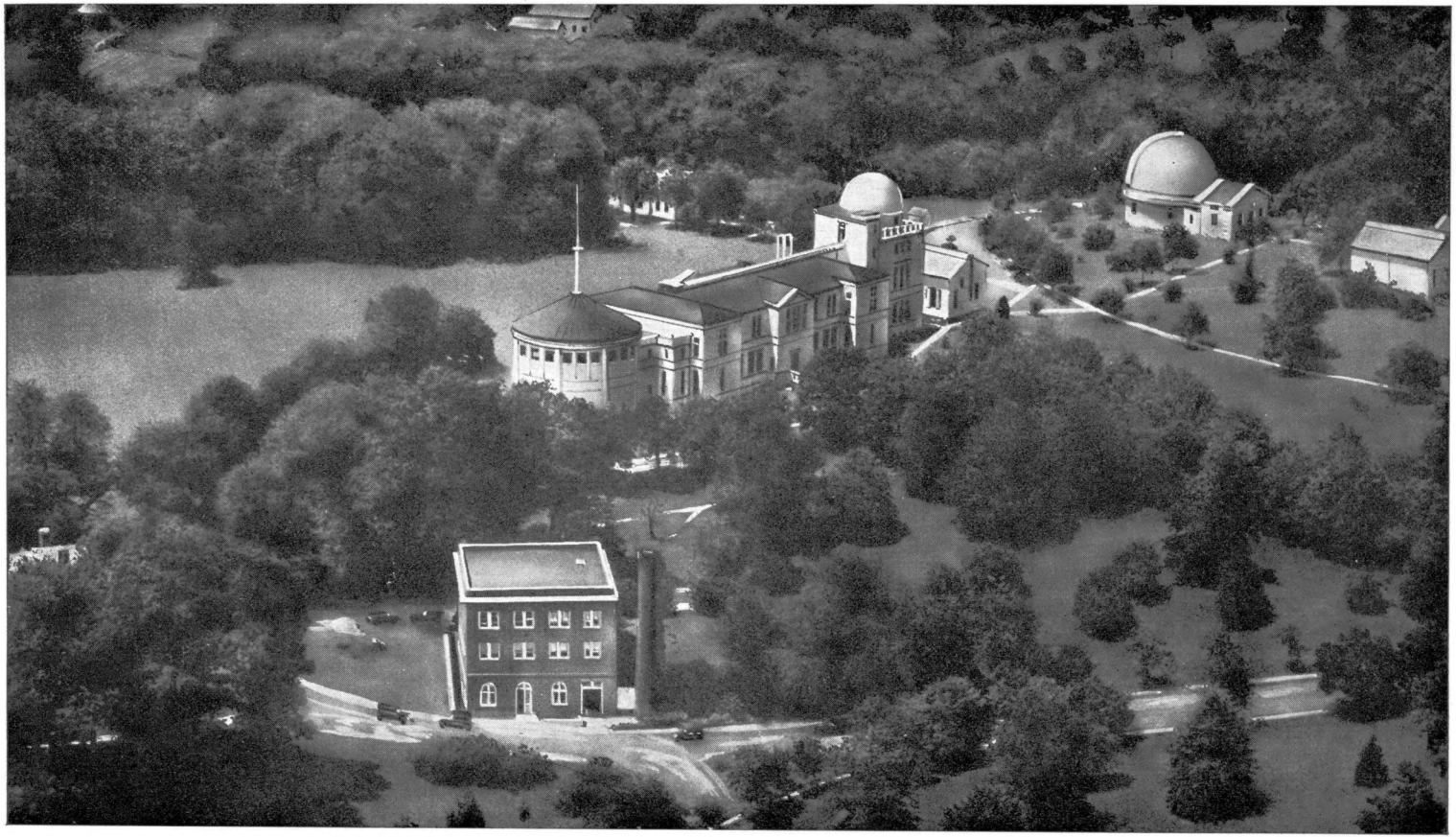

The United States Naval Observatory.

L'Observatoire Naval des Etats-Unis d'Amérique.

THE UNITED STATES NAVAL OBSERVATORY

(Extract from an article by CAPTAIN J.F. HELLWEG, U.S. Navy (retired) Published in *United States Naval Institute Proceedings,* Vol. 62, Annapolis, October 1936, page 1464).

How would the Naval Service like to "walk back the cat" to the gay nineties with infrequent checking of chronometers when the ship happened to be in port and in touch with a Western Union Telegraph office; or, if in an isolated place, to send the assistant navigator ashore with an artificial horizon to make observations for chronometer corrections ?

Our present-day methods and the lightning rapidity with which the navigator of today can obtain the exact error of his chronometers are a long step from the day when the superintendent of the Naval Observatory pushed a button that connected the Observatory with the fire alarm system of the capital.

The Navy as a whole knows little about the Naval Observatory except that it sends out the "tick" and publishes the *Nautical Almanac.* Few realize the effort that must be put forth continuously in order to insure the "tick" on time and the publication of books six months ahead of the date when they will be necessary for navigation.

Prior to 1830, the navigational requirements of ships were supplied by the purchase abroad through commercial agents, most of whom knew little or nothing about the requirements. Naturally, the results were far from satisfactory. Upon receipt, instruments were frequently found entirely unsuited, or useless; charts and publications were in foreign languages; longitudes were not reckoned from a zero meridian; and all required great effort and translation before availability for use in our naval service. When ships were decommissioned, their charts, navigational instruments, etc..., were piled in a storehouse at the navy yard where they lay neglected until reissue. Too frequently they were found to have deteriorated, necessitating further purchase — and the cycle repeated itself.

From 1809, when an amateur astronomer, William LAMBERT, presented his memorial to Congress recommending the establishment of a first meridian at the permanent seat of government, until 1830, all efforts to establish a national observatory had failed. LAMBERT determined the longitude of Washington and submitted his calculations to Congress with his memorial. As late as 1835 the Secretary of the Navy invited attention to the vital importance to the government of establishing a naval observatory, its effect on the defense of the country, its great influence on the Navy and on our commercial and economic life as well as our scientific advancement.

In 1830 the Secretary of the Navy upon recommendation of Lieutenant GOLDSBOROUGH established the Depot of Charts and Instruments and placed that officer in charge. His duties were defined as : the determination of the errors of chronometers, the translation of all books, charts, pamphlets, and other nautical information into English, and the reduction of all charts to the meridian of Greenwich. In 1833 Lieutenant WILKES, a scientist of note, relieved Lieutenant GOLDSBOROUGH. Becoming incensed at the procrastination of Congress in providing suitable accommodations, Lieutenant WILKES built his own observatory, 16 feet square, 1,000 feet north of the Capitol, on Capitol Hill, with his private funds. Therein he mounted a transit, made by TROUGHTON in England in 1815, and loaned to WILKES by the Coast Survey. He also installed a 3 1/2 inch portable telescope, a transit instrument, a sideral clock, and other accompanying equipment. In 1835 a lithographic press was installed and chart production was begun. The following year he was sent to Europe to purchase scientific instruments to be used on his exploring expedition. Lieutenant GILLIS who relieved him purchased the necessary equipment and instruments for the inauguration of the series of constant observations in astronomy, magnetism, and meteorology. He obtained a portable 4 1/2 inch achromatic telescope, equatorially mounted, a variation transit, a comet seeker, a sidereal chronometer, and subsequently a sidereal and a mean time clock. Observations with these new instruments began in 1838 and continued until 1842, thus laying the foundations of a permanent naval observatory.

Lieutenant M.F. MAURY relieved Lieutenant GILLIS in 1842, and in 1844 moved all the equipment to a new and permanent building.

WILKES was an astronomer, but MAURY devoted his time to the development of the hydrographic and meteorological work. He laid the foundations for the present internationally known system of hydrographic information and publications and established his fame as an oceanographer. One year later be began the systematic observations of the sun, moon, planets, and brighter stars, which have been continuous. In 1846 MAURY published the first volume under the remarkable title "The first Volume of Astronomical Observations ever issued from an Institution Properly Entitled to the name of Observatory on this Side of the Atlantic". The work of the Naval Observatory was soon noted throughout the astronomical world. It was at the Naval Observatory, in 1847, that the planet Neptune, which had been discovered in 1846, was found to be the same star which had been seen twice by the French astronomer LALANDE in 1795. Based on the Naval Observatory's determinations, the orbit of Neptune was reduced with great accuracy.

Between 1854 and 1860 three minor planets were discovered by the Observatory. In 1873 Congress appropriated money for the purchase and installation of the 26-inch refractor telescope. At the time of its installation it was the largest telescope in the world. It became famous in August, 1877, as the instrument with which Professor Asaph HALL discovered the moons of Mars.

The Naval Observatory was the first to use the telegraph in the determination of longitude between Baltimore and Washington and later between Havana and stations in the United States. In September, 1903, the Navy began the installation of the first broadcasting apparatus in Navesink, New Jersey, and in the spring of 1904 the broadcasting of correct time by radio signals on low power was inaugurated, followed in 1912 by broadcasting daily on high power from Arlington.

The mission of the Naval Observatory is stated : (1) to maintain continuous fundamental astronomical observations and calculations; (2) to prepare, publish, and distribute the *American Ephemeris, Nautical Almanac,* and other astronomical publications for maritime, commercial, and scientific use; (3) to derive, maintain, and disseminate the most accurate time for the national use; (4) to develop, procure, and supply navigational instruments and equipment for vessels and aircraft of the Navy; and (5) to contribute to the international advancement of navigation and astronomy.

The mission necessitated organizing a number of task groups, to each of which is assigned a definite objective, of which there are four : (1) time service, (2) publication of nautical information for navigational purposes, (3) continuous observations of sun, moon, planets, and bright stars for positional astronomy, and (4) the development, procurement, and distribution of all navigational instruments for the naval service. Eighty per cent of these tasks are almost exclusively naval.

The Naval Observatory differs very materially from all other observatories in that it is really the Material Section of the Bureau of Navigation except for printing press, ships' libraries, and band instruments. The task of this branch includes the formulating of all plans for the issue, development and care of navigational instruments.

The Naval Observatory is divided into two major branches : (1) the Nautical Branch, and (2) the Astronomical Branch. In addition to these two divisions, which might be considered our productive activities, there are the less attractive but necessary house-keeping activities. The Naval Observatory covers 72 acres in the best residential section of Washington. There are 55 buildings, some housing expensive instruments, all requiring upkeep.

Nautical Branch. — It is believed that the compass office, the time service, and the Nautical Almanac Office have the most far-reaching and immediate effect on the naval service. An error or a delay in any of these offices will be felt on every ship.

The compass division consists of two sections, the gyro section and the magnetic section. It is charged with the development, procurement, and repair of all compass material for the Navy, instruction of naval personnel, and the supervision of upkeep, etc.

The equipage division needs no explanation to the naval service. Everyone is familiar with the service navigational requirements. It is only necessary to note that all designs and details of navigational equipage under the Bureau of Navigation are controlled by the Naval Observatory. In addition to its duties in connection with the development of navigational instruments, it is charged with the preparation of specifications, the review of reports from ships, and the final action on all surveys. A close liaison is maintained with the Bureau of Aeronautics in the development of instruments used for the navigation of aircraft. For these purposes it has been necessary to develop a corps of expert horologists and navigational instrument makers.

The aeronautical section is one of the most important and rapidly growing units at the Observatory. It carries on the research and experimental work in the design, development, and improvment of aeronautical, navigational, and meteorological equipment.

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The question of a universal standard time constituted one of the most troublesome problems that had to be solved by the Nautical Almanac Office in the early days.

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The old records disclose a number of telegrams, letters, etc., from various communities, municipalities, etc..., desiring to buy time. The city of Leavenworth, Kansas, wanted to buy time once a month and the mayor of that city, considered an outstanding progressive, was willing to pay for the time to be delivered to the principal jeweler in Leavenworth. The jeweler was to communicate the time throughout the city and also to the railroads.

In 1884, upon invitation from the United States, an international meridian conference was held in Washington and agreed to establish a single prime meridian for the entire world for the measurement of longitude and time. The meridian of Greenwich, already adopted by several of the leading maritime nations including the United States, was accepted.

Six years ago the Naval Observatory was broadcasting time manually three times a day with an accuracy of .01 or .02 of a second. It is now broadcasting time automatically 20 times a day with a possible least count of .001 of a second. An automatic apparatus containing a crystal clock, a chronograph, and an automatic broadcaster was designed and constructed, and for the past two years all signals have been automatically broadcast by this apparatus.

In order to insure maintenance of accurate time, a clock vault was designed and constructed four years ago. This time vault consists of two vaults, one within the other. The inner vault is separated from the outer vault by a 30-inch air space. Both vaults were designed to prevent the transmission of heat through their walls. Both are controlled by separate thermostats; the outer vault is heated by gas and the inner one by electricity. The structure is fitted with regular magazine lighting. Each pier for each precision timepiece is oriented so as to be in the "dead angle" of adjacent piers to prevent the sympathetic influence of the swinging pendulums. Pressure and temperature are maintained constant.

To permit visitors to see the clocks "that keep the nation's time", an old periscope was obtained and was let down through the roofs of both vaults. During the last Navy Day "at home" over 2,000 people peered through the periscope which is used to make daily visual inspections of the operation of all the standard clocks.

The orthodox method of determining time by visual observations of the transit of stars has been abandoned. The Naval Observatory is the pioneer in the photographic determination of time. These developments have given the United States the most accurate time in the world. In the near future it is hoped that we will be able to determine time with an accuracy of .001 or .0002 of a second.

The Navy is so well acquainted with the *Nautical Almanac* that a detailed description is considered unnecessary. The Nautical Almanac Office consists of four sections : the stellar section, the solar section, the lunar section, and the satellite section.

The *Nautical Almanac* and the *Ephemeris* have grown to such proportions that in order to avoid the expense and the needless duplication of the work an agreement has been reached by all the principal maritime nations of the world to divide the work and to exchange the output of each office. This international exchange agreement has proved excellent, the major part of the work being divided between Great Britain, France, Germany, and the United States. We are justly proud that most of the theories of the sun, moon, planets, and satellites, and the tables based on them by means of which the ephemerides are prepared, were developed in the Nautical Almanac Office of the United States Naval Observatory.

Within the past two years letters have been received from two of the principal maritime nations notifying this Observatory that after 1936 they will employ Naval Observatory formulas and methods in their determination of certain functions.

The *Ephemeris* is published three years in advance and the *Nautical Almanac* one year in advance to insure having on hand at all times, even on a long cruise, the current almanac showing the positions of the sun, moon, and stars, arranged for every day of the year.

The Astronomical Branch provides for continuous observations of the sun, moon, planets, and fundamental stars for the determination of absolute positions. This work includes the determination of the position of the equator and the equinox among the stars .

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The new 40-inch reflector is the largest example of that particular type of reflector in the world. It took over three years to construct, and only recently has been placed in service.

The 9- and 6-inch transit circles have been used for years in our fundamental astronomical work. The 6-inch has gained a reputation for excellence in positional astronomy exceeded by none. For years the 6-inch was used in time determination also, and averaged about 7,000 stars annually in that work.

The P.Z.T. (photographic zenith tube) has been used for years in the determination of the variation in latitude. Several years ago it was modified for use in determining time photographically. This institution, as far as known, is the pioneer in photographic determination of time. The results have been uniformly excellent.

The 5-inch photoheliograph takes daily pictures of the sun and records all sun spots found. For years the Western Union Telegraph Company has maintained at its own expense a daily record of our sun spot data. They have found that there is a direct relation between the presence or absence of sun spots and the transmission of messages by wire.

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