History Of Weather Observing at the Naval Observatory, Washington, D.C. 1838-1913

Current as of
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Executive Summary

The Naval Observatory was founded on Dec 6, 1830 as the Depot of Charts and Instruments. It is one of the oldest scientific organizations in the nation. The Observatory originated as a result of the U.S. Navy's need to improve navigation on the high seas, especially in the determination of longitude. The link from navigation to astronomy was natural.

The significant step from depository of navigation materials to scientific investigation occurred in 1834 when the Depot moved from its original location (near the White House) to a site north of the Capitol. The higher ground at this location provided a prime opportunitye for the construction of an observatory, allowing the natural transition from navigational observation to astronomical examination. Routine weather observing also began at this location.

The step into weather observing was initiated in 1838 by Officer in Charge Lt James Melville Gilliss, based on a broad interpretation of a directive from the Secretary of the Navy. Consequently, the Depot and Observatory began taking weather and magnetic observations as part of a process to better understand the physical science of astronomy. The program was taken to an even higher level of quality by Lt Matthew Fontaine Maury, first Superintendent of the Naval Observatory. The weather observations were published in Observatory documents and made widely available.

Initial weather observations were taken four times daily for pressure, temperature, atmospheric moisture, wind, and weather. Weather observing continued at the Capitol Hill site until 1842 when the Observatory moved to temporary quarters on Pennsylvania Avenue. The temporary quarters were needed while permanent facilities were being built at Foggy Bottom in west Washington.

In 1844 the Observatory moved into permanent facilities at Foggy Bottom. It was at this location that an instrument shelter was first used in 1862 by the Observatory, and installed just southwest of the main building. Weather instruments were consolidated around the instrument shelter, except for the barometer (inside the main building) and wind vane (on top of the main building). In 1874, the instrument shelter and its enclosure were moved approximately 20 yards to the west.

In 1893, the Naval Observatory moved to its current location on Massachusetts Avenue NW. The instrument shelter was established approximately 200 feet south of the main building, with the rain gage 50 feet south of the instrument shelter. The barometer was hung in the main building with the wind instruments on the roof of the building.

In the late 19th Century, the Naval Observatory began to deemphasize weather observing to concentrate more on the science of astronomy. Although observations are in the National Climate Data Center database into 1913, parameters observed diminished during the later years of the program.

Naval Observatory Historical Overview

The Naval Observatory was founded Dec 6, 1830 as the Depot of Charts and Instruments. It is one of the oldest scientific agencies in the nation.

The Depot of Charts and Instruments was the result of the U.S. Navy's need to improve navigation on the high seas, especially the determination of longitude. The Depot of Charts and Instruments initially was founded for the purpose of caring for the U.S. Navy's chronometers, charts and other equipment necessary for Navy ships to successfully navigate the seas. As part of the responsibilities of the new organization, in Jul 1831, all navy yards were ordered to ship their charts and nautical books to the new Depot. Navigation instruments from the yards were already acquired by the Depot in early 1831.

Shortly after the formation of the Depot, the natural linkage of astronomical investigation to navigation created the need for an associated observatory. The significant step from depository of navigation materials to scientific examination occurred in 1834 when the Depot moved from its original location (near the White House) to a site north of the Capitol. The higher ground at this location provided a prime opportunity for the construction of an observatory. This transition essentially had its beginning in the late 1830s, the approximate time weather observations were first taken by the Depot and Observatory.

The step into weather observing was initiated in 1838 by Officer in Charge Lt James Melville Gilliss based on a broad interpretation of a directive from the Secretary of the Navy. Consequently, the Depot and Observatory began taking weather and magnetic observations as part of a process to better understand the physical science of astronomy. The observations were published in Observatory documents and made widely available.

During the 1840s, the Navy Depot was transformed into an Observatory and Hydrographic Office that started down the path toward international leadership in science. The magnetic and meteorological observations were part of the evolution from inventory and calibration to science as described by Lt Gilliss in 1845:

> "I should have regarded it as time misspent to labor so earnestly only to establish a depot. My aim was higher. It was to place an institution 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."*

* - From *Sky and Ocean Joined* by Steven J. Dick.

In 1844, the Observatory moved to a location at 24th and E Streets NW (Foggy Bottom) where it would reside for almost 50 years. Having the facilities and equipment unparalleled in the Nation, and under the leadership of its new Superintendent Matthew Fontaine Maury, the Observatory began to build its worldwide reputation in science. In 1854, the Secretary of the Navy directed the new name should be, "United States Naval Observatory and Hydrographic Office," and in 1866, the Hydrographic Office moved to another location in Washington D.C. to become the Naval Oceanographic Office.

The Civil War years saw a heavy demand on the Naval Observatory as it struggled under the increased workload of providing navigational instruments and charts to the U.S. Navy tasked with a massive blockade of the Confederacy.

In the post-Civil War years, the Observatory became one of the world's leading astronomical observatories. Thousands of astronomical observations were made and documented, and teams were dispatched around the world to record astronomical events, e.g., recording the transit of the planet Venus across the solar disk. In 1873, the largest refracting telescope in the world (26 inches) was installed at the Naval Observatory.

After nearly 50 years at Foggy Bottom, being hampered by fog and deteriorating buildings, the Naval Observatory moved to its current location on Massachusetts Avenue in northwest Washington. At the time, the site was located well outside the city, but the municipality quickly spread to encompass the Observatory.

Since its formation in 1830, the Naval Observatory has been located at five separate sites within the city of Washington D.C:

1. 17th and G Streets NW – 1830-1834
2. North Capitol Street approximately 1,200 feet north of the Capitol – 1834-1842
3. Temporary quarters at 2222 Pennsylvania Avenue NW – 1842-1844
4. Foggy Bottom at 24th and E Streets NW – 1844-1893
5. 3200 Massachusetts Avenue NW – 1893-Present

Weather observing began in 1838 at the Capitol Hill Observatory just north of the Capitol and continued at the temporary quarters, Foggy Bottom location, and at the Massachusetts Avenue location. Official observations at the Naval Observatory ended in 1913 (based on records in the National Climate Data Center database).

Location Descriptions

After establishing the Depot of Charts and Instruments in Dec 1830, it was apparent a suitable location was needed to store the chronometers and other navigation instruments not assigned to Navy ships. In February 1831, a site was selected at 17th and G Streets, just northwest of the White House (Figure 1). The building was a two-story brick house comprised of two relatively small rooms and a dry cellar. No weather observations were taken at this location.

Figure 1. First location of the U.S. Navy Depot of Charts and Instruments at 17th and G Streets NW (plotted on a current map of Washington D.C.). The Depot was at this location from Feb 1831 until May 1834.

In Mar 1833, a new Officer in Charge (Lt Charles Wilkes) was assigned to the Depot and he quickly realized a new location was needed. The soil around the old building was continually wet, increasing the humidity, and affecting instrument work of the Depot. The new location was a building on higher ground 1,000 - 1,200 feet north of the Capitol (Figure 2). Elevation for this site was quoted as "72 feet above ordinary low water at the base of Capitol Hill" (topographical map indicates the elevation approximately 65 feet). The higher ground provided a good location for the construction of an observatory. This location became known unofficially as the "Depot and Observatory" or "Capitol Hill Observatory." The Capitol Hill location was approximately one and one-half miles east southeast of the site at 17th and G Streets. Meteorological observations were first taken by the Depot and Observatory at this location beginning in 1838.

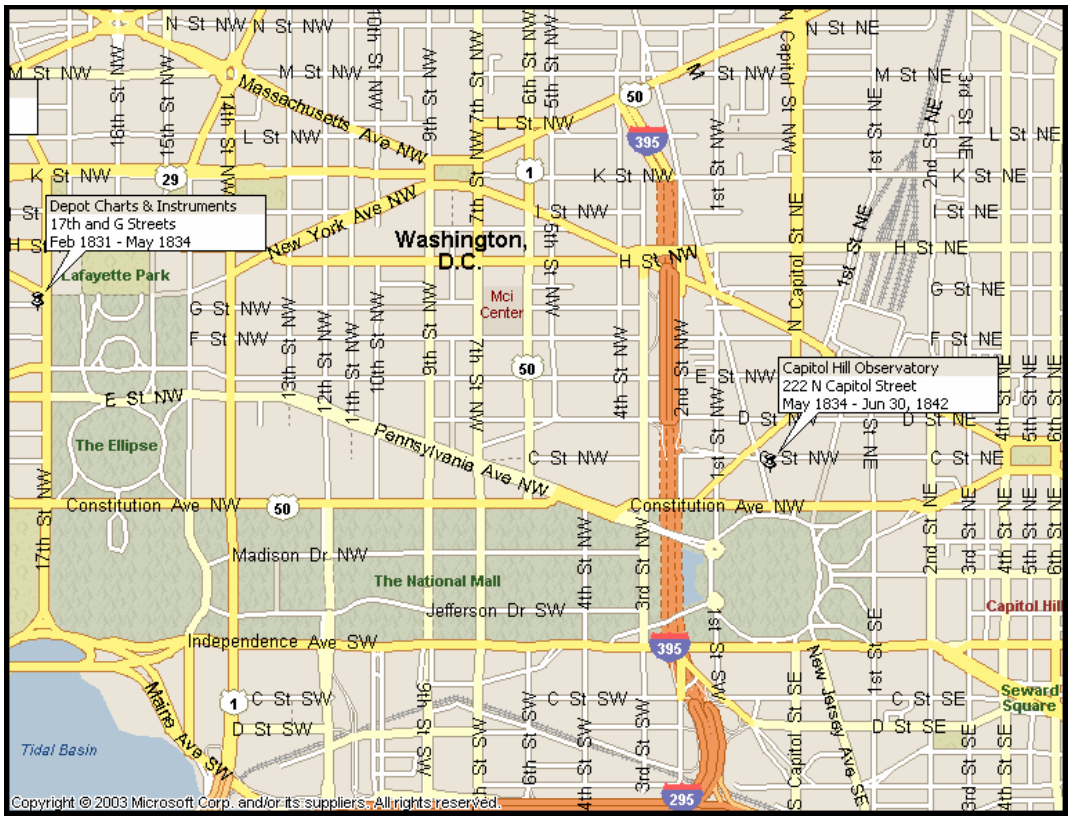


Figure 2. Location of the U.S. Navy Depot of Charts and Instruments May 1834 – Jun 30, 1842 (plotted on a current map of Washington D.C.). Also shown is the previous location of the Depot.

By 1841, it was apparent the Capitol Hill location was inadequate for the Depot and Observatory. In particular, the building was unsuitable and space was lacking. Actions were started for a permanent home for the Navy Depot and a search started for temporary quarters. By mid 1842, a temporary location was found at 2222 Pennsylvania Avenue NW (Figure 3) approximately two miles west northwest of the Capitol Hill site. The last observation was taken at the Capitol Hill site on Jun 30, 1842. Approximate elevation for the Pennsylvania Avenue site is 70 feet.

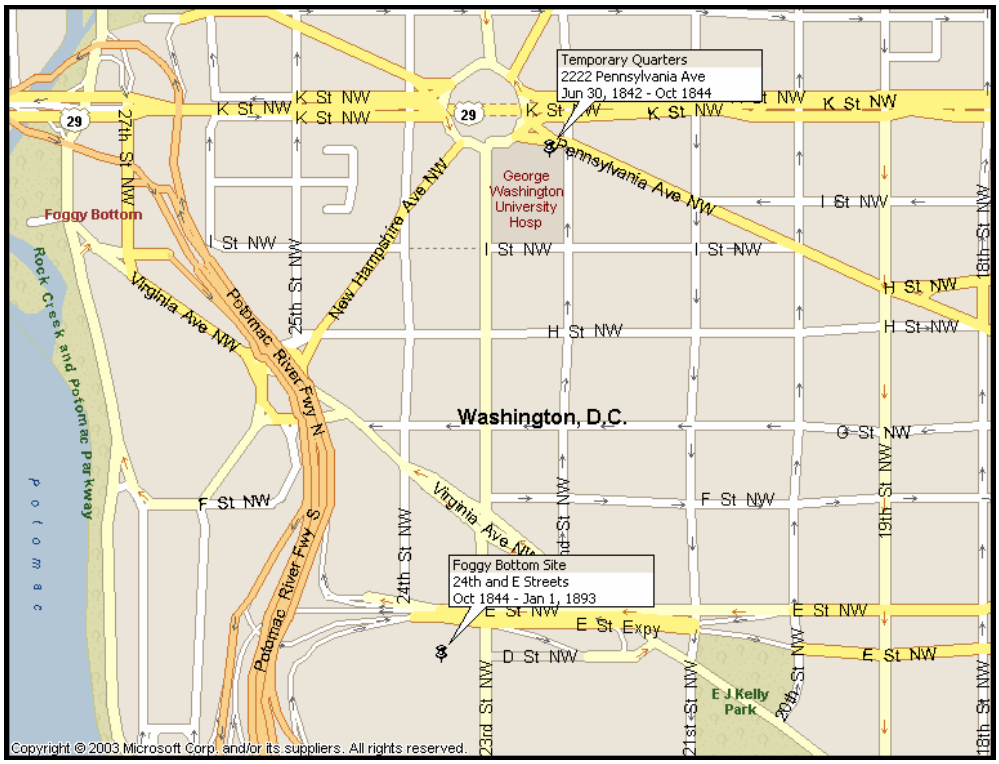


Figure 3. Temporary quarters (Jun 30, 1842 – Oct 1844) for U.S. Navy Depot of Charts and Instruments, as well as Foggy Bottom location for the U.S. Naval Observatory (Oct 1844 – Jan 1, 1893). Locations are plotted on a current map of Washington D.C.

In Oct 1844 the permanent home was ready at Foggy Bottom (Figure 3), located almost one-half mile south southwest of the temporary quarters. The size of the new site was approximately 17 acres, situated on the north bank of the Potomac River. The highest point was about 100 feet above the river with the ground sloping on both the south and west sides (Naval Observatory document listed the elevation as, "103 feet above mean half-tide water of the Potomac" (elevation on the topographic map is approximately 90 feet).

Almost 50 years later, it became apparent a new location was needed for the Naval Observatory. Nearness of the Potomac River to Foggy Bottom created health problems for the Observatory's staff, as well as causing problems with the instruments. A location almost two miles northwest of the Foggy Bottom site was selected-a location in the country and away from the populated Washington D.C. On Jan 1, 1893, the Naval Observatory moved into its current home on Massachusetts Avenue NW (Figure 4), almost two miles northwest of the Foggy Bottom location. Approximate elevation for this location is 265 feet.

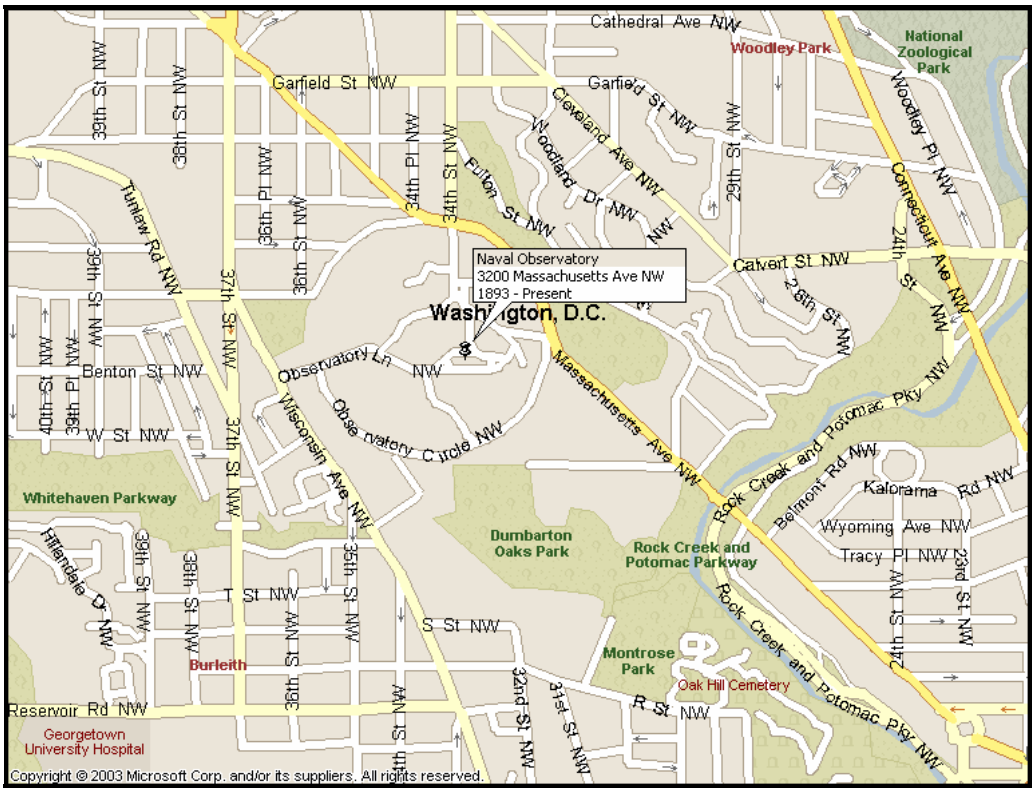


Figure 4. Current location of the Naval Observatory (Jan 1, 1893 to present) plotted on a current map of Washington D.C.

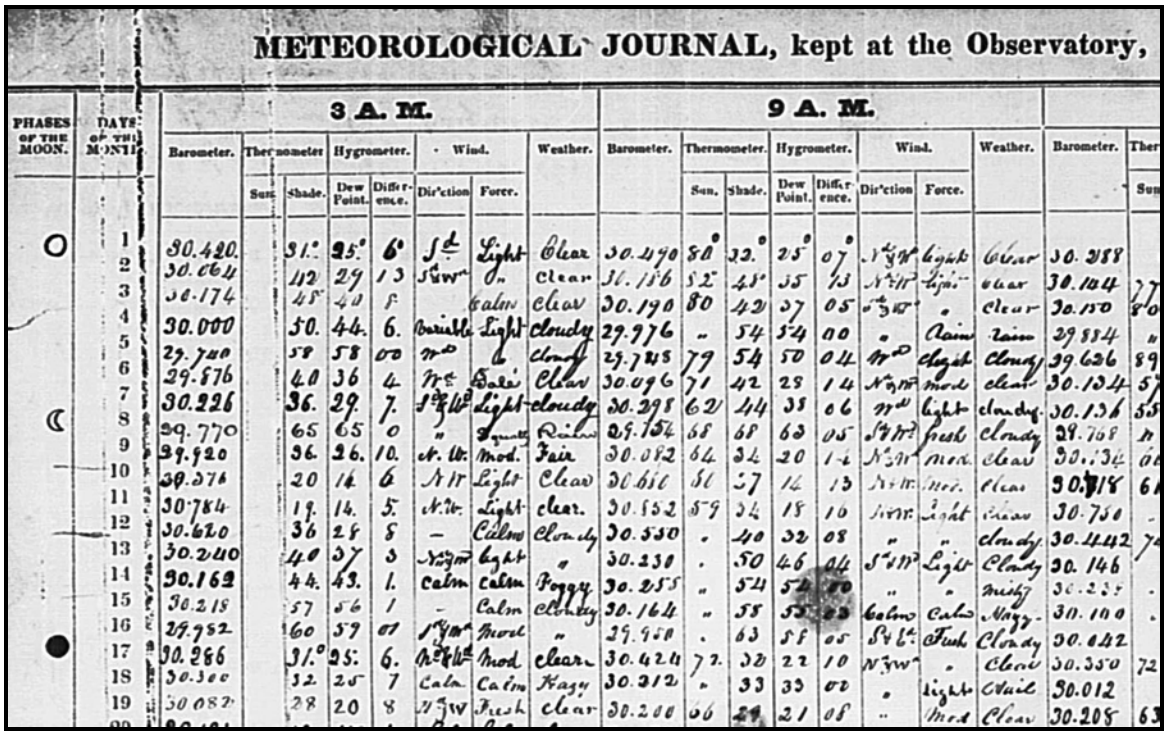
Instrumentation Descriptions

Location at 17th and G Streets NW – Feb 1831-May 1834

All sources indicate no weather observations were taken at this location.

Capitol Hill Location – 1834-1842

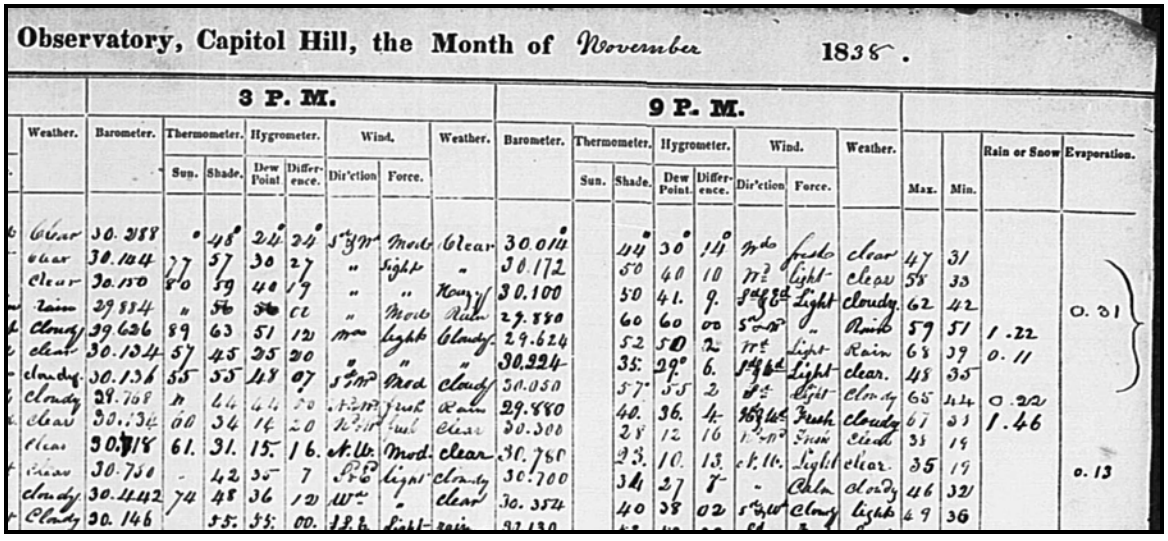
First weather observations by the Naval Observatory were taken in 1838 at the Capitol Hill location. Naval Observatory records indicate the first observations were taken in Jul 1838, and first observations in the NCDC database are for Nov 1838 (Figures 5a and 5b).



METEOROLOGICAL JOURNAL, kept at the Observatory,

PHASES OF THE MOON.	DAYS OF THE MONTH.	3 A. M. Barometer.	Thermometer. Sun.	Thermometer. Shade.	Hygrometer. Dew Point.	Hygrometer. Difference.	Wind. Dir'ction	Wind. Force.	Weather.	9 A. M. Barometer.	Thermometer. Sun.	Thermometer. Shade.	Hygrometer. Dew Point.	Hygrometer. Difference.	Wind. Dir'ction	Wind. Force.	Weather.	Barometer.	Ther Sun
○	1	30.420		31°	25°	6°	S.E.	Light	Clear	30.490	80°	32°	25°	07°	N.W.	Light	Clear	30.288	
	2	30.664		42	29	13	S.W.	"	clear	30.556	52°	48°	35	13	N.W.	Light	clear	30.424	77
	3	30.174		48°	40	8°		Calm	clear	30.190	80	42	37	05	S.W.	"	Clear	30.150	80
	4	30.000		50.	44.	6.	Variable	Light	Cloudy	29.976	"	54	54	00	"	Calm	Rain	29.884	"
	5	29.720		58	58	00	N.E.	"	Cloudy	29.748	79	54	50	04	N.E.	Light	Cloudy	29.626	89
	6	29.876		40	36	4	N.E.	Calm	Clear	30.096	71	42	28	14	N.W.	Mod.	clear	30.134	57
☾	7	30.226		36.	29.	7.	S.E.	Light	cloudy	30.298	62	44	38	06	N.E.	Light	cloudy	30.136	55
	8	29.770		65	65	0	"	Squally	Rain	29.154	68	68	63	05	S.W.	Fresh	Cloudy	29.768	"
	9	29.920		36.	26.	10.	N.W.	Mod.	Fair	30.082	64	34	20	14	N.W.	Mod.	Clear	30.134	60
	10	30.276		20	14	6	N.W.	Light	Clear	30.656	51	27	14	13	N.W.	Mod.	Clear	30.718	61
	11	30.784		19.	14.	5.	N.W.	Light	clear.	30.752	59	34	18	16	N.W.	Light	Clear	30.750	-
	12	30.620		36	28	8	—	Calm	Cloudy	30.550	"	40	32	08	"	"	cloudy	30.442	74
	13	30.240		40	37	3	N.W.	light	"	30.238	"	50	46	04	S.W.	Light	Cloudy	30.146	
	14	30.162		44.	43.	1.	Calm	Calm	Foggy	30.255	"	54	52	02	"	"	misty	30.255	"
	15	30.218		57	56	1	-	Calm	Cloudy	30.164	"	58	53	05	Calm	Calm	Hazy	30.100	"
	16	29.952		60	57	03	S.W.	Mod.	"	29.958	"	63	58	05	S.W.	Fresh	Cloudy	30.042	
●	17	30.286		31.°	25.	6.	N.W.	Mod.	clear.	30.424	32°	32	22	10	N.W.	"	Clear	30.350	72
	18	30.300		32	25	7	Calm	Calm	Hazy	30.212	"	33	33	00	"	Light	Hail	30.012	
	19	30.082		28	20	8	N.W.	Fresh	clear	30.200	66	29	21	08	"	Mod.	Clear	30.208	63

Figure 5a. First observations available for the Naval Observatory (Nov 1838). Left part of the form is depicted with the right part in Figure 5b. From the official station history files at the National Climatic Data Center.



Observatory, Capitol Hill, the Month of November 1838.

Weather.	3 P. M. Barometer.	Thermometer. Sun.	Thermometer. Shade.	Hygrometer. Dew Point	Hygrometer. Difference.	Wind. Dir'ction	Wind. Force.	Weather.	9 P. M. Barometer.	Thermometer. Sun.	Thermometer. Shade.	Hygrometer. Dew Point.	Hygrometer. Difference.	Wind. Dir'ction	Wind. Force.	Weather.	Max.	Min.	Rain or Snow	Evaporation.
Clear	30.288	°	48°	24°	24°	S.W.	Mod.	Clear	30.014		44°	30°	14°	N.E.	Fresh	clear	47	31		
clear	30.144	77	57	30	27	"	Light	"	30.172		50	40	10	N.E.	Light	clear	58	33		
Clear	30.150	80	59	40	19	"	"	Hazy	30.100		50	41.	9.	S.E.	Light	cloudy	62	42		0. 31
Rain	29.884	"	56	56	00	"	Mod.	Rain	29.880		60	60	00	S.E.	"	Rain	59	51	1.22	
Cloudy	29.626	89	63	51	12	N.E.	Light	Cloudy	29.624		52	50	2	N.E.	Light	Rain	63	39	0. 11	
clear	30.134	57	45	25	20	"	"	"	30.224		35.	29°	6.	S.E.	Light	clear.	48	35		
cloudy	30.136	55	55	48	07	S.W.	Mod.	cloudy	30.050		57°	55	2	N.E.	Light	Cloudy	65	44	0.22	
Cloudy	29.768	n	44	44	00	N.W.	Fresh	Rain	29.880		40.	36.	4.	S.E.	Fresh	Cloudy	61	31	1.46	
Clear	30.134	60	34	14	20	N.W.	Fresh	Clear	30.300		28	12	16	N.W.	Fresh	Clear	35	19		
Clear	30.718	61.	31.	15.	16.	N.W.	Mod.	clear	30.780		23.	10.	13.	N.W.	Light	clear.	35	19		
Clear	30.750	-	42	35	7	S.E.	Light	Cloudy	30.700		34	27	7	-	Calm	Cloudy	46	32		0. 13
cloudy	30.442	74	48	36	12	W.	"	clear	30.354		40	38	02	S.W.	Light	Cloudy	49	36		
Cloudy	30.146		55.	55.	00.	S.E.	Light	Rain	30.130											

Figure 5b. First observations available for the Naval Observatory (Nov 1838). Right part of the form is depicted with the left part in Figure 5a. From the official station history files at the National Climatic Data Center.

The following were measure/observed four times daily (3 AM, 9 AM, 3 PM, 9 PM) during the initial observations:

1. Atmospheric pressure (inches of mercury)
2. Temperature (shade and sun; degrees Fahrenheit)
3. Dew point temperature (degrees Fahrenheit)
4. Wind direction (eight point compass)
5. Wind force (calm, light, moderate, etc.)
6. Weather type (clear, cloudy, rain, etc.)

In addition, maximum and minimum temperatures were recorded daily, as well as evaporation (nearest one-hundredth of an inch) and 24-hour precipitation (nearest one-hundredth of an inch).

In Jan 1841, the observations were taken four times daily (3 AM, 9 AM, 3 PM, and 9 PM) with the parameters changed to the following:

1. Atmospheric pressure (inches of mercury)
2. Temperature (attached thermometer, shade, and in the sun; degrees Fahrenheit)
3. Wet bulb and dew point (degrees Fahrenheit)
4. Wind direction (eight point compass)
5. Wind force (calm, light, moderate, etc.)
6. Weather type (clear, cloudy, rain, etc.)

In addition, maximum and minimum temperatures were recorder once daily, as well as daily values of rain or melted snow.

NOTE – Based on recorded temperatures from the attached thermometer, it appears the barometer was located in an unheated room.

In 1845, Lt Gilliss wrote the following regarding establishing meteorological observations at the Capitol Hill Observatory:

> "At the time the instructions were received from the Hon. Secretary of the Navy to make a series of observations during the absence of, and in connection with the exploring expedition, there were neither suitable instruments belonging to the Depot, nor assistants connected with it, to make observations of any kind.'
>
> 'Its superintendent, among other duties, was required to rate the chronometers for the navy, and to keep a meteorological journal, to be transmitted to the Navy Department quarterly. Of the instruments with which the former was performed,…those for the latter purpose were, a float-gauge barometer, thermometers divided from 2° to 2°, (such as are usually supplied to ships of war,) and a Daniel's hygrometer.'

'Recognizing the astronomical observations as of paramount importance to the objects of the exploring expedition, (as the instructions distinctly imply,) it was hoped that a continuous series in magnetism and meteorology, carefully made, might prove in some degree, useful to the solution of the great physical problem under investigation by order of European Governments, even if they could not bring to their recommendation the refinements of observatories especially established to that end. At all events, the subjects were new to the officers who would necessarily take part in them, and the experience consequent to their labors could not fail to benefit the naval profession. Duly appreciating the arguments presented, the Hon. Secretary of the Navy authorized the purchase of a new variation transit, a dip circle, float-gauge barometer, and two standard thermometers, and ordered additional assistants, to enable me to carry on the observations regularly."

Barometer

The float-gage barometer was made by Troughton and Simms, and the diameter of its tube was .36 inch. It was suspended to the casing of a window in the chronometer room, at a height of six feet above ground.

In the autumn of 1840, the mercury in the barometer was badly oxidized, and in Jan 1841, the case was split after accidentally being struck. While being repaired, an interim barometer made in France was used. When the original float-gage barometer was returned, a comparison of readings from the two barometers was made. This was the first evidence of barometer comparisons being made at the Naval Observatory.

Because of continuing problems with the float-gage barometer, a new instrument was installed Aug 17, 1841 (made by Troughton and Simms). It was placed against the north wall of the chronometer room at a height of 6 feet above ground. The barometer of the cistern was 72 feet above ordinary low water at the base of Capitol Hill (based on levels that were recorded at the time in the office of the Commissioner of Public Buildings).

NOTE – Available documents indicate three buildings were relevant to the Capitol Hill location of the Naval Observatory. The most southern building was the one used for storing charts and navigational instruments. Approximately 90 feet to the north was the observatory, and approximately 50 feet south of the observatory was a small building (six feet by 10 feet) that was used for storing various astronomical/meteorological instruments. It could not be determined where the chronometer room was located, but it appears the chronometer room was located in the house used to store the charts and navigational instruments.

Thermometers

Two thermometers were used as standards at this site. Both were made by Troughton and Simms with scales divided into one-half degree increments. One of the standard thermometers was kept in the chronometer room, and the other air (or exposed)

thermometer placed on the outside on the north side of the house (where the charts and navigational instruments were stored). The thermometer on the side of the house was suspended within a small white box that was open at the bottom and with apertures under its top. The thermometer was about one foot from the wall of the house, and six feet above the ground, and was protected from the direct and reflected rays of the sun in the morning and afternoon by a large green screen.

The wet-bulb thermometer was made by Brown of New York. Its bulb was covered with soft muslin scraped into a fine fringe about the top for the purpose of readily absorbing moisture. The wet-bulb thermometer was hung on the same post, but just below the air thermometer. This thermometer was divided into two-degree increments.

A thermometer, made by Tagliabue of New York, was enclosed in a cylinder of glass, with apertures at the bottom and the top. The thermometer was hung exposed throughout the day to the full sun, on the south side of a post, and four feet above ground. This instrument was referred to as the "Sun Thermometer" and was divided by two-degree increments.

Another thermometer, similar to the Sun Thermometer, had its bulb coated with a mixture of lampblack and varnish. It was on the same post as the Sun Thermometer with its bulb six inches above a sand soil. It was referred to as the "Radiating Thermometer."

The following description of the maximum and minimum thermometers (referred to as self-registering thermometers) was given in the 1845 *Magnetical* (sic) *and Meteorological Observations*:

> "Made by Troughton and Simms, and divided to one degree. They are upon the plan devised by Dr. Rutherford, and detailed in the *Transactions of the Royal Society of Edinburgh*, vol. 3. Two thermometers, one mercurial, the other of alcohol, with tubes bent at right angles to their bulbs; are placed horizontally on the same block of boxwood. Each has its own scale. The mercurial tube has a steel index above its column, pushed before it by the expansion, and left at the maximum temperature. The alcoholic column has an index of glass, with a small knob at each end, floating freely in the spirit. This (the spirit) readily passes beyond the index on expansion; but their attraction is such that, on contraction of the column, the index is drawn towards the bulb by the last particles of the liquid, and thus indicates the minimum temperature. With the former, the end of the index next to, and in the latter, the end fartherest from its bulb, is the temperature to be observed."

A "Daniell's Hygrometer was installed at this site. The 1845 document contained the following description:

> "This is a glass tube, about eight inches long and one-fourth of an inch in diameter, bent to form two right angles, with legs of unequal lengths, terminating in bulbs rather more than an inch in diameter; that to the longer leg being

blackened on the inside. A small mercurial thermometer, with a pyriform bulb, is fixed within the longer leg, so that its bulb is near that of the blackened one, which latter is two-thirds filled with sulphuric ether. The bulb to the shorter leg is covered with fine muslin, and the whole is supported on a brass stand.'

'The internal thermometer to the instrument used from Jul 1838, to Nov 9, 1839, was made by Newman, London, and divided to two degrees; that in use from Mar 1840, to Aug 1841, by Pike, New York; and the last was by Troughton and Simms. It was of much larger size than ordinary, and its thermometer was divided to one degree."

Rain Gage

The rain gage used from Jul 1838, to Jan 1840, was a tin cone nine inches high, with a base of five inches. It held three inches of rain, and the measuring rod was a strip of tin graduated in hundredths of an inch for the first three-tenths of an inch, and graduated in five one-hundredths of an inch increments above three-tenths of an inch.

The following is from the 1845 Naval Observatory document and describes the rain gage that became operational after Jan 1840:

"The gauge which replaced it was of analogous form, exposing precisely the same receiving surface, viz: 19.63 square inches; but the rain passed immediately into a glass bottle, and was measured in a graduated cylinder of glass 0.75 inch in diameter. Their ratio being as 19.63 inches to 0.59 inch, each hundredth received would fill 33 and one-third hundredths of the cylinder."

Both rain gages occupied the same location-five feet above ground and free from all obstacles to rainfall. No exact location was given.

Wind Instruments

The following was described in the Naval Observatory document regarding the "Lind's Wind Gauge" that was used at this site:

"A glass tube, nearly in the form of the letter U, contracted at the bottom to prevent rapid oscillation of the contained liquid, but of the same capacity in both legs, is attached to an ivory scale divided into inches and hundredths. One of the legs is so bent that when the instrument is upright its aperture may be placed perpendicular to the direction from whence the wind blows; the other is also open. The force of the wind is computed from the height of the column of water that it sustains, and which is equal to the difference of the reading in the two legs."

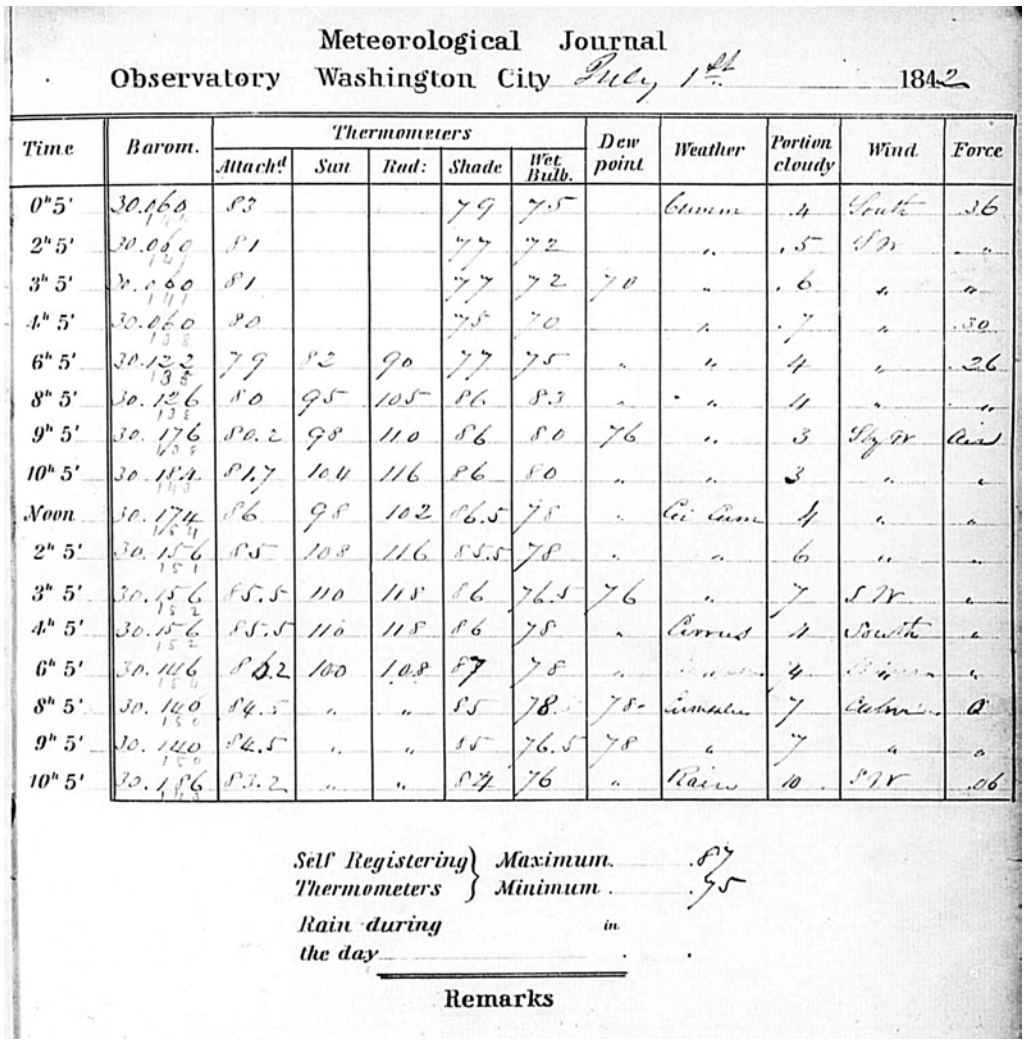
After Nov 1841, the force of the wind was taken from the table in a book by the committee of the Royal Society, being in pounds upon a square superficial foot exposed perpendicular to the direction of the wind.

Also after Nov 1841, a wind vane was place on top of the observatory, and the direction of the wind read from an attached compass card. The 1845 Naval Observatory document stated that houses interrupted all winds from south southeast to south southwest. The report said that when the wind was from the south, the wind vane "was useless."

Temporary Quarters on Pennsylvania Avenue – Jun 30,1842 – Oct 1844

No information could be found in the Naval Observatory documents nor in the database of NCDC that specified type, location or exposure of the weather instruments at the temporary quarters from Jun 30, 1842 through Oct 1844. It is assumed the same weather instruments used at the Capitol Hill site. Only one note was found that related to the instruments. On Aug 6, 1842, the following note was attached to the observation form: "At 4 PM the Radiating Thermometer was moved west of the house and placed 3 inches above the ground."

Prior to the move to temporary quarters, only daily observations were in the NCDC database. Beginning Jul 1, 1842, the first day in temporary quarters, hourly observations for the Naval Observatory are listed in the NCDC database (see Figure 6) for the following hours: Midnight, 2 AM, 3 AM, 4 AM, 6 AM, 8 AM, 9 AM, 10 AM, Noon, 2 PM, 3 PM, 4 PM, 6 PM, 8 PM, 9 PM, and 10 PM. All observations were indicated at five minutes past the hour. The hourly observations for the Naval Observatory continued in the NCDC database through Feb 2, 1913 (although observation times changed to Midnight, 3 AM, 6 AM, 9 AM, Noon, 3 PM, 6 PM, and 9 PM on Jan 1, 1867)-the last set of observations in the database.



Meteorological Journal

Observatory Washington City July 1st 1842

Time	Barom.	Thermometers: Attach'd	Sun	Rad:	Shade	Wet Bulb.	Dew point	Weather	Portion cloudy	Wind	Force
0h 5'	30.160	83			79	75		Cirrus	4	South	36
2h 5'	30.060	81			77	72		"	5	"	"
3h 5'	30.060	81			77	72	70	"	6	"	"
4h 5'	30.060	80			75	70		"	7	"	50
6h 5'	30.122	79	82	90	77	75	"	"	4	"	26
8h 5'	30.126	80	95	105	86	83	"	"	1	"	"
9h 5'	30.176	80.2	98	110	86	80	76	"	3	Sly W	Calm
10h 5'	30.184	81.7	104	116	86	80	"	"	3	"	"
Noon	30.174	86	98	102	86.5	78	"	Ci Cum	4	"	"
2h 5'	30.156	85	108	116	85.5	78	"	"	6	"	"
3h 5'	30.156	85.5	110	118	86	76.5	76	"	7	S W	"
4h 5'	30.156	85.5	110	118	86	78	"	Cirrus	4	South	"
6h 5'	30.146	80.2	100	108	87	78	"	"	4	"	"
8h 5'	30.140	84.5	"	"	85	78	78	Cumulus	7	Calm	Q
9h 5'	30.140	84.5	"	"	85	76.5	78	"	7	"	"
10h 5'	30.186	83.2	"	"	82	76	"	Rain	10	S W	.06

Self Registering Thermometers } Maximum. 87 Minimum. 75

Rain during the day in.

Remarks

Figure 6. Hourly observations taken at the Observatory on Jul 1, 1842-the first day in temporary quarters. From the official station history files at the National Climatic Data Center.

Foggy Bottom Site – Oct 1844- Jan 1,1893

NOTE – No definitive information could be found regarding the transfer of weather observing from the temporary quarters to Foggy Bottom. Hourly observations in the NCDC database indicate the move to Foggy Bottom likely was in late Sep 1844 or Oct 1844. Prior to Sep 1844, all hourly observations essentially were complete, i.e., most, if not all the blocks in the forms contained weather information. Beginning in late September, most of the blocks in the hourly forms were left blank and this continued into the early weeks of 1845. It is possible that during the transition of the move, when new meteorological and astronomical equipment was arriving and had to be installed, daily weather observing was given a lower priority.

Information was sketchy regarding weather instruments and observations at the Naval Observatory from the early 1840s until the early 1860s. However, a note by Lt Gilliss in the *1842 Annual Report for the Secretary of the Navy* indicates essentially new weather instruments were used when the Observatory moved into the Foggy Bottom facilities in 1844. Lt Gilliss' note stated:

> "Meteorological Instruments – These were received last May, and are safely preserved; the erection of the registering anemometer being delayed until the completion of the Superintendent's house."

The following descriptions of the instruments at Foggy Bottom are based on information contained in the Naval Observatory publications, *Astronomical and Meteorological Observations Made at the United States Naval Observatory* from the early 1860s through the early 1890s. Most of the material relates for the period of the publications, i.e., early 1860s through early 1890s, but reference is occasionally made to earlier years. Material in quotes are directly from the publications. For convenience, these publications will be referred to as the "Naval Observatory reports" or "Naval Observatory documents."

Figure 7 is an engraving of the Naval Observatory buildings at Foggy Bottom, and Figure 8 shows a top-down view of the buildings, along with locations of the weather instruments from 1861 through 1892.

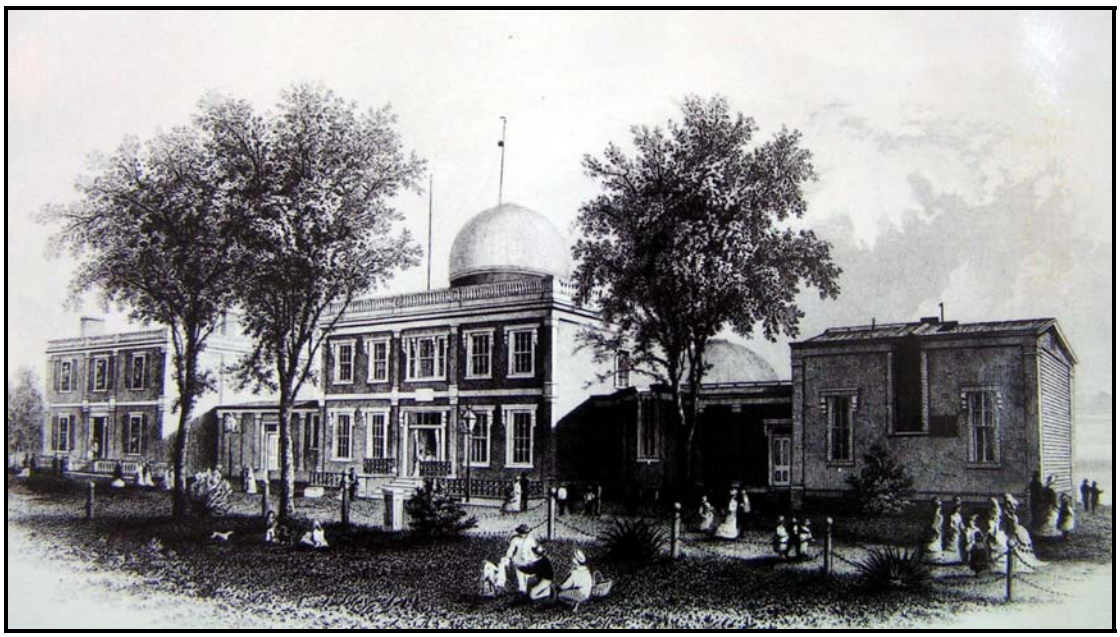


Figure 7. Naval Observatory buildings at Foggy Bottom (circa 1880). View is towards the southeast. The main building, in the center (with the dome), housed the operational barometer (located in the ground-floor room on the extreme right. The Superintendent's house is on the extreme left of the engraving and housed the "standard" barometer. The transit circle house is located on the extreme right. Before May 1862, the dry bulb and wet bulb thermometers were hung on the north walls of the building connecting the main

building with Superintendent's house (east wing) or the one connected to the transit circle house (west wing), depending on the time of year. Wind instruments were installed over the dome of the main building. From the Naval Observatory.

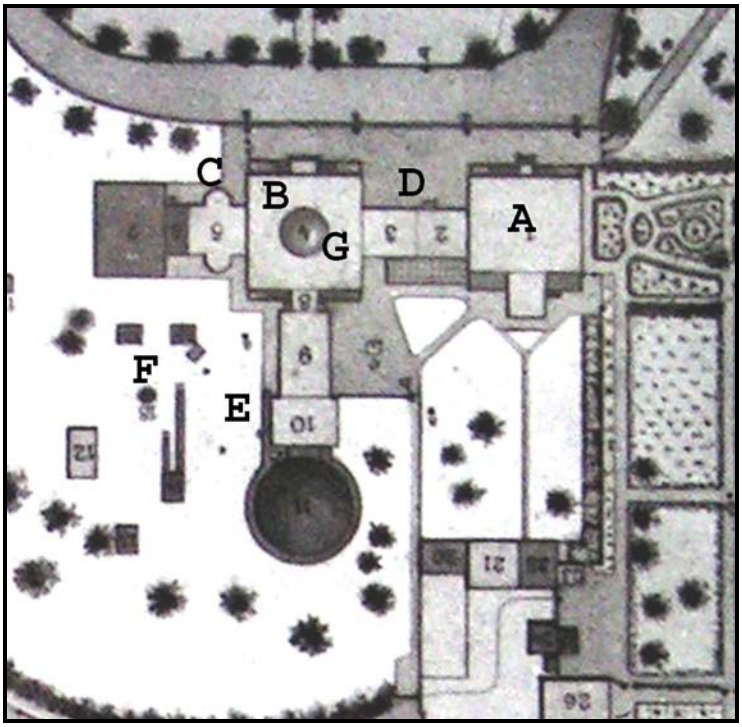


Figure 8. Locations of the weather instruments at the Foggy Bottom location-1861 – 1892. Center building is the main building with the Superintendent's house on the right and the transit circle house on the left. North is at the top of the page. Location "A" – Green Barometer in Superintendent's house; "B" – Location of operational Newman's Barometer; "C" and "D" – Locations of dry bulb and wet bulb thermometers (hung together) prior to May 1862 (dry bulb and wet bulb thermometers were moved together between points "C" and "D" based on time of the year; "E" – Location of the instrument shelter, rain gage, and solar thermometer from May 1862 to Apr 9, 1874; "F" – Location of the instrument shelter, rain gage, and solar thermometer from Apr 9, 1874 through Dec 31, 1892; "G" – Location of the wind vane on the dome of the main building. Building drawings from the Naval Observatory.

Barometer

From the 1862 Naval Observatory report:

> "The instrument was made by Newman, of London with a tube 0.580 inch in diameter. During the latter part of 1853 it appears to have been injured, and a new tube of the dimensions already given was inserted… An accumulation of dust in the cistern and partial oxidation of the mercury near the top of the column made it desirable to take down the instrument at the close of March of the present year (1861). Before doing so, a careful comparison with a new standard, put up in

the southwest room by Mr. James Green, showed a correction necessary of -0.017 inch.'

'On the 30th of January, 1862, a series of simultaneous comparisons was made during three hours, at intervals of 15 minutes, with the standard of the Smithsonian Institution. Each observation being corrected for temperature and reduced to the level of mean half-tide of the Potomac at Washington…'

'Rejecting the discordant comparisons at 1h 45m, the Observatory barometer stands 0.04 inch higher than the Smithsonian instrument."

Individual results of that comparison were listed in the 1862 document.

"The cistern of this instrument (Newman barometer) is of glass, and 3 inches in diameter. It is fitted into a frame of bronzed brass, which turns in a bracket secured to a mahogany board. The tube has an internal diameter of 0.532 inch. The frame supporting it is of similar metal, and colored as is that of the cistern. Its upper extremity is a pivot which rests in a socket of a second bracket projecting from the top of the mahogany board, and the instrument is adjustable to a vertical position by three horizontal screws that act against a pivot of the cistern-frame which rests in the lower bracket. The scale is silvered and divided to 0.05 inch. It is attached to a brass rod inside the frame and which terminates in an ivory point within the cistern. Both rod and scale may be moved by a slow-motion screw, the scale being adjusted when the ivory point and its reflected image are just in apparent contact. The scale may be read by means of a vernier to 0.002 inch.'

'The temperature of the mercury in the cistern is shown by an ivory scale thermometer divided to 1° which is within the tube-frame, its bulb immersed."

Location of the Barometer in 1861:

"The barometer is fixed between two north windows of the northwest room on the first floor of the building (main building), its cistern 103 feet above mean half-tide water of the Potomac. All the observations have been corrected for the difference between the temperature of the mercury in the tube and 32° Fahrenheit, by Guyot's table, giving the corrections to be applied to English barometers with brass scales extending from the cistern to the top of the mercurial column, published by the Smithsonian Institution (Tables, meteorological and physical, prepared for the Smithsonian Institution by Arnold Guyot, P.D., LL.D., Washington, 1859). The additional corrections for difference with Royal Society and Smithsonian standards, capillarity and elevation above tide-water have not been applied."

Figure 9 shows the location of the operational barometer in the main building during the 1860s, 1870s, 1880s, and through 1892. NOTE – It is possible the operational barometer

was at this location as early as Oct 1844; however, no information could be found regarding the barometer at Foggy Bottom prior to 1861.

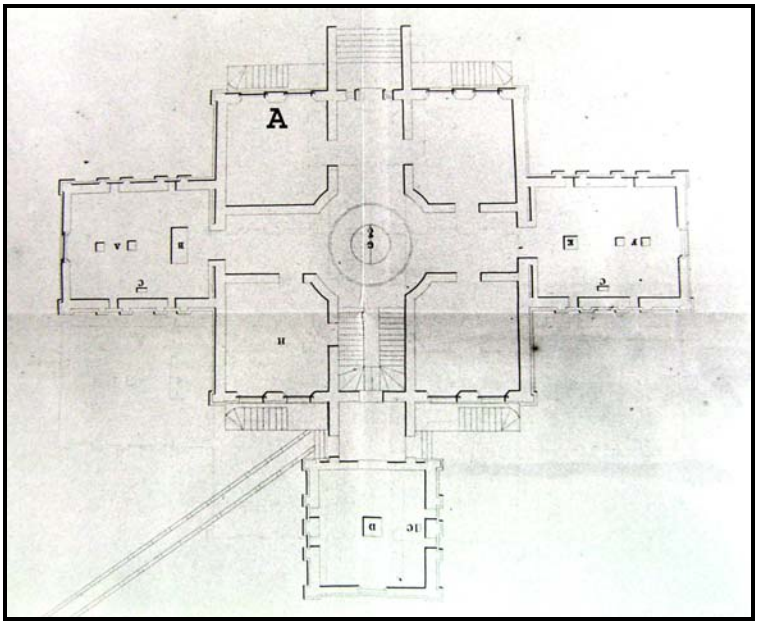


Figure 9. Location of the operational barometer (Newman's barometer) from 1861 through 1892 (point "A") in the main building at the Foggy Bottom location. North is at the top of the page. Map from the Naval Observatory.

In Mar 1862, a standard barometer, made by James Green (Figure 10), was mounted in the office of the Superintendent. The cistern of the Green barometer was six inches higher than the Newman barometer that was used for daily measurements in the main building. The Green barometer was used as a standard for comparing the Newman barometer.

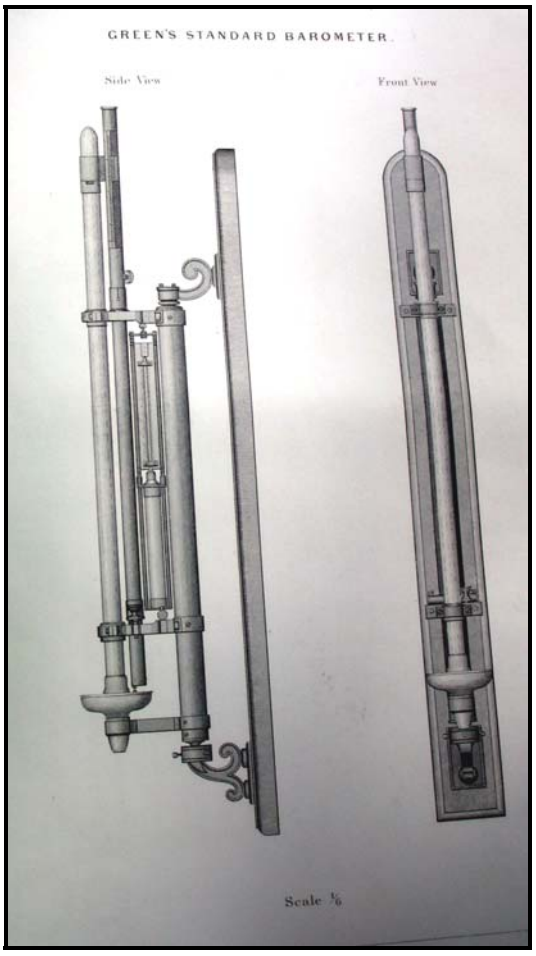


Figure 10. Front and side views of the James Green barometer located in the Superintendent's office. From the Naval Observatory.

No changes in location or exposure of the operational barometer occurred at this location, i.e., through Jan 1, 1893.

Thermometers

The thermometer used at the Naval Observatory in 1861 was made by G. Tagliabue, of New York, for use on naval vessels. It was a mercurial copper-cased thermometer, ten inches long, furnished with a silvered metallic scale divided from -10° to +130° Fahrenheit in one degree increments. The temperature was taken in the shade.

The wet-bulb thermometer was of similar materials, dimensions, and construction. It was made by James Green, of New York with a scale of single-degree increments from -25° to +153°.

The exposed and wet-bulb thermometers were placed beside each other and three feet above the ground, against the north walls of the east and west wings. According to the 1862 report:

> "Their places being changed from one wing to the other as the morning and afternoon sun-beams made such change necessary between the vernal and autumnal equinoxes."

Three other thermometers were placed on a post three and one-half feet high, located southwest of the main building. These thermometers were made for the naval service and were exposed to the direct sun. One was made by James Green with a one-degree scale from -13° to +150°. This thermometer in the sun faced southeast.

The other two thermometers in the sun were made by G. Tagliabue. One thermometer was divided into one-degree increments with a range of -10° to +152°. This thermometer faced southwest. The second Tagliabue thermometer was divided into two-degree increments with a range of -28° to +232° and faced south. The document explained how the three sun thermometers were exposed and read:

> "They (the three thermometers) were prevented by wires from moving in any direction, and that instrument was read whose scale was most nearly perpendicular to the rays of the sun; but, because of the bands across the bottom of the copper cases, these rays could not reach the bulbs of either instrument unless the altitude of the Sun exceeded 45°."

In May 1862, an instrument shelter was constructed and new thermometers placed in the shelter. The shelter was located about 4 yards southwest of the southwest corner of the south wing of the Observatory (see Figures 8 and 11). The shelter was constructed of wood, painted white both inside and outside. It was in the form of an octagonal, and its dimensions were six feet in diameter, six feet three inches high. The inside of the shelter had a ceiling with an open space between the ceiling and the roof of the shelter. The roof was made of tin, left bright on the under side. The door was on the north side. The sides and door were of double lattice-work, with a space of three inches between the inner and outer lattices. The lattices terminated within a foot of the ground. The shelter was placed over grass sod.

Four thermometers were placed in the shelter. All four thermometers were made by James Green of New York and were suspended five feet from the ground, near the center of the shelter, on metallic frames held by a single brass rod, which was screwed to the ceiling of the shelter. Two rods were placed across the shelter to prevent the shelter and instruments from being bumped.

The "dry thermometer" was a mercurial thermometer whose bulb was 1.5 inches long and 0.2 inch in diameter. The scale was divided into one-half degree increments from -30° to +125°.

The "wet thermometer" was similar to the dry thermometer in materials, construction, and dimensions. Its scale ranged from -35° to +115°. Its bulb was covered with linen, which was kept moist.

No significant changes occurred through 1892 with respect to the type of dry bulb and wet bulb thermometers used.

The following description of the maximum thermometer occurred in the *Astronomical and Meteorological Observations Made at the United States Naval Observatory* in 1862:

> "This (the maximum thermometer) differs from the instruments described (i.e., dry and wet thermometers) only in the addition of a small register above the column of mercury and in the extent of its scale. The register is of steel, but to obviate as far as possible the risk of entanglement from the action of mercury, a small porcelain disk is interposed between its extremity and the top of the column. Even this proved ineffective with the first instrument, its register becoming immovable Sep 5 (1862). Its scale extended from -12° to +127°. That of the new one, substituted for it Sep 8, extends from -32° to +163°."

Between 1865 and 1868 the maximum thermometer was changed. The 1868 document (*Astronomical and Meteorological Observations Made at the United States Naval Observatory*) stated the following:

> "This (maximum thermometer) is a mercurial thermometer, with a bulb 1.5 inch long and 0.2 inch in diameter. The scale is of glass, 12 inches long, 0.8 inch wide, 0.1 inch thick, and is graduated to half degrees from -50° to +120° F. A short distance above the bulb the internal diameter of the tube is so contracted that, while with the increase of temperature the mercury passes this point freely, with the least decrease of temperature the column is broken at the contracted point if the instrument is nearly horizontal, and the top of the column marks the highest temperature. The top of the scale is attached by a metallic clamp to a pivot, around which the instrument revolves freely in a vertical plane. This pivot is secured to a walnut board fixed to a post about three feet from the ground, and the thermometer is placed nearly horizontal by resting the scale near the bulb on a wooden pin in the board. After each observation the instrument is adjusted by removing the pin and allowing the thermometer to swing freely from the pivot at the top of the scale, which motion is sufficient to reunite the column of mercury."

By 1890, the maximum thermometer was replaced with one with a scale of -33° to +123° F.

In 1862 , the minimum thermometer was a "transparent spirit thermometer," with bulb and tube of the same form but greater dimensions than those of the other instruments. The thermometer ranged from -18° to +105°. The registering index for this thermometer consisted of a piece of steel wire floating in the "spirit", enclosed in thin blue glass, with a knob at its outer extremity, i.e., fartherest from the bulb. The minimum thermometer was reset using a small magnet.

Between 1865 and 1868, the minimum thermometer was replaced with a thermometer with a range from -67° to +131° F. By 1890, the observers ceased using a magnet to reset the minimum thermometer and: "After each observation, the bulb end of the instrument was raised until the index moved down to the end of the column of liquid and then the instrument is returned to its normal position."

The maximum/minimum thermometers were placed in the shelter beside each other in horizontal positions and were read only at midnight.

The 1868 *Astronomical and Meteorological Observations Made at the United States Naval Observatory* stated that all the thermometers, except for the solar thermometer, were located in the instrument shelter. The bulbs of the dry and wet bulb thermometers were 4.2 feet above ground, the maximum thermometer 3.2 feet above ground, and the minimum thermometer 5.8 feet above ground. The document also stated that a standard thermometer (Troughton and Simms) was suspended between the dry and wet bulb thermometers and was used as a check on the other thermometers.

Three "solar" thermometers were in use in 1861, with the number reduced from to one in 1862. This thermometer was made by James Green and was a mercurial thermometer, 12 inches long, with a blackened spherical bulb, enclosed with its tube, within a cylinder of glass of the same form, but about three times the diameter of the thermometer. The air was evacuated from the glass cylinder and the thermometer kept in the center of the cylinder by cork collars, one near each extremity. The scale of the thermometer was in degrees Fahrenheit and ranged from -15° to 177°.

The solar thermometer and cylinder rested in metallic crutches three inches high, fastened to a board 16 inches by 5 inches. The instrument, along with its cylinder and board, were placed on the grass, with the thermometer lying parallel to the ground.

The 1868 *Astronomical and Meteorological Observations Made at the United States Naval Observatory* made the following comments with regard to the solar thermometer:

> "The scale is engraved on the thermometer tube, and has a range from +5° to +173° F. The temperature is registered in the same way as in the maximum thermometer, and after each observation the instrument is adjusted by holding it in a vertical position and gently tapping the external bulb. This thermometer rests in metallic crutches about three inches high, which are attached to a board 16 inches long and 5 inches wide. The board is painted green and placed on the grass about three yards west of the Meteorological Observatory." (NOTE – The term "Meteorological Observatory" refers to the instrument shelter.)

By 1874 the solar thermometer had been replaced with one with a range of -10° to 215° Fahrenheit. The solar thermometers were located with the instrument shelter (see Figure 8).

The 1890 report contained the following information regarding the solar thermometer:

> "A solar thermometer with blackened bulb, inclosed in a glass tube and bulb of the same form as the thermometer, but about three times its diameter, has been read during 1890 at the same time as the other thermometers. This instrument, however, has been changed so often, without determining the errors of any of the various instruments used, that it has not been deemed advisable to publish the readings."

The 1863 volume of the document, *Meteorological Observations Made at the U.S. Naval Observatory* made the following comment with regard as to how representative the thermometer readings were at the Naval Observatory:

> "…as the building (instrument shelter) is on a grass-plat, instruments within it should indicate correct temperatures. But as there is a dense growth of trees entirely surrounding the Observatory buildings, and the area, enclosed by trees and buildings within which the thermometers are suspended, does not exceed one acre in extent, it may be doubted whether our thermometers show true temperatures either during calm and clear weather or high winds. In both cases, the enclosed air becomes unduly heated."

The 1870 The 1868 *Astronomical and Meteorological Observations Made at the United States Naval Observatory* stated:

> "The increasing density of the shade-trees and shrubbery in the Observatory grounds, and especially about this building, will soon render some new arrangement necessary."

On Apr 9, 1874, the instrument shelter was moved to a location 18.8 yards west of the south wing of the main building and 17.3 yards south of the Transit Circle room. Elevation above ground of the dry, wet, maximum, and minimum remained unchanged.

Figure 11 shows the approximate location of the instrument shelter from May 1862, to Apr 9, 1874. Figures 12 through 14 shows the location of the instrument shelter from Apr 9, 1874 through Dec 31, 1893.

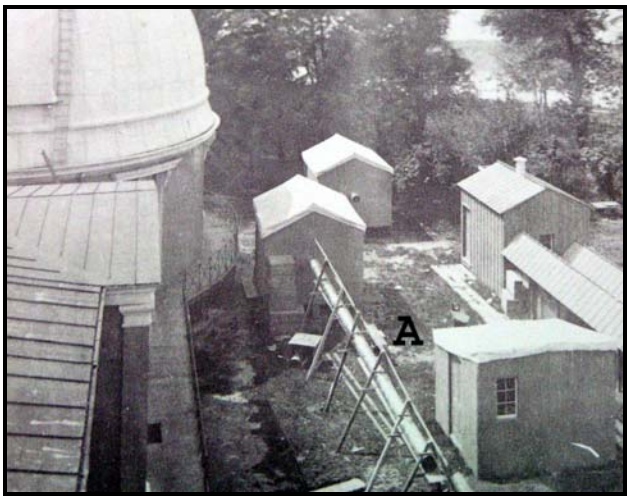


Figure 11. Approximate location of the instrument shelter from May 1862, to Apr 9, 1874 (point "A). Circa late 1870s or 1880s. View is towards the southwest from the south wing. Photograph from the Naval Observatory.

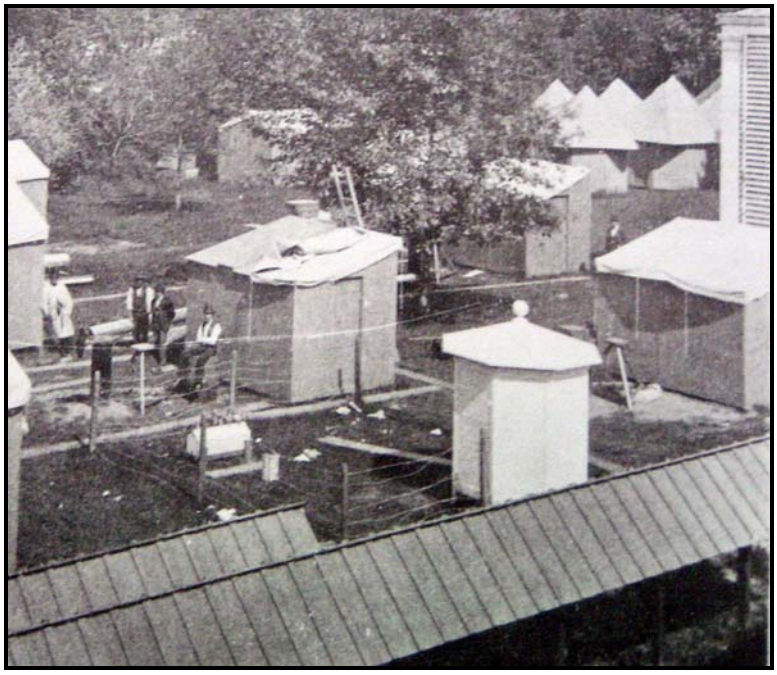


Figure 12. Instrument shelter location from Apr 9, 1874, through Dec 31, 1892. Photo taken from the south wing toward the northwest. Instrument shelter is just right of center. Based on information in the Naval Observatory documents, it appears the oblong white box to the left of the shelter is likely the location of the rain gage with the board in front used for the solar thermometer. The instrument shelter, rain gage, and solar board all are enclosed by a small fence. From the Naval Observatory.

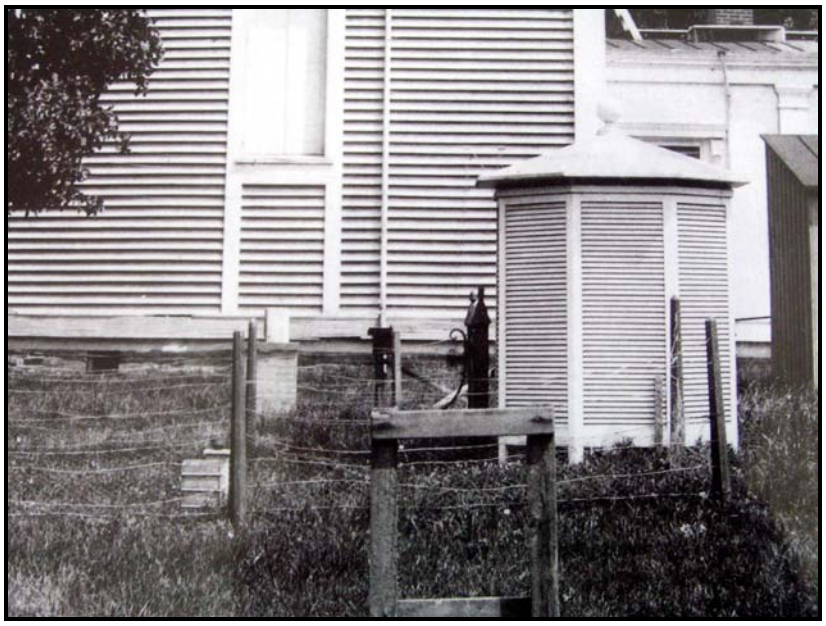


Figure 13. Instrument shelter looking north with the West Transit Circle House located in the background (circa late 1870s or 1880s). From the Naval Observatory.

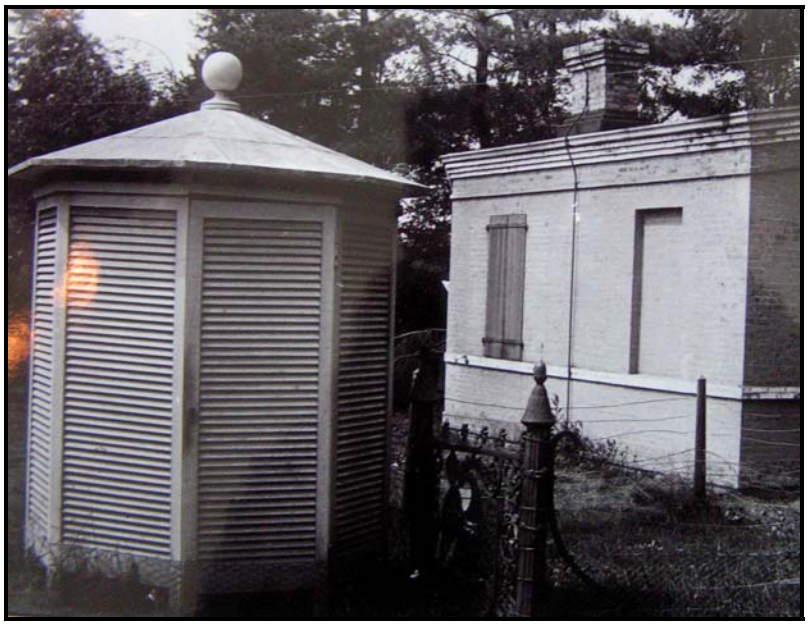


Figure 14. Instrument shelter looking southwest (circa late 1870s or 1880s). Building to the right of picture identified only as a "fire-proof building." From the Naval Observatory.

Rain Gage

In 1861 the rain gage was located to the southwest of the main building, 5 feet 2 inches above the ground (no information could be found regarding location at the Foggy Bottom

site prior to 1861). The Naval Observatory document indicated the rain gage was, "…free from all shelter in driving rains."

According to the Naval Observatory document, the rain gage was made in the following way:

> "It is a cylinder 4.1 inches in diameter, soldered to an inverted cone, loaded with lead on the outside and near the apex. The cone rests in an aperture of a box, whose top is horizontal, which, with the lead, prevents its disturbance during violent winds. There is an aperture at the apex of the cone through which the rain-water passes as fast as it descends to a receiving bottle within the box referred to. The water thus collected is measured in a graduated glass cylinder with an internal diameter of 0.60 inch. It was not attended to at the end of the day as it should have been, but at irregular intervals; but, as the apex of the cone closes the mouth of the bottle except through the small aperture, the amount lost by evaporation has been very inconsiderable."

The document indicated the rain gage was located within the enclosure of the instrument shelter, i.e., a small fence surrounded the shelter and the rain gage was situated within this fence. Figure 8 indicates the two separate locations of the instrument shelter and rain gage from 1861 through 1892.

The document for 1863 entitled, *Meteorological Observations Made at the U.S. Naval Observatory*, stated the top of the rain gage was 2 feet above ground. No changes were indicated through 1892.

Wind Instruments

The Naval Observatory document made the following comments with regard to wind measurements in 1861:

> "A vane revolves freely on a spindle at the top of the time-ball staff, and the point of the compass to which it is directed by the wind is estimated from the known azimuths of the lines of the building. By daylight a close approximation to the truth is arrived at; but at night, and especially on cloudy ones, when such guide to the judgment is not visible, the recorded directions are probably no more reliable than as rough guesses. The velocity of the atmospheric current is stated in numerals, of which 0 denotes a calm, 1 a very light breeze, and 10 a violent gale. These numbers, under the head "Force," are mere estimates, and, at best, but approximative (sic)."

Figure 15 shows the wind vane on top of the main building.

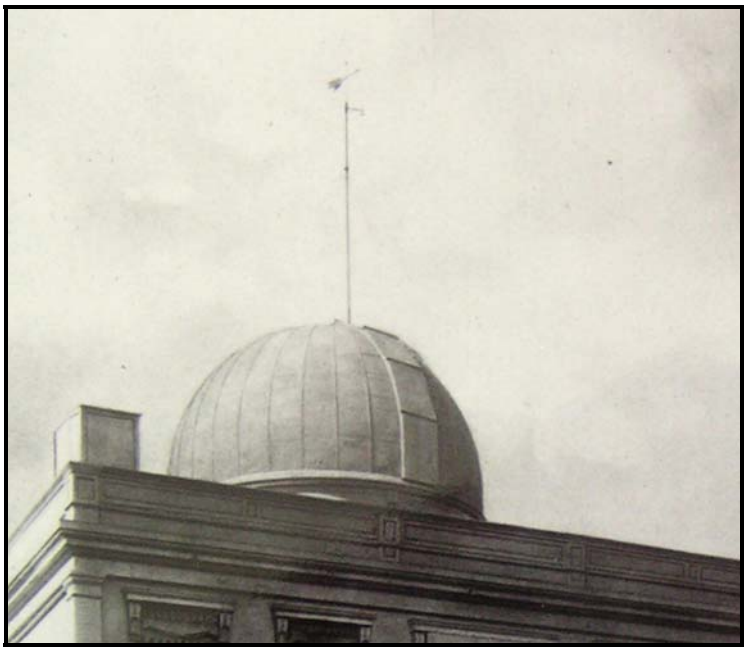


Figure 15. Wind vane on top of the main building at Foggy Bottom (circa early to mid 1880s). View is towards the northeast. From the Naval Observatory.

In Jan 1886, a Robinson anemometer was mounted on the northwest corner of the Superintendent's house, and was located 39 feet above ground. The cups were about 4 inches in diameter and the distance from the center of the axis to the outer edge of the cups was 9 inches. Wind readout was registered on a Gibbon recorder in the main Observatory building. This devise was developed by Lt. David J. Gibbon of the U.S. Army and adopted for operational use in the Signal Service in 1872. It consisted of a clock, a cylinder 3.82 inches in diameter and 3.75 inches long, which revolved once in 6 hours, and a recording pencil activated by a magnet. The devise would record the wind in miles per hour, or the aggregate distance in miles of wind that passed the anemometer. According to Naval Observatory records, the anemometer was "old and not in the best of order so that the records were not as good as desirable."

Cloud Types

Naval Observatory documents from the early 1860s through 1892 contained descriptions of cloud types used in their observations similar to what was contained in the 1861 document below:

> "The nomenclature of Howard is used, C., K., S., N., being symbols for the forms which he denominates cirrus, cumulus, stratus, nimbus, and the double letters, C.S., C.K., etc., their combinations to indicate cirro-stratus, cirro-cumulus, etc. The portion of the sky obscured is simply a naked-eye estimate from careful scrutiny of the whole hemisphere. 0 denotes a clear sky and 10 total obscuration.

Massachusetts Avenue NW Location – Jan 1, 1893 – Feb 2, 1913

Figure 16 shows the location of the weather instruments at this site from Jan 1, 1893 through Dec 31, 1902.

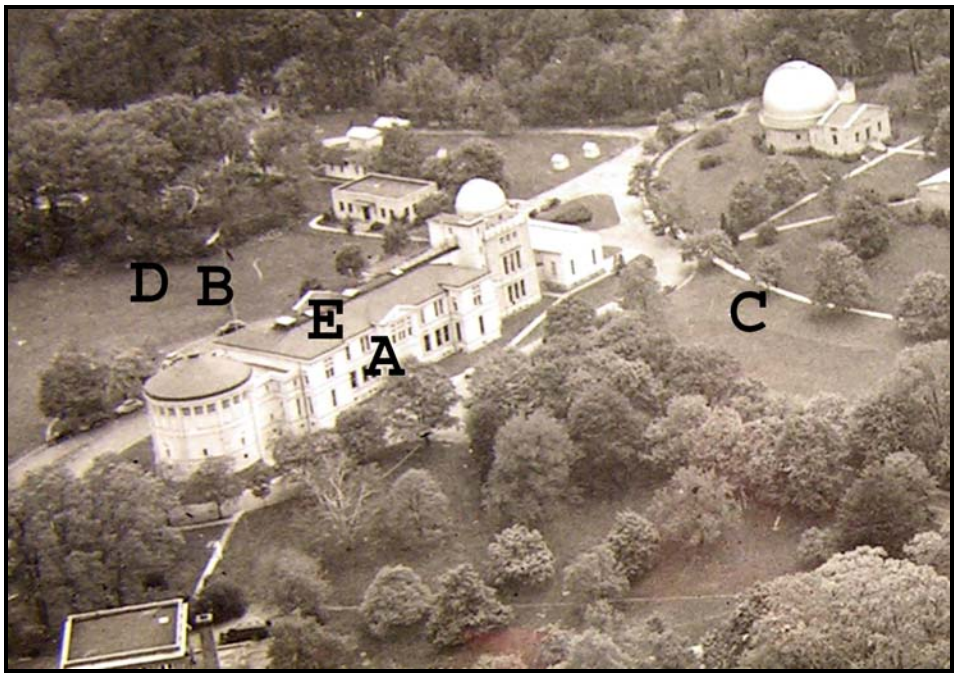


Figure 16. Photograph of the Naval Observatory (circa 1940s) with locations of weather instruments form 1893 through 1902 transposed. View is southwest. Location "A" is the position of the operational barometer; "B" – Approximate location of the instrument shelter and attendant thermometers after Aug 29, 1894; "C" – Approximate location of the dry/wet bulb thermometers and maximum/minimum thermometers from Jan 1, 1893, to Aug 29, 1894; "D" – Approximate location of the rain gage from 1893 through 1902; "E" – Location of wind vane and anemometer. View is southwest. Photograph from the Martin Luther King Jr. Memorial Library.

Barometer

From Jan 1, 1893 to Jun 30, 1899, the Newman barometer was the operational instrument with the Green barometer serving as a standard for comparison. On Jun 30, 1899, the Green barometer became the operational barometer at the Naval Observatory (the change occurred between 9 PM and Midnight). Both the Green and Newman barometers were mounted to a "substantial" mahogany board, which was firmly secured to the east wall of the entrance hall of the main building, near the south door.

The Newman barometer was compared with a standard at the Weather Bureau in 1895 and again in 1899. The Green barometer was compared with the same Weather Bureau standard in 1899.

No information was found regarding the barometers after 1902.

Instrument Shelter

The old shelter was moved from Foggy Bottom to the Massachusetts location in 1894 and placed 200 feet south of the south door of the entrance hall of the main building. The dry bulb, wet bulb, maximum thermometer, and minimum thermometer were located in the instrument shelter and were supported by means of arms and brackets to an upright metallic shaft which was set in the ground in the center of the shelter.

The thermometers were installed in the instrument shelter around 3 PM on Aug 29, 1984. Before this time, the thermometers were housed in a temporary structure placed about 170 feet northwest of the north door to the entrance hall of the main building. A note in the Jan 1,1893 observations stated, "The thermometers are protected in a well made house similar to that used by the Weather Bureau…"

No information was found regarding the instrument shelter after 1902.

Thermometers

All the thermometers used at this site were tested by the Weather Bureau.

The dry bulb thermometer was made by Henry J. Green and was divided into degrees Fahrenheit.

The web bulb thermometer was made by Henry J. Green and was divided into degrees Fahrenheit. The bulb was covered with soft linen that was kept moist.

The maximum thermometer was made by J. & H.J. Green and was divided into degrees Fahrenheit. The thermometer used the same principle in determining the maximum temperature as described for the instrument at Foggy Bottom. The thermometer was reset the same way as the maximum thermometer that was at Foggy Bottom.

The minimum thermometer was made by Henry J. Green and was divided into degrees Fahrenheit. The thermometer was read and reset identical to the minimum thermometer described for the Foggy Bottom location.

No information was found regarding the thermometers after 1902.

Rain Gage

The rain gage was located in the center of a circular plot of ground that was about 50 feet south of the instrument shelter. The plot was 20 feet in diameter and was enclosed by a wire fence.

The rain gage was a metal cylinder 8 inches in diameter and 10.5 inches high. Four and one-half inches below the top, and inside the cylinder an inverted cone was soldered to the cylinder. The cone had a small hole at its apex through which the rain water would pass to the lower part of the cylinder. According to Naval Observatory documents, the rain gage was clear of obstructions to rainfall, even for driving rain storms. The rain and melted snow were measured in a glass cylinder, with an internal diameter of two and eleven-sixteenths inches, so graduated that the depth of rain could be determined to the nearest one-hundredth of an inch.

No information was found regarding the rain gage after 1902.

Wind Instruments

From Jan 1, 1893, to Jul 18, 1893, the velocity of the wind at this site was estimated by the watchman at the regular observation times, i.e., when the barometer and thermometers were read. An arbitrary scale from "0"to "10" was used in which "0" indicated calm winds and "10" indicated a violent hurricane. At the same time, the direction of the wind was determined from a wind vane on top of the main building (Figure 17).

Figure 17. Wind vane and anemometer over eastern roof of the main building (circa 1902). View is southeast. From the Naval Observatory.

In Jul 1893, a wind vane and anemometer (same type of instruments used by Weather Bureau offices) were installed on the roof of the main building. The wind instruments were electrically connected to a triple register (same as the Weather Bureau register) located in a small room near the north door of the entrance hall of the main building.

Wind direction was recorded each minute and wind speed recorded each time the motion of the air corresponded to one mile.

No information was found regarding wind instruments after 1902.

Weather Observations after 1902

Toward the end of the 19th Century, the Naval Observatory concentrated more on astronomy and deemphasized meteorological observing. References in Naval Observatory documents to meteorological observing diminished significantly after 1902. The last daily observation record in the NCDC database for the Naval Observatory is on Feb 2, 1913. However, significantly before early 1913, weather observation forms reflected the reduced attention through various parameters not being observed. By 1913, weather observations at the Naval Observatory were being taken at Midnight, 3 AM, 6 AM, 9 AM, Noon, 3 PM, 6 PM, and 9 PM for the following parameters:

1. Atmospheric pressure
2. Temperature from the attached thermometer, i.e., inside temperature
3. Sky conditions/weather
4. Wind direction and force

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References and Data Sources

References

Annual Reports of the U.S. Naval Observatory (years 1842 through 1915). Secretary of the Navy. Government Printing Office. NOTE – *Initial title of this publication was Annual Reports of the Depot of Charts and Instruments.* Many of these reports are also listed under *Report of the Secretary of the Navy*.

Astronomical and Meteorological Observations Made at the United States Naval Observatory (years 1845 through 1913). Secretary of the Navy. Government Printing Office. NOTE – The initial name of this publication was "*Magnetical and Meteorological Observations Made at Washington Under Order of The Hon. Secretary of the Navy*." In 1870, the name was changed to "*Meteorological Observations Made at the United States Naval Observatory*."

The Naval Observatory, Its History, Activities and Organization. Gustavus A. Weber. The Johns Hopkins Press, Baltimore. 1926.

Sky and Ocean Joined: The U.S. Naval Observatory 1830-2000. Steven J. Dick. Cambridge University Press, 2003.

Data Sources

Much of the information regarding the history of the Naval Observatory came from Steven J. Dick's book entitled, *Sky and Ocean Joined: The U.S. Naval Observatory 1830-2000*. This book contains considerable insight into the early years of the agency. t.

Considerable information regarding instrument location and exposure was found in the Navy Observatory publications entitled, *Astronomical and Meteorological Observations Made at the United States Naval Observatory*. Volumes for the following years were especially rich in relevant information: 1845, 1861, 1862, 1863, 1865, 1868, 1870, 1874, 1880, 1890, and collective results 1893-1902.

Annual Reports of the U.S. Naval Observatory from 1842 through 1915 provided critical information regarding the evolution of the agency from Depot of Charts and Instruments to the Naval Observatory. Although specific information regarding meteorological instruments and/or observations was sparse in the volumes of this document, an overview of changes in the agency were described.

The NCDC database for the Naval Observatory is extensive, beginning in November 1, 1838, and continuing almost without break until February 2, 1913. However, the database primarily consists of daily or hourly weather observations with little information regarding type, location, or exposure of the instruments. The best descriptive information in this regard in the database is for the 1860s decade. The almost continuous availability of weather observations did serve as a general time line in pinning down, or confirming transfer dates to new locations.