

**ANNALS OF THE
ASTRONOMICAL OBSERVATORY
OF HARVARD COLLEGE VOLUME
93; THE HENRY DRAPER
CATALOG 7H AND 8H**

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ANNIE J. CANNON & EDWARD C. PICKERING

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MRS. HENRY DRAPER.
1839-1914.

ANNALS
OF
THE ASTRONOMICAL OBSERVATORY OF HARVARD COLLEGE

VOLUME 93

THE HENRY DRAPER CATALOGUE

7^h AND 8^h

BY
ANNIE J. CANNON
CURATOR OF ASTRONOMICAL PHOTOGRAPHS
AND
EDWARD C. PICKERING
DIRECTOR OF THE OBSERVATORY

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PREFACE.

THE Henry Draper Memorial is due to the unflinching devotion of Mrs. Draper to the memory of her husband. It is literally true that he never entered his observatory without her. For many years, and until her health failed, she frequently came to Cambridge to see the progress of the work devoted to his memory. At the very last, she showed the greatest interest in the results attained. It seems, therefore, very appropriate that her portrait should appear as a Frontispiece of this, the third volume of the greatest work yet undertaken as part of the Henry Draper Memorial.

EDWARD C. PICKERING,
Director of the Observatory of Harvard College.

CAMBRIDGE, U.S., December 25, 1918.

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THE HENRY DRAPER CATALOGUE.

THE Henry Draper Catalogue originated in the attempt to collect in a single catalogue a description of all the stellar spectra which could be classified on the photographs of the Henry Draper Memorial. It was shown in May, 1885, that by placing a prism in front of the objective of a photographic telescope, excellent spectra could be obtained of all the stars of sufficient brightness in the field of the instrument. The immediate effect was that the photographic image of each star, instead of appearing as a point, was spread into a line, the rays of different wave lengths being diverted by the prism to different points upon the plate. These lines were then broadened into bands by giving a rate to the driving clock differing slightly from sidereal time. The principal lines in the spectra appear in these bands. The advantages of this method are, first, that the spectra of several hundred stars can be obtained on a single photograph, while with a slit spectroscope only one star can be photographed at a time. Secondly, the loss of light is so small that, even if stars are faint, satisfactory spectra can be obtained. Thirdly, the spectra can be identified with certainty, since they occupy the same relative positions on the photographs as stars on a chart plate, or map.

The classification of the spectra required for the Henry Draper Catalogue was begun by Miss Annie J. Cannon on October 2, 1911, and practically completed September 30, 1915. Some additional spectra were taken from later plates, where faint stars had not been classified previously. The total number of spectra classified is 242,093, relating to about 222,000 stars. The greater portion of the northern stars were classified from 709 plates taken with the 8-inch Draper Telescope, mounted at Cambridge. In like manner, 1,409 plates of the southern stars were used, taken with the Bache Telescope, mounted at Arequipa, Peru. Each of these instruments has, for an objective, an 8-inch Voigtlander Portrait Lens, corrected by Alvan Clark and Sons. Two prisms having angles of 13° and 5° were originally used with each instrument. They formed spectra having a dispersion such that for the 8-inch Draper Telescope the intervals between the lines $H\beta$ and $H\epsilon$ were 5.61 and 1.60 mm., respectively.

The corresponding intervals for the Bache Telescope were 5.80 and 2.23 mm. It appeared that the definition was better with the prism giving the larger dispersion attached to the 8-inch Draper Telescope, and with the prism giving the smaller dispersion attached to the Bache Telescope. For this reason, the spectra of much fainter stars could be classified from the photographs taken in Arequipa, than from those taken in Cambridge. Exceptions were made in the case of southern stars which are too dense on plates of small dispersion, and of northern stars so near together that their spectra are superposed on plates of long dispersion. Some northern stars between 0° and $+10^{\circ}$ in declination were also classified from plates of short dispersion taken in Arequipa.

In November, 1900, two prisms, having nearly equal angles of about 6° , were attached to the 8-inch Draper Telescope. They were mounted so that they could be rotated by any desired amount, which was measured by means of a graduated circle. When placed in opposite directions they nearly neutralized each other, while, when turned in the same direction, the dispersion was double that of one of the prisms. The angles adopted were such that the dispersions were the same as those previously employed, 5.61 and 1.60 mm.

A number of photographs showing fainter stars were taken with the 16-inch Metcalf Telescope. The regions selected were the centres of the Harvard Standard Regions described in H.A. 14, 477, and a few others, such as the Pleiades, Praesepe, etc. The distance between the lines $H\beta$ and $H\epsilon$ was here 3.90 mm.

On all of the plates described above, the spectra of the bright stars were dense, so that they could not be classified. Accordingly, spectra taken with a larger dispersion were used. For stars north of declination -20° , from one to four prisms were attached to the 11-inch Draper Telescope. The interval between the lines $H\beta$ and $H\epsilon$ varied from 19.63 to 80.50 mm. These spectra have already been described in H.A. 28, Part 1, but as a different system of classification was there employed by Miss Maury, the spectra were again classified by Miss Cannon. This work was extended to stars of the fifth magnitude, and a few that were fainter, by means of H.A. 56, No. 4. For the southern stars, brighter than the sixth magnitude, the spectra are taken from H.A. 28, Part 2, and H.A. 56, No. 5. From one to three prisms were employed, and the interval from $H\beta$ to $H\epsilon$ varied from 21.57 to 72.15 mm.

From August, 1885, to November, 1894, Seed 26+, from December, 1894, to December, 1899, Cramer Crown, from January, 1900, to May, 1911, Seed G. E. 27, and since June, 1911, Hammer Special plates were generally used.

Substantially the same classification has been used in all the publications of the Henry Draper Memorial, except in the case of H.A. 28, Part 1. Slight changes have

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been introduced from time to time as experience showed that the classification could be improved. For instance, Class H, used in H.A. 27, has been abandoned, since it has been found that it is identical with Class K, when photographed under favorable conditions. The letters were originally applied empirically, a separate letter for each class of spectrum which appeared to be different. Later, it was found that nearly all the spectra fell into the classes B, A, F, G, K, and M, which thus formed a continuous sequence. Intermediate spectra are indicated by numbers representing tenths of the interval. Thus, A₅ represents a spectrum midway between A₀ and F₀. The numeral is omitted when a precise classification cannot be made. Class B was found to precede A, but the letters could not be reversed without causing confusion. Class P, designating gaseous nebulae, and Class O, stars of the fifth type, appear to precede Class B. The unanimous adoption of this system by an International Committee appointed by the Solar Union has secured its universal acceptance. The countries represented on this Committee were Canada, England, France, Germany, Holland, and the United States.

The designations of the lines used in describing the spectra, are generally the same as in the previous volumes. An exception is made, however, in the case of the series of lines first found in the spectrum of ζ Puppis. Professor Pickering showed these lines to be so closely represented by a modification of Balmer's formula, that he assumed them to be due to "hydrogen under conditions of temperature or pressure yet unknown," as stated in H. C. 16, January 12, 1897. The lines were therefore called "additional hydrogen lines," with the specific designations as follows: line 5411, H β' ; 4541.9, H γ' ; 4200.3, H δ' ; 4026.0, H ϵ' ; 3924.0, H ζ' ; 3860.8, H η' ; 3815.7, H θ' ; 3783.4, ϵ' . Recent investigators, however, find by experiments in the laboratory that these lines are probably due to helium. They are now commonly called ζ Puppis lines and this designation is accordingly adopted here.

The classification and designation of peculiar spectra present great difficulties. Some spectra are so peculiar that they can not be assigned to any known class, and are marked Pec. in Table I. Others show deviations of various kinds and degrees, and yet resemble the typical spectra in the most essential characteristics. In the latter case, the class which the peculiar spectrum resembles most nearly is given, followed by the letter p. A description of the deviation from the typical spectrum will then be found in the Remarks following Table I. The deviations may occur in several ways, as has already been discussed in H.A. 28, 143. First, in the width of the lines. The difference in the width of the lines, especially whether the lines are diffuse or sharp, was early recognized. On September 8, 1887, the spectra of α Cygni, in which the lines are very sharp, and of α Aquilae, in which they are diffuse, were

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