

Mr. Pitman gave the one-semester course in Introductory Astronomy and also the first half of the year course in Descriptive Astronomy, while Mr. van de Kamp was in Europe until Christmas on a Fulbright award. He lectured at the Institut d'Astrophysique in Paris, and on December 11 gave the annual lecture for the Société Astronomique de France. During the second semester Mr. van de Kamp gave the second half of the course in Descriptive Astronomy and a seminar in double stars.

In June Miss Lippincott received the M.A. degree in Astronomy, her thesis was an astrometric study of the unresolved binary Ross 614; Miss Smith finished an astrometric study of Algol. The results of both investigations are to be published in this journal. Measurements for parallax and mass-ratio continued. Mr. van de Kamp and Miss Lippincott published a summary of thirty Sproul parallaxes of high accuracy.

Photographic observations with the twenty-four-inch refractor were made on 119 nights, a total of 2050 plates were taken. Evening observations were made on 111 nights; morning observations on 57 nights; 49 nights included both evening and morning observations.

Peter van de Kamp, *Director*

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Appointments to the staff were: Julena S. Duncombe, August 1, 1949; and S. M. Bestul, January 9. Bevan P. Sharpless was retired, January 1. Losses by resignation or transfer were: Elma Oehrtmann, September 9; Beatrice M. Rosen, November 14; Carl L. White, January 30; and Betty K. Murphy, February 7. The appointments of Lillian Feinstein and Blanche R. Hollander as part-time piecework computers were terminated.

Congress passed legislation authorizing the relocation of the Observatory, but has not appropriated funds for the purpose.

The number of visitors during the year was 15,000.

U. S. Naval Observatory Circulars Nos. 1-20 were issued. The contents of the individual circulars are noted in the following accounts of the work to which each relates.

Star observations for the determination of time and the variation of latitude were made throughout the year, using the photographic zenith tubes at Washington, D. C., and at Rich-

mond, Florida. The work at the latter station was on a preliminary basis until the end of February, since it was necessary to complete a year of observing in order to obtain a uniform system of star places. Since then, the time signal transmissions and corrections have been based on the work of both stations. A total of 2277 star observations were made on 190 nights at Washington, and 3928 star observations were made on 257 nights at Richmond.

Time signals based on these determinations were transmitted every two hours by NSS, the Naval Radio Station at Annapolis, and continuously by WWV, the standard frequency station of the National Bureau of Standards. Secondary time transmissions were also made from naval radio stations located in California, Hawaii, and the Canal Zone, and by station WWVH, the National Bureau of Standards station in Hawaii. The average error of the Annapolis time transmissions on 9425 kilocycles, as indicated by the time determinations at Washington and Richmond, was 0^o007.

The variation of latitude for Washington and Richmond for the year 1949, excepting January and February at Richmond, has been prepared for publication. Since the two stations have nearly the same longitude, it is hoped that a study of the comparative latitude results over a sufficient period may give information of considerable value. The variation of latitude at Washington for 1948 was published in *A. J.* 55, 13.

A description of the Naval Observatory Time Service was issued as *U. S. Naval Observatory Circular*, No. 14.

The Nautical Almanac Office completed its 100th year. Established by an Act of Congress approved on March 3, 1849, it began work at Cambridge, Massachusetts, in the latter part of 1849.

The *American Ephemeris and Nautical Almanac* for 1951 was issued Jan. 13. The *American Nautical Almanac* for 1951 was issued May 16; and the three parts of the *American Air Almanac* for 1950 were issued July 18, and Dec. 14, 1949, and March 10, 1950.

The tracks of total solar eclipses during 1955-1960, calculated at the request of the Chairman of Commission 13 of the International Astronomical Union, from tabular positions of the sun and moon supplied for the purpose by the British Nautical Almanac Office, were issued in *U. S. Naval Observatory Circulars* Nos. 2 and 16.

Work on a spaced list of 3087 stars between declinations $+35^\circ$ and $+50^\circ$ was continued with the 6-inch transit circle. As usual, the observing program included the sun, moon, planets, FK3 stars, and short lists of PZT stars, to which were added in January Ceres, Pallas, Juno, and Vesta. The total number of observations was 7729.

The results of observations made with this instrument during the period 1925-1941 were published as *Publications of the U. S. Naval Observatory* 16, Part I. The reductions and discussion of the observations of the 1941-1948 period are in progress and should be completed in 1951.

The new 7-inch transit circle, under construction at the Observatory, is approaching completion. It has been decided to mount it in the east transit house, which was formerly occupied by the 9-inch. The latter has been dismantled and stored, and preparations are under way to remove the old piers and replace them with suitable ones for the new instrument.

For use with the 26-inch refractor, a double slide plateholder and a new tail piece assembly were constructed; it is now possible to attach quickly either a micrometer, a plateholder or a photometer without the use of tools. A special focal-plane shutter for securing lunar photographs is included in the plateholder. The Rep-sold micrometer was replaced by the much lighter Clark II micrometer. Considerable changes, both mechanical and optical, were made in Clark II to improve the ease of measurement.

Experiments in the use of high powers with the 26-inch refractor for the measurement of close double stars were made by Markowitz. A single negative lens of 12.5 mm focal length is used to increase the magnification by 3.3 and to reduce the apparent diameter of the spider threads to $0''.04$. Powers of 1300 to 2500 were used to measure 546 pairs in the period October to July. The separations of the pairs are under $1''$, with some exceptions, and about half the separations were from $0''.15$ to $0''.50$.

The 15-inch Cooke triplet was mounted in place of the 10-inch lens on the astrographic telescope. Numerous tests of the new objective were made. During the year, plates of 12 asteroids and 1 comet were obtained, and 86 plates were reduced.

The sun was photographed on 255 days, and was observed with the spectrohelioscope on 217 days. The positions, areas, and counts of sun-

spots are published monthly in the *U. S. Naval Observatory Circular*, the tabular material being set up automatically by means of a card-operated typewriter. During the year, the data from January 1948, when publication in the *Monthly Weather Review* was discontinued, to April 1950, inclusive, appeared in *Circulars* No. 3, 4, 6, 8-13, 15, 17, 19.

Tests have shown that a birefringent filter constructed for the Naval Observatory by Baird Associates is fully satisfactory. The filter and associated equipment are now being remounted in the old south transit room, and a coelostat is being set up to the south. It is planned to have a practically continuous patrol of the sun for the observation of flares. The filter has a band width of one angstrom and has a total tuning range of four angstroms, centered at $H\alpha$.

The mirrors of the 40-inch Ritchey-Chretien reflector were aluminized by The Perkin-Elmer Corporation in July. With apparatus mounted on this telescope, the light from 551 early-type stars was analyzed by Hall and Mikesell for polarization. The results are in press in *Publications of the U. S. Naval Observatory* 17, Part I. Hall has measured polarized light from the Orion nebula.

Seventy-four plates were taken at the 26-inch by Markowitz with a calcite crystal in developing a photographic method of determining polarization. Objects studied include the clusters h Persei and NGC 1502, and the triple system β Monocerotis; independent observations by Hall at the 40-inch and by Markowitz at the 26-inch indicate that components B and C are less polarized than A, but additional observations of this system are desirable.

The frequency and amplitude of the fluctuations in the intensity of starlight as produced by rapid variations in the optical properties of the earth's atmosphere were being studied by Mikesell. A 12-inch telescope mounted in a fixed position is used for continuous observation of Polaris with a multiplier phototube. The energy in bands 6 c.p.s. wide in the frequency range of 18 to 2000 c.p.s. was automatically recorded. Possible correlations of the energy at different frequencies with seeing and with meteorological conditions are being investigated. Preliminary results show maximum energy at the lowest frequency, and imperceptible amplitude beyond 400 c.p.s.

The status of the cooperative undertaking with the Yale University Observatory and the Watson Scientific Computing Laboratory, under

the auspices of the Office of Naval Research, is as follows:

(a) The first-order general theory of the motion of Mars by Clemence was published in *Astronomical Papers of the American Ephemeris*, **11**, Part II. Preliminary investigations have been made of methods for the calculation of the higher order general perturbations.

(b) The definitive positions and motions of the primary reference stars for use in reducing photographic observations of Pluto were derived by H. R. Morgan and are in press in *Astr. Pap. Amer. Eph.* **11**, Part III.

(c) Morgan's work on the preparation of the new fundamental star catalogue is practically finished for the equatorial half of the sky; and the extensions to the north and south poles are nearing completion. For the investigation of the constant of precession, a considerable amount of work has been done on observational determinations of the position of the equinox among the stars at different epochs from 1780 to 1940.

Provisional systematic corrections to the GC and the FK3 for the equatorial half of the sky have been published in *A. J.* **54**, 145.

The completion of the southern sky has been made possible by the receipt from H. M. Astronomer of an advance copy of the *Second Cape Catalogue 1925*, and a manuscript copy of results for the *First Cape Catalogue 1950*, both in process of publication. For the northern stars, the Astronomer Royal has supplied positions from the *First Greenwich Catalogue 1950*, now being reduced. These important contributions are highly appreciated.

(d) The numerical integration of the orbits of Ceres, Pallas, Juno, and Vesta at the Cincinnati Observatory was completed by Paul Herget, and the constants of the orbits determined by Clemence and Hertz. The rectangular heliocentric coordinates for 1920–1960 are in press. A geocentric ephemeris of Juno for the opposition of 1950, prepared in the Nautical Almanac Office, and ephemerides of Juno for 1951 and Ceres, Pallas, Vesta, 1950–51, calculated in the British Nautical Almanac Office, were published in *U. S. Naval Observatory Circular*, Nos. 5, 7, 18, 20. Beginning with 1952, these ephemerides will appear in the *American Ephemeris* and in the *British Nautical Almanac*. The primary purpose of this work is to improve the accuracy of determinations of fundamental right ascensions and declinations.

(e) Hertz has continued his discussion of the meridian observations of Jupiter, with the primary object of improving our knowledge of the mass of Saturn. A discussion of the meridian observations of Venus has been commenced by Duncombe; it is hoped to settle the long-standing question as to the motion of the node. The discussion of photographic observations of the satellites of Saturn, in the hands of Hollander, was continued; in addition to supplying information on the mass of Saturn, this material should yield results of interest on the motions of the apsides of the satellites.

(f) Preliminary algebraic developments for the reconstruction of the theory of precession and nutation have been completed by Woolard.

(g) A numerical integration of the motions of the five outer planets at the Watson Scientific Computing Laboratory was nearly completed; and the rectangular coordinates for 1653–2060 are in press. Extensive comparisons of the integration with observations and with existing tables have been made. The integrations for Jupiter and Saturn agree much better with observations than Hill's tables do; significant errors in the tables are indicated, but it is not yet possible to state the cause.

Further reference to this cooperative undertaking will be found in the Report of the Yale Observatory.

The meridian observations of the moon at Washington, 1947–48, were discussed by Watts, *A. J.* **55**, 111. The discussions of the observations during the past 25 years indicate that about 1940 the rate of rotation of the earth increased by one part in 150 million.

The survey of the marginal zone of the moon, begun in 1947 by Watts, is proceeding according to schedule. The measurement of photographs of the moon was started in December, and 108 out of 580 plates on hand were measured. The survey is based on photographs made at the Yale-Columbia Southern Station at Johannesburg, and the Lowell Observatory, as well as the series obtained at Washington. An abstract of a paper by Watts and Adams, "Photographic and Photoelectric Technique for Mapping the Marginal Zone of the Moon," appeared in *A. J.* **55**, 81.

A study of atmospheric refraction at large zenith distances by Clemence is in progress.

An international conference on the fundamental constants of astronomy, held in Paris,