension of injury to the astronomical clock. Mitchell's work proved the apprehension to be groundless. His revolving disk is an invaluable invention. To the perfection of such methods and instruments, together with the routine work of observation, he gave all the energies not of necessity employed in outside labors devolving on him for his support. Unhappily these, at an early date, became almost absorbing.

For the Astronomical Society, having secured their observatory and their director, had failed to secure a basis for his support. This certainly was as much their regret as his. Nor was their astronomer as unfortu-

nately situated as the first Astronomer Royal of England, for whom Charles II. provided an observatory, but "no instruments," for Flamsteed used to say he earned his £100 "by labor harder than threshing:" he had to thresh and to find his own corn. Mitchell relied on his professorship in the Cincinnati College: in two years the college was burned down. He then relied on publications and lectures. He published the *Sidereal Messenger*, a work of three volumes. He delivered lectures of rare power and beauty in the chief cities of the Union. He stirred up an enthusiasm by these lectures, which quickened the movements resulting in the establishment of some of our first observatories of this day. But for his support, unhappily for the observatory, he was compelled to accept the position of chief engineer of the Mississippi and Ohio Railroad from 1848-52; and finally, in 1853, that of director of the magnificent Dudley Observatory at Albany, New York. He did not, however, remove from Cincinnati till 1859. In 1861 his country claimed him from astronomy for her own service. He was not one who could forget the sacred obligations of his training at the Military Academy; but promptly responded as patriot and soldier, and his stirring addresses before entering the field will not soon be forgotten, nor his untimely loss to science.\*

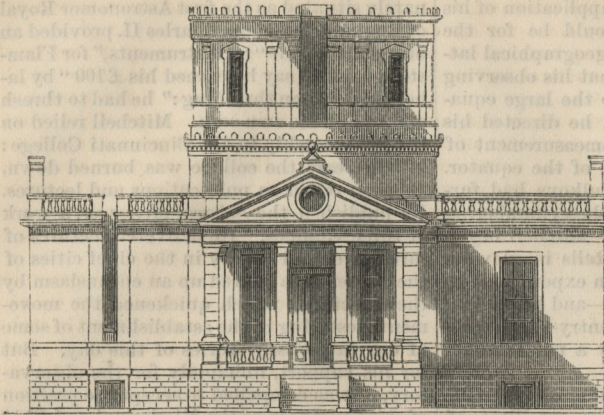
The observatory remained in charge of Mr. Henry Twitchell, of Cincinnati. Mitchell's enthusiasm had gathered around him from time to time young men as learners, among whom were M. Yarnall, then as now a professor in the United States navy; Mr. Twitchell was his chief assistant for twelve years. On his resignation, Mr. William Davis, of Cincinnati, received the use of the building to keep it in repair and make his own amateur observations. For two years he continued a series of observations of moon culminations, such as had been begun in 1856 for the Coast Survey.

On the 1st February, 1869, Mr. Cleveland Abbe, formerly employed at the Pulkova Observatory, and more recently at the United States Naval Observatory at Washington, accepted the place of director.

His first annual report submitted a plan of wide and useful astronomical and magnetic and geodetic investigations. On these he entered vigorously. He first adopted for this country the issuing of daily meteorological bulletins, now so widely known as adopted and used by the United States Signal Service Bureau.

\* General Ormsby McKnight Mitchell's most honorable chronicle reads thus: "Born in Kentucky, 1810; graduated at West Point, 1829; Assistant Professor of Mathematics in the Academy to 1831; Professor in the College of Cincinnati, 1834-44; Director of Cincinnati Observatory, 1844-54; of Dudley Observatory, 1859-61; Brigadier-General U.S.A., 1861; Major-General commanding the Department of the South, 1862. Died in command at Beaufort, South Carolina, 1862."





NEW CINCINNATI OBSERVATORY—FRONT ELEVATION.

The pressure of labors incident to the revival of the institution, the want of some instruments indispensable to the astronomer, but especially the embarrassment of the whole work of the observatory by its unfortunate location, were very serious discouragements. Mr. Abbe urged its removal, which had been, indeed, advocated by Mitchell as far back as 1856. Having carried forward a part of his proposed plans so far as the means at his command permitted, Mr. Abbe in 1870 obtained leave of absence to accept an appointment as astronomer to the Darien Canal expedition, under Commander Selfridge, United States Navy. His call to the Signal-office in 1871 has thus far prevented his return to the observatory whose improvements he had advocated.

During the years since Professor Mitchell's leaving the institution, its future had appeared dark enough. In taking charge of the Dudley Observatory in 1859 he announced his expectation that "the Cincinnati Observatory was soon to be placed on a permanent foundation, and that each observatory would be occupied on a star catalogue down to the tenth magnitude." But we have seen how readily his highest aims in astronomy yielded to that of defending the Union. It is not surprising that the interval of the war should retard the plans he had formed, and prevent, under all circumstances, their subsequent execution by his successors.

But in 1870 a movement was originated by Abbe, which, at the time of preparing this article, promises by its development to secure results worthy of the noble founder of the observatory, and of the West. A tripartite agreement has been secured between Mr. Longworth's heirs, the Astronomical Society, and the city, by which the sale of the old site was permitted, and the city pledged to maintain the observatory in connection with the university; original investigations,

and not mere educational uses, being guaranteed as its object. The real estate on Mount Adams brought \$50,000. On Mount Lookout, one of the highest points in Hamilton County, adjacent to a park not likely to be built up to the injury of astronomical observations, the corner-stone of the new observatory was laid, August 28, by the Mayor of Cincinnati, after an able address by Hon. Rufus King. The site is free from the smoke and heated air of the

factories, which had invaded Mount Adams, destroying accurate observations. The corner-stone was the same with that laid by Adams in 1843. The observatory is to be seventy-one feet by fifty-six, with an elevation of sixty feet. It will be built of brick, trimmed with freestone. The pier of the Munich equatorial is to be of solid brick, with like capping; its height thirty-six feet, and its diameter seventeen feet. The iron revolving turret dome adds half a story. The meridional instruments occupy the wings. The front elevation, a view of which, by the kindness of Mr. Julius Dexter, present secretary of the Astronomical Society, and of the architect, Mr. Samuel Hannaford, we are able to lay before our readers, commends itself by its architectural taste.

The whole new enterprise owes its success thus far to the munificence of Mr. John Kilgour, of Cincinnati, who donated the site and a liberal grant of money. Cincinnati holds that she has good ground of expectancy of success. What they need, what every observatory needs, is, first of all, an astronomer with provision for his maintenance, that he may be, as some of our congregations say when they call a pastor, "free from other avocations and cares." A true astronomer, then, first of all—before even the most imposing edifice or instruments. And one may prove himself to be such, says Admiral Smyth in his *Celestial Cycle*, even without a spacious observatory. Kepler observed on the bridge at Prague; Schroeter studied the moon, and Harding found a planet, from a *gloriette*; Olbers found two planets, and Goldschmidt one, from an attic. Goldschmidt—at first, like our own Clark of Boston, a portrait-painter—found the planet with a spy-glass, satisfied the astronomers inside of the Imperial Observatory, had it named after the city of Paris, *Lutetia*, and received the gold medal of the year. An astronomer with a true conception of his work, with the splendid



objects before him, and the advantages of our day, may largely repay the benefactions of the liberal by the lasting benefits not of mere theory, but of the practical usefulness of discovery.

Will Cincinnati secure such a one, and retain him? Certainly every lover of science and every admirer of the astronomer who laid down his life in our defense will devoutly hope for the highest renewed honors to crown the scenes of his earliest labors of peace, and perpetuate his well-earned and unsullied fame.

## II.—THE UNITED STATES NAVAL OBSERVATORY.

The history of this observatory is no little remarkable. It shares with our other government scientific institutions in strange records as to its birth and name. The Military Academy was at first known only as the "School for Engineers," unorganized, and sheltered for its very existence under the wing of the War Department; and the "Naval School" at Philadelphia, and afterward at Annapolis, was for years little more than a rendezvous from which restless midshipmen could escape from study, or the Navy Department could pick them up for sea service. To this day, having no legislative organization, it has Congressional authority by the successive appropriations granted to the Navy Department, and by such legislation as our Congressmen have made when giving to themselves

the nomination of candidates to the academy.

Of the Naval Observatory it may be still more strikingly shown that, although, like the two institutions we have named, it is now firmly fixed in the ideas of the country, its origin and growth have been very strangely secured. Holding the enviable position accorded to it by the much older European observatories, it has to look back upon a very humble birth, and was christened, as one may say, under a false name.

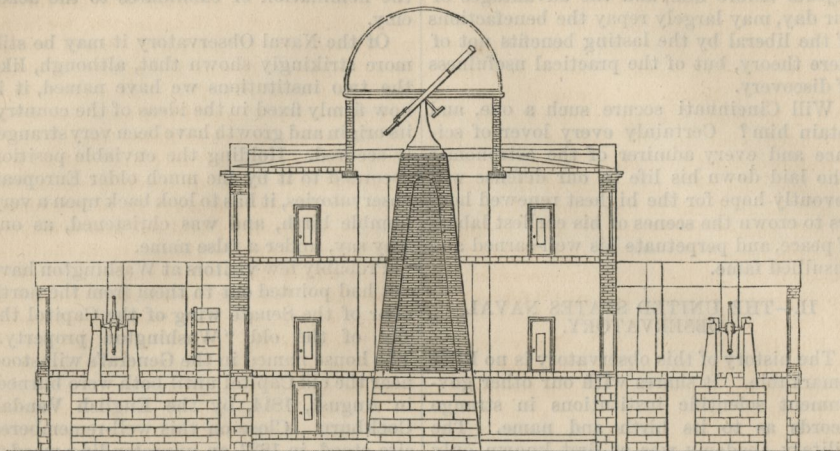
Probably few visitors at Washington have not had pointed out to them from the north door of the Senate wing of the Capitol the site of the old "Washington property." The house named in the General's will stood near the old Capitol until both were burned, in August, 1814, by the English Vandal, Cockburn. Close on this well-remembered site stood, in 1833, an unpretending wooden building but sixteen feet square, erected at the expense of a lieutenant of the navy, and equipped with a five-foot Troughton transit instrument. This was our Naval Observatory in embryo.

The transit was one of the instruments made for the Coast Survey, under the supervision of Mr. Hassler, its first superintendent, during his long detention in England; for it may be remembered that the beginnings of our Coast Survey work also were slow enough. Under the act of 1807 Mr. Hassler was appointed superintendent, but this was not till the year 1811; and on his



UNITED STATES NAVAL OBSERVATORY, WASHINGTON, D. C.





SECTION OF MAIN BUILDING—UNITED STATES NAVAL OBSERVATORY, 1844.

visit to London to secure his instruments, then so slowly constructed, he was caught there by the breaking out of the war. Returning only in 1815, and the survey itself being soon arrested by Congress, his instruments and the "fixed observatory," the establishment of which he was the very first in this country to propose, rested quietly *in statu quo ante bellum*. In 1832 the Coast Survey was revived; but as an observatory was peremptorily forbidden by the law, the transit was loaned to Lieutenant Wilkes for his observations; and Mr. Hassler from this date, instead of further urging the creation of an observatory under the Coast Survey, or of exhibiting any jealousy of the new institution when afterward secured, accepted its legitimate separate existence and objects, and always gave them his cordial support.

Lieutenant Wilkes's observations were, however, at first only for obtaining clock errors, needed for determining the true time for rating the naval chronometers then under his charge. This testing of all the chronometers and other naval instruments used by our ships (begun in 1830 by Lieutenant Goldsborough) had been at once found a wise and useful economy for the navy. The secretary, therefore, established this little receptacle for charts and instruments by placing an officer in charge, permitting him to build his own little observatory and do his own work. The "Dépôt" was the christening then given to the establishment. This was all that Wilkes or any one of his successors dared call it even as late as 1842, when establishing the veritable present astronomical institution. Hassler had proposed an observatory, and Gallatin and Jefferson had indorsed his plan; Monroe, when Secretary of State, had recommended it in a report to the House of Representatives; President Adams had urged it in 1825, in

1838, and in 1842; but for partisan reasons it was again and again peremptorily forbidden, and remains so to this day to the Coast Survey.

But in 1838 a new call was made upon the Dépôt, which turned the whole current of its future. The exploring expedition was about to sail for the South Seas. It would be of prime importance, in determining the longitude of places to be visited by the expedition, that corresponding astronomical observations should be made at home, to be compared on its return. Secretary Paulding gave the observations in the United States to Lieutenant Gilliss, Wilkes's successor at the Dépôt, and to Professor Bond, of Cambridge. For the years 1838-42 Gilliss worked most accurately and unremittingly. With the help of an achromatic telescope, added by the Navy Department, and the transit before mentioned, he observed and recorded 10,000 transits; and his observations, afterward tested by Professor Peirce, were ranked by him among the highest then made. They are in the libraries of the astronomers of Europe. They procured, in fact, the founding of the present Naval Observatory.

For this, however, hard work in abundance was to be done. Gilliss urged the unsuitableness of his building erected alongside of Wilkes's wooden square room, and his want of space to erect a permanent circle. He won over the old Navy Commissioners and the indorsement of the secretary to their recommendation for something better. He pressed the Naval Committees frequently and closely, but enlisted scarcely one except Mallory, of the House. Almost to a man they kept away from the Dépôt, although it was "so near," and no help seemed available. But a celestial visitant now appeared, as, singularly enough, another did in 1843



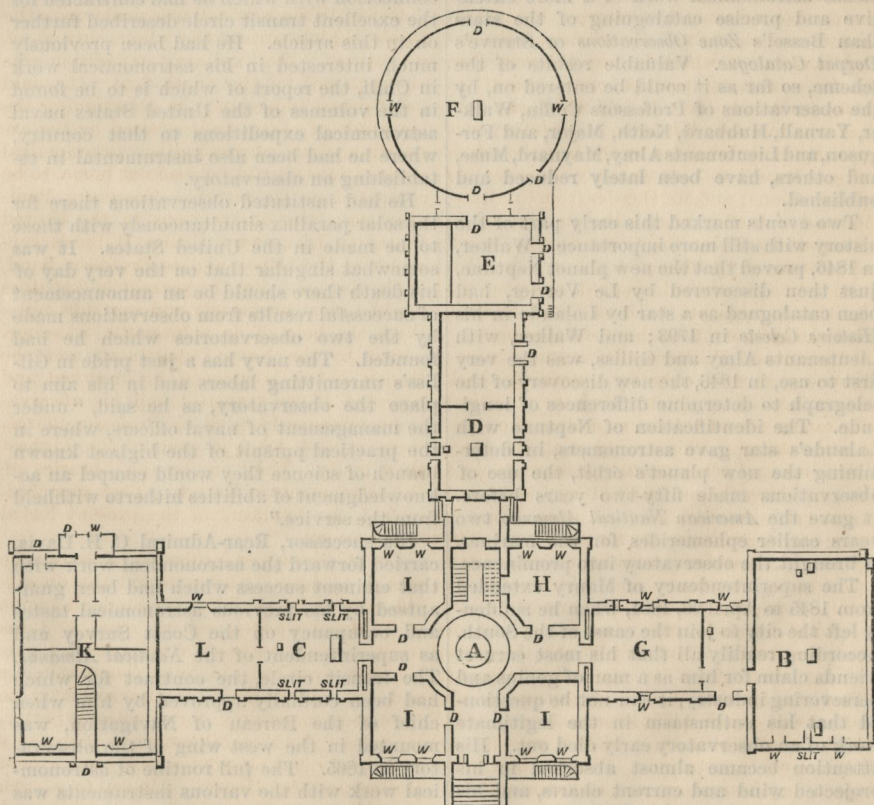
for the benefit of the Cambridge Observatory. It gained the day for Gilliss, and for an observatory at Washington. He had closely observed Encke's comet, and read a paper on it before the National Institute. When he made, shortly after this, his last intended visit to the Senate committee, Preston of South Carolina asked, "Are you the one who gave us notice of the comet? I will do all I can to help you." In a week a bill passed the Senate; and, strangely enough, passed the House also, without discussion, on the last day of its session. It appropriated \$25,000; but still "for a Dépôt of Charts and Instruments."

But the Secretary of the Navy was no longer officially bound by the name. The report of the committee, which secured the bill, was so expressly in favor of astronomical, meteorological, and magnetic objects, that Congress was justly understood to sanction them. Gilliss was sent abroad for instruments and plans for an observatory.

The site chosen by President Tyler for the building was fraught with historic interest. It embraces the whole of "Reservation No.

4," made, by the old commissioners for laying out the city of Washington, for a national university—a favorite idea of General Washington. It was the landing-place of Braddock, April 11, 1755. At a later day it was known as Camp Hill, from its being occupied by the American forces the day before their unfortunate advance and retreat from Bladensburg. The square embraces a little more than nineteen acres in measurement. It is now tastefully laid out and ornamented. Nearly central within it stands the building of which the front elevation is given on page 531. It is on the second highest eminence within the city limits, commanding the view of the public buildings, of the neighboring cities of Georgetown and Alexandria, and of Arlington.

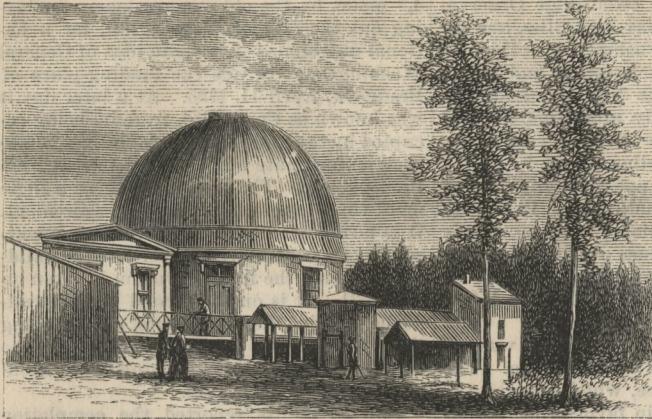
In 1844 Gilliss reported the completion and equipment of the central building shown in our plate. He had secured the excellent equatorial, the meridian circle, the transit, prime vertical, and mural circle on which so much valued work has been done. He had begun a library, to which nearly two hundred volumes of the highest standard



THE UNITED STATES NAVAL OBSERVATORY—GROUND PLAN.

A, Pier of Equatorial. B, Transit Circle. C, Mural Circle and Transit. D, Prime Vertical. E, Computer's Room for Great Equatorial. F, Great Equatorial. G, Library. H, Superintendent's Office. I, I, I, Offices. K, Superintendent's Dwelling. L, Chronometer-Room. D, Door. W, Window.





NEW DOME FOR THE GREAT EQUATORIAL—UNITED STATES NAVAL OBSERVATORY.

works were donated by the Greenwich, Paris, Berlin, and Vienna institutions.

Lieutenant M. F. Maury was placed in charge, and entered on his duties with zealous purposes. He proposed in 1846 the immense astronomical work of a more extensive and precise cataloguing of the stars than Bessel's *Zone Observations* or Struve's *Dorpat Catalogue*. Valuable results of the scheme, so far as it could be entered on, by the observations of Professors Coffin, Walker, Yarnall, Hubbard, Keith, Major, and Ferguson, and Lieutenants Almy, Maynard, Muse, and others, have been lately reduced and published.

Two events marked this early part of the history with still more importance. Walker, in 1846, proved that the new planet Neptune, just then discovered by Le Verrier, had been catalogued as a star by Lalande in his *Histoire Celeste* in 1793; and Walker, with Lieutenants Almy and Gilliss, was the very first to use, in 1846, the new discovery of the telegraph to determine differences of longitude. The identification of Neptune with Lalande's star gave astronomers, in determining the new planet's orbit, the use of observations made fifty-two years before. It gave the *American Nautical Almanac* two years earlier ephemerides for the mariner. It brought the observatory into prominence.

The superintendency of Maury extended from 1845 to April 26, 1861, when he suddenly left the city to join the cause of the South. According readily all that his most earnest friends claim for him as a man of genius and persevering industry, it can not be questioned that his enthusiasm in the legitimate work of an observatory early died out. His attention became almost absorbed in his projected wind and current charts, and his shortened ocean routes. Of this no proof is needed other than that shown in the few annual volumes of astronomical observations which he published in the years 1846-

50, and in the failure to issue any others for the eleven following years. His labors in connection with ocean routes are now daily more and more appreciated.

In 1861 Lieutenant J. M. Gilliss was at length placed in charge. He re-established and vigorously pressed forward astronomical work as well as the duties of the "Hydrographical Office," a title which had been added to

that of the Naval Observatory. At the time of his very sudden death, after a brief superintendency of less than four years, he was earnestly engaged in bringing forward the legitimate work of the observatory, in connection with which he had contracted for the excellent transit circle described further on in this article. He had been previously much interested in his astronomical work in Chili, the report of which is to be found in the volumes of the United States naval astronomical expeditions to that country, where he had been also instrumental in establishing an observatory.

He had instituted observations there for the solar parallax simultaneously with those to be made in the United States. It was somewhat singular that on the very day of his death there should be an announcement of successful results from observations made by the two observatories which he had founded. The navy has a just pride in Gilliss's unremitting labors and in his aim to place the observatory, as he said, "under the management of naval officers, where in the practical pursuit of the highest known branch of science they would compel an acknowledgment of abilities hitherto withheld from the service."

His successor, Rear-Admiral C. H. Davis, carried forward the astronomical work with that eminent success which had been guaranteed by his previous astronomical tastes and occupancy on the Coast Survey and as superintendent of the *Nautical Almanac*. The transit circle, the contract for which had been cordially approved by him when chief of the Bureau of Navigation, was mounted in the west wing of the observatory in 1865. The full routine of astronomical work with the various instruments was maintained by the several professors in charge. In addition to various other calls upon Admiral Davis by the Navy Department, he prepared, under a resolution of the



Senate, a report on the subject of an inter-oceanic ship-canal, 8000 copies of which with its accompanying maps were distributed by Congress and by the observatory. Within two brief years he took command of the South Atlantic squadron.

Rear-Admiral B. F. Sands, succeeding him in the year 1867, has most efficiently improved the opportunities of a longer superintendency to inaugurate and carry forward some of the most important astronomical operations of the day. To these we can only refer.

The phenomena of the total eclipses of 1869 in the United States and of 1870 in the Mediterranean countries were closely observed. Their fully illustrated reports were published by Congress in large editions, now exhausted.

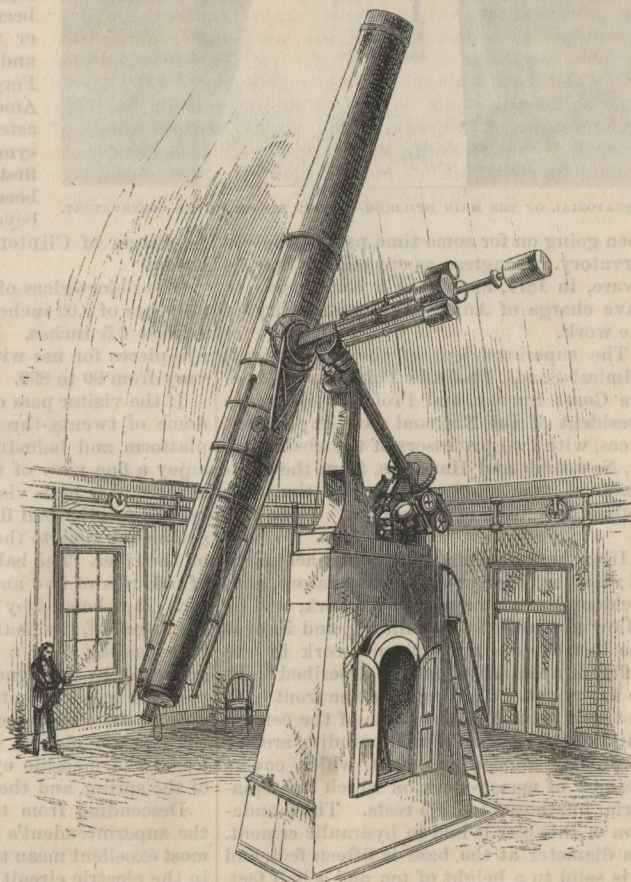
Beyond the regular and severely exacting astronomical routine of observations, two centres of interest have been recently occupying the utmost activities of the institution: the reception, mounting, and use of the new great equatorial, and preparations for going out to observe the transit of Venus of December 8, 1874.

The great equatorial has but one near approach to itself in the diameter of its object-glass—that of the private amateur establishment of Mr. R. S. Newall, at Gateshead, England, whose telescope has an objective of twenty-five inches in diameter. The Naval Observatory glass has twenty-six inches clear aperture. It is not easy to realize what this power is, and what it promises. The reader must imagine himself within a dome, itself forty-one feet in diameter and forty feet in height, looking through a tube made of three sections of steel stretching away for thirty-two feet; the whole telescope and its metallic base weighing about six tons.

Among the friends of the observatory who aided in secur-

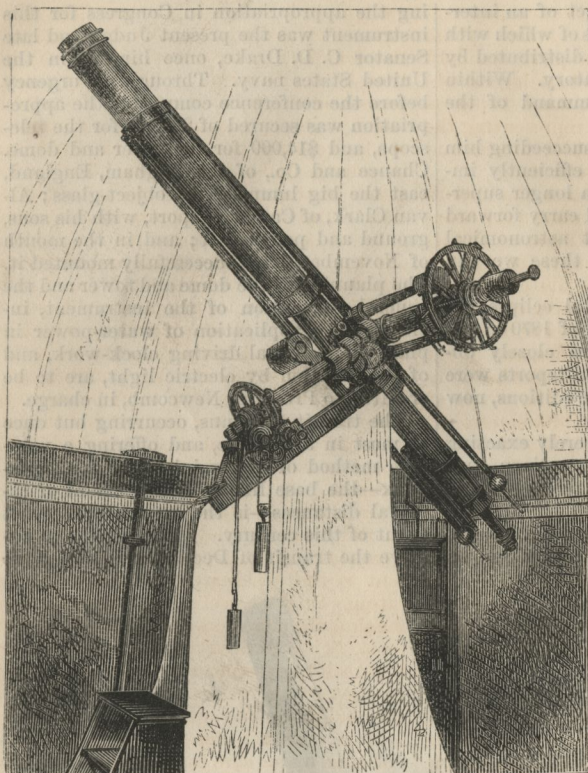
ing the appropriation in Congress for this instrument was the present Judge and late Senator C. D. Drake, once himself in the United States navy. Through his urgency before the conference committee the appropriation was secured of \$50,000 for the telescope, and \$14,000 for its tower and dome. Chance and Co., of Birmingham, England, cast the big lump for the object-glass; Alvan Clark, of Cambridgeport, with his sons, ground and polished it; and in the month of November, 1873, successfully mounted it. The planning of the dome and tower and the general conception of the instrument, including the application of water-power in place of the usual driving clock-work, and of illumination by electric light, are to be credited to Professor Newcomb, in charge.

The transit of Venus, occurring but once at most in a lifetime, and offering a valuable method of determining the sun's parallax—the base line of measurement of celestial distances—is the astronomer's great event of this century. Preparations to observe the transit of December 8, 1874, have



THE GREAT EQUATORIAL—UNITED STATES NAVAL OBSERVATORY.





EQUATORIAL OF THE MAIN BUILDING—UNITED STATES NAVAL OBSERVATORY.

been going on for some time past at the observatory. Congress, as our readers may be aware, in 1871, appointed a commission to have charge of America's responsibility in the work.

The superintendent of the observatory, Admiral Sands, Professor Peirce as head of the Coast Survey, and Professor Henry as President of the National Academy of Sciences, with two professors of the observatory, Newcomb and Harkness, form the commission. One hundred and fifty thousand dollars have been appropriated.

If we have now made the reader acquainted with the progress of the observatory, and, incidentally, with a part of its work, will he follow us through the building, and inspect the instruments and officers' work in the different apartments not yet described? If he has registered his name in the front hall, and will ascend to the dome of the central building, he will find himself winding around a circular wooden casement, which covers the pier of mason-work on which the equatorial purchased in 1845 rests. The foundation of this pier is laid in hydraulic cement. Its diameter at the base is fifteen feet, and it is solid to a height of ten and a half feet, where the diameter is twelve feet. On this

is a conical pier of hard-burned brick, of which the diameter at the base is twelve feet, and the height twenty-eight feet; the diameter at the top is seven feet, and the walls three feet thick to within ten feet of the top, gradually increasing in thickness, the last three feet being solid. The pier is capped by New York flagging stone, on which rests the pedestal, which is one block weighing seven and a half tons. On this stands the fine equatorial made by Merz and Mähler, Munich, at a cost of \$6000, its object-glass being valued at more than half that sum.

The work of this instrument under, successively, Professors Ferguson, Walker, Hubbard, and Hall, has been chiefly upon the smaller planets, the asteroids, and comets. Mr. James Ferguson was the first of Americans to discover an asteroid, naming Euphrosyne in 1854, the thirty-first on a list which has been recently enlarged beyond even a hundred.

by Peters of Clinton and Watson of Ann Arbor.

The object-glass of the equatorial has an aperture of 9.62 inches and a focal length of 14 feet 4.5 inches. Its powers of positive eye-pieces for use with its filar micrometer vary from 90 to 899.

If the visitor pass out from this revolving dome of twenty-three feet diameter to the platform and balustrade around it, he may enjoy a fine view of the city and the Potomac; and if he is visiting precisely at 12 M. he will see the ball drop from the flag-staff, giving the time to the city and the shipping on the river. The ball itself is a frame-work of oak ribs of two and a half feet in diameter. It is hoisted by halyards to the top of the flag-staff, the metal eye at the end of the rope passing over a steel spring, which is governed by a magnet. At the instant of noon the pressure on the key by the naval officer in the chronometer-room below breaks the electric circuit, the magnet above releases the metallic eye by the flying back of the spring, and the ball drops.

Descending from the dome, and passing the superintendent's office, in which are a most excellent mean time clock, with others, in the electric circuit with the clocks at the departments, ticking each, beat for beat, the



visitor finds himself in the library, now embracing nearly six thousand volumes. These are mostly works of the highest standard value, astronomical and meteorological observations and discussions, some being as old as the year 1482, others representing the full work of the European observatories and learned societies to the present date.

From the library we pass into the transit-circle room, built in 1869, to admire the beautiful instrument, with its collimators and its chronograph. The focal length of the object-glass is 12 feet 1 inch; its clear aperture 8.52 inches; and the power of its eyepieces 135 to 396. The diameter of its circles at the outer edge is 45.30 inches, and at the graduation 43.40 inches, both circles being divided to every two minutes. The power of the reading microscopes is 45.3 diameters. Its collimators have a focal length of 2 feet 11 inches. This instrument, under Professors Newcomb, Harkness, and Eastman, and their assistants, has had for its chief work the more accurate determination of the stars whose places are computed in the *Nautical Almanac*, and of those needed by the Coast Survey. The chronograph, made by Alvan Clark, is of the form known as the Hipp chronograph, with modifications by Professor Harkness.

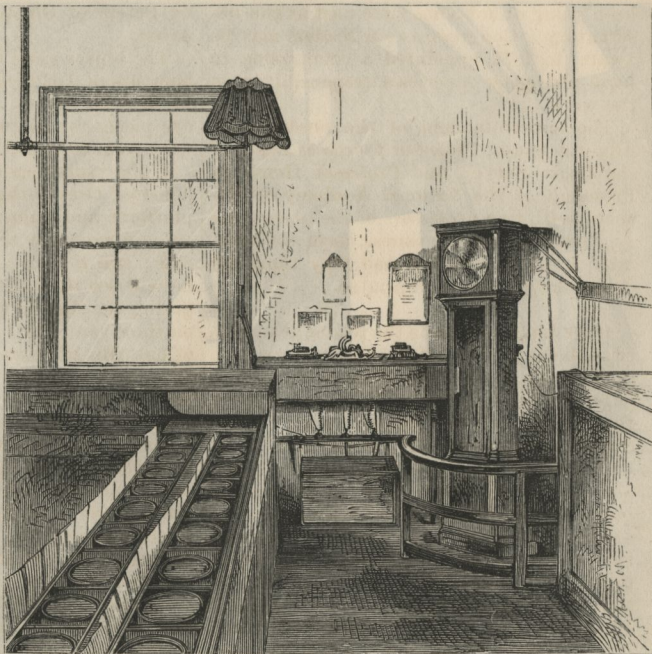
If the visitor now pass to the eastern wing of the observatory, he will find, side by side, the mural circle and the smaller transit instrument, with their clock and chronograph. The mural circle has an object-glass of 4.10 inches, and a focal length of 5 feet 3.8 inches, the highest power of the eyepieces being 240. The diameter of the circle at its outer edge, where the graduation is placed, is 60.35 inches. It is divided to every five minutes; the power of its reading microscope is 17.1 diameters. The transit has a focal length of 7 feet 0.4 inches, and its object-glass an aperture of 5.33 inches.

The open door of our plate on page 538 leads us into the chronometer-room. This shows another and a distinct but important office of the observatory. The relation of all its work to the interests of practical

navigation is sufficiently clear. The whole series of astronomical observations made by the different instruments is designed, like those of the Greenwich Observatory, as expressed in the royal warrant of the astronomer, "to rectify the tables of the motions of the heavens and the places of the fixed stars, in order to find out the so-much desired longitude at sea, and perfect the art of navigation." But the direct appliance of the navigator at sea to determine his longitude, in addition to the use of these and of his own observations of the heavens, is found in his faithful chronometer at his side. The room is usually well filled with these, which are daily wound and compared with a standard clock. A close record is kept of their rates. The rule of their trial is, to apply twice the difference between the greatest and the least rates during a period of at least six months; rejecting those whose variation exceeds eight seconds.

On the purchase of new instruments, or on the return of the United States vessels from their cruises, chronometers are usually sent to the observatory for inspection and rating. On the vessel's going again into commission, chronometers are furnished from this room, being packed with great care, with their self-registering thermometers, and dispatched by the hands of a trusty officer to the navigating officer of the sea-going vessel.

More than 200 time-keepers have been at one time under care in this room. As many as eighty in 1867 were condemned and with-



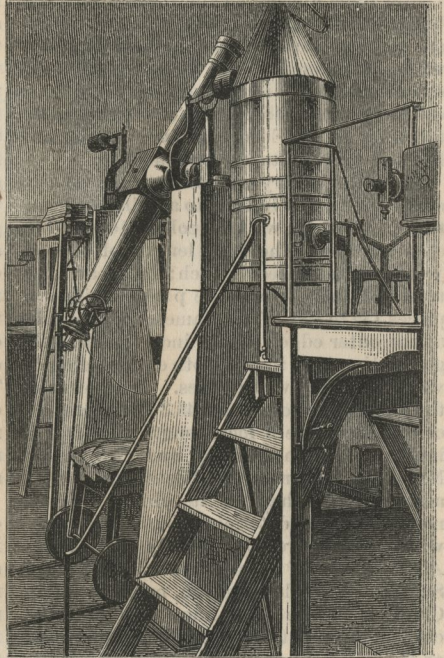
PART OF THE CHRONOMETER-ROOM—UNITED STATES NAVAL OBSERVATORY.



drawn from use. It is as gratifying as it is creditable to American skill to find that the chronometers of Messrs. Negus and Co., of New York, equal, if they do not excel, any of foreign workmanship.

From this room of the observatory the exact time is furnished daily at 12 M. to the Western Union Telegraph office in Washington for dispatch throughout the United States. The naval officer, standing by the standard mean clock, and having the astronomical correction of that clock also before him, at three minutes before 12 M. calls the telegraph operator at his office, and, at the instant of true noon, taps the electric key, giving the time to the company's office. He also drops the dome ball, as before named. The chronometer-room is under the very efficient direction of Commander A. W. Johnson, U.S.N.

We have now taken our visitor through the building so much enlarged since its first erection in 1844, and have had a look at the larger astronomical instruments, omitting some, and excluding from our limited columns notice of the daily meteorological records kept from the time of the establishment of the institution, as well as of the separate reports of cyclones, meteoric showers, etc., made in different years by the professor in charge of this branch, J. R. Eastman, U.S.N. The seven-teen annual volumes of astronomical and meteorological observations now published

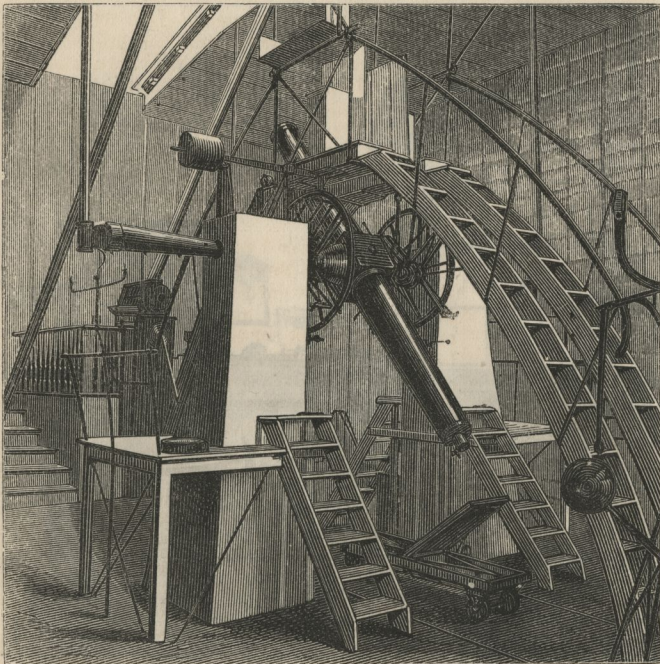


TRANSIT INSTRUMENT—U. S. NAVAL OBSERVATORY.

best set forth in themselves the work of the observatory. The latest of these volumes vie in extent and in value with the publications of Greenwich and Paris. The star

catalogue, issued as Appendix No. 1 to the volume for 1871, embraces more than 100,000 observations, giving the places of 10,000 stars. It is the twenty years' work of Professor M. Yarnall, embracing the reduction of his own observations and those of others from the year 1845 to 1871. The astronomer knows how to appreciate such a work.

The visitor who comes to gratify even an amateur taste can hardly fail to be interested in his inspection of the observatory. And better still for science, the Congress of the nation, in whose hands is the destiny of the insti-



TRANSIT CIRCLE—UNITED STATES NAVAL OBSERVATORY.

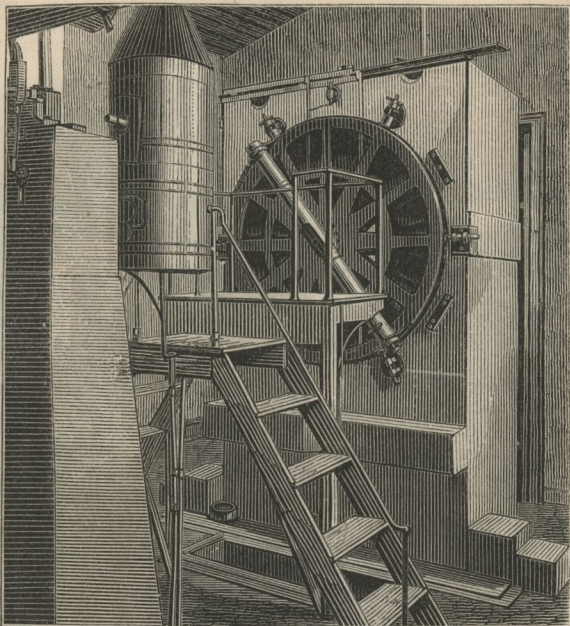


tution, has promptly appreciated its claims, and does not withhold the liberal though economical appropriations asked for it as due to astronomy and to this branch of naval efficiency. Happily what Mr. Seward affirmed in his life of Adams is no longer true of our government, that "while so large a portion of its resources have been wasted in promoting party measures, little or nothing is devoted to the encouragement of the arts and sciences which exalt and refine a people."

### III.—WEST POINT OBSERVATORY.

This was erected in 1839 for astronomical purposes and the accommodation of the library of the academy and its philosophical apparatus. The institution of an observatory is to be credited to Professor W. H. C. Bartlett, LL.D., so well known for more than thirty years as its director. In 1840, Professor Bartlett visited Europe for the government, inspected and reported upon its chief observatories, submitting also a plan for an observatory at Washington, and purchasing for West Point while abroad its three large instruments, the equatorial, the transit, and the mural circle.

The transit instrument in the east tower was made by Ertel and Son, and its object-glass by Merz and Mähler, at Munich, the whole cost being about \$1130. It was mounted in 1843, the memorable year for observatories in the United States. Its object-glass has a clear aperture of 4.62 inches, and a

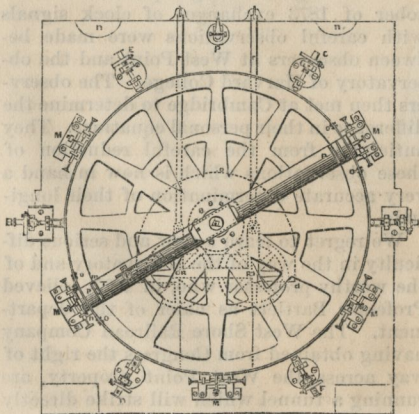


MURAL CIRCLE AND SMALLER TRANSIT INSTRUMENT—UNITED STATES NAVAL OBSERVATORY.

focal length of 76.75 inches. It is provided with four eye-pieces and one dark glass, and has an illuminating apparatus, giving either a bright field with dark lines, or a dark field with bright lines, which can be modified at will by means of a colored wedge. The reticule has seven vertical and two horizontal lines. An extra vertical wire is driven in a horizontal direction by means of a micrometer screw, each division of which corresponds to 0.334". It has a striding level, each small division being  $1.23'' = 0.082s$ . The steel pivots have not sensibly changed their equality of dimensions since the instrument was mounted.

The west tower has the mural circle, by Troughton and Simms, of London. This was cast in one entire piece of brass. Its diameter is five feet, and its graduations are on two bands, one of gold, the other of palladium. The telescope has a clear aperture of four inches, with a focal length of sixty inches.

The central main tower has a revolving dome of twenty-seven feet in diameter, which rests on six 24-pound cannon-balls, turning between cast iron annular grooves. The equatorial, made by Mr. Henry Fitz, of New York, has a focal length of fourteen feet, and a clear aperture of nine and three-quarter inches. It has thirteen eye-pieces. The hour circle reads to two seconds of time, and the declination circle to twenty seconds of an arc, each circle being twenty inches in diameter. This instrument cost \$5000.



PLAN OF MURAL CIRCLE—U. S. NAVAL OBSERVATORY.





WEST POINT OBSERVATORY—NORTH FRONT.

The sidereal clock, by Hardy, has a Bond break-circuit attachment, and is connected with the several instruments by wires and break-circuit keys. Besides these there are valuable portable instruments in the observatory, which loans them from time to time to topographical and surveying parties in our West and Northwest, or to stations of the Engineer Corps, like the one at Willett's Point, New York. Several valuable additions, including a Bond chronograph, theodolites, and sextants, have been made within the last two years.

The purposes of the observatory of the academy are most effectively secured by confining its workings to the end of educating the cadets in the knowledge and practical use of the instruments. During the spring months they are taken in parties of two, three, or four to receive such instruction, and are required themselves to make observations with each instrument, and reduce them. During the summer encampment a month is devoted to further instruction in connection with a field observatory at Fort Clinton, where they use a field transit, zenith telescope, and other instruments. Each makes his own records, and works out his results for the ordinary problems of time, latitude, longitude. Würdeman of Washington is constructing for this field observatory a new transit and zenith telescope.

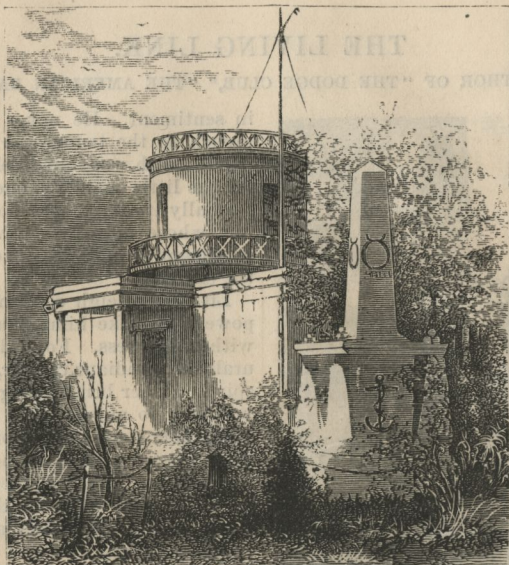
Although the chief design of the observatory has been from the first to secure such proficiency in the cadets as would prove of

most value to them in the field work to which so many army officers are called, and although neither the professors nor their assistants, who are daily instructors in several other branches, can find time available for lengthened series of observations, still at different times valuable observations have been secured in the midst of pressing duties. Among these are those of Professor Bartlett on the great comet of 1843, published in the transactions of the American Philosophical Society, and recent observations under Professor Michie and his assistants, Lieutenant Bass and others, for determining the longitude of the observatory.

On five nights during September and October of 1873 exchanges of clock signals with careful observations were made between observers at West Point and the observatory of Harvard College. The observers then met at Cambridge to determine the difference in their personal equations. They anticipate from the careful reduction of these observations which is now in hand a very accurate determination of their longitude.

We regret to learn a new and serious difficulty in the way of the observatory and of the worthy professor who, in 1871, relieved Professor Bartlett as chief of the department. The West Shore Railroad Company having obtained from Congress the right of way across the West Point property, are running a tunnel which will strike directly under the mural circle tower. If this ne-





ANNAPOLIS OBSERVATORY.

cessitates the removal of the observatory, we trust that Congress will promptly enable the director to locate it in a position free from all disturbing influences, and with an outfit of the best instruments of every form; and that a *personnel* may be detailed from year to year sufficient in number to accomplish what the head of the department desires to attain in astronomical pursuits.

#### IV.—ANNAPOLIS OBSERVATORY.

We can not complete this sketch of our government observatories without a just, though necessarily very brief, notice of the observatory used in the instruction of midshipmen at Annapolis. Our picture gives a correct view of the building, having near it the monument erected to the memory of several passed midshipmen who were lost in the ill-fated brig *Somers*.

The Department of Astronomy was created in 1853, and until 1865 was in charge successively of Professors Chauvenet and Coffin. Since that time a graduate of the academy has from time to time been in charge. The course in astronomy is of necessity limited, most of the midshipman's time in this department being required for the study of practical navigation. We learn from the report of Lieutenant-Commander R. L. Phythian to Admiral Porter in 1869 the following facts: "The instruments used in this department are the chronometer, the sextant, the artificial horizon, the azimuth compass, the surveyor's chain and compass, the theodolite, and the plane-table. The observatory is supplied with a sidereal clock, an equatorially mounted telescope, and a su-

perior meridian circle. These instruments are used in instruction only to show the midshipmen the principles of them. There is not sufficient time for them to acquire a practical knowledge of their use by observing with them."

The equatorial referred to by Lieutenant-Commander Phythian is a refractor constructed in 1857 by Alvan Clark. It has an object-glass of 7.75 inches clear aperture, and nine feet six inches focal length. The tube is mounted equatorially in the German style on a solid cast iron pier, provided with a spring governor driving clock. The finder is a small telescope with an object-glass of 1.7 inches clear aperture, and 20.25 inches focal length. This instrument, loaned by Admiral Porter to one of the parties which observed the solar eclipse of 1869, under Professor Harkness, U.S.N., and Dr. Curtis, U.S.A., is reported by them as having been of most valuable service in the expedition. The meridian circle in this little observatory has also a high reputation.

It is not unlikely that in proportion as the course of study at the Naval Academy advances, by the means now used in requiring a better preparation on the part of students before entering the institution, there will be ample time and a more hearty disposition for the use of these fine instruments, though here, as at West Point, the astronomical work must remain mostly educational. At the great institution at Pulkova a number of army and navy officers reside to perfect themselves for geodetic and astronomical work to be carried on through the empire. Will it be thus in the United States?