# I. Introduction

This is the fifth of a projected seven volumes in a program of systematic reclassification of the Henry Draper stars on the MK system and contains all HD stars between $\delta_{1900} = -12^\circ.0$ and $\delta_{1900} = +5^\circ.0$. The previous volumes [VOL1-4] cover from $\delta_{1900} = -90^\circ.0$ and $\delta_{1900} = -12^\circ.0$. It is recommended that users read the accompanying text before utilizing the catalogue in order to take full advantage of its contents and to learn the notation and practices followed.

The stars were classified visually on objective-prism plates taken with the Michigan Curtis Schmidt telescope at Cerro Tololo Inter-American Observatory. The $4^\circ + 6^\circ$ prisms yield a dispersion at $H_\gamma$ of 108 $\AA/mm$, and the average resolution is about 2 $\AA/mm$, comparable to that of the original MK system [MKK]. The spectra were taken on IIaO plates and widened to 0.8 mm, with $20^m$, $4^m$, and $1^m$ exposures being obtained. The high quality of the spectra is illustrated in our second *Atlas* [HN]. In order to maintain a uniform, consistent system, all the spectral classification was done by one person (Houk).

Over 170 standard stars were used. (See Tables 1-3 and section III). The HD stars were identified using computer-generated plots to the scale of the Schmidt plates [HC]. Of the 31,075 HD stars in the catalogue, 30,235 or over 97% were classifiable. Previously published types are listed for the 3% not classifiable on our plates. Over 96% of the stars in the catalogue have both temperature and luminosity types. Many of those that do not are peculiar stars. Internal classification errors were obtained using the 11% of the stars classified independently on more than one plate. Both the internal and external errors are similar to those usually obtained in classification of slit spectra. 16% of the stars have remarks in the back of the volume giving further information.

Sections below include II Acknowledgments, III. Spectral Classification, IV. Description of Catalogue, V. Description of Remarks, and References

# II. Acknowledgments

A project of this scope, involving eventual reclassification of all the HD stars, necessarily involves the dedicated efforts of large numbers of people. These have contributed to the project in such substantial ways that it was decided the acknowledgments should hold the place of honor at the beginning, rather than appearing at the end as is customary.

First we acknowledge our enormous debt to Annie J. Cannon and the Harvard College Observatory for the Henry Draper Catalogue [CP], upon which our work is largely based. The present project scarcely would have been possible without the *Henry Draper Catalogue* as a foundation. Even with our present-day advantage of electronic computers and high-quality spectra the undertaking is proving a formidable one, and we appreciate and marvel more than ever at what Miss Cannon was able to do with the resources she had on hand.

We owe much to W. W. Morgan and P. C. Keenan for their encouragement and advice especially in the early stages of the project.

The role of William P. Bidelman in this undertaking is a large and critical one. For many years he had urged that such a project be carried out and he ultimately started it himself, while at the University of Michigan. He and Orren Mohler were instrumental in getting the Michigan Curtis Schmidt telescope moved to the Cerro Tololo Inter-American Observatory with the aid of a grant from the National Science Foundation. Bidelman also directed the southern observing program from 1967 through 1969. We thank him for much advice and help.

The reclassification itself might never have gotten under way if C. R. Cowley had not consented to become principal investigator and project director, obtaining the original grant from the National Science Foundation (with Anne Cowley as co-principal investigator). We thank them both very much for their support and input.

For day-to-day help on many phases of producing Volume 5 , including the training of assistants, but especially the computer programming and documentation, headed by graduate student and co-author Carrie Swift, we are deeply indebted to undergraduates Michael Allinger, James Barta, Clair Branch, Michelle Cornog, Aimee D'Onofrio, Aaron Evans, David Frankel, Carla Goodnoh, Robert Piontek, and

Sarah Winfrey who all did fine work and went far beyond the call of duty, often under time pressure.

The sheer amount of data involved produced a plethora of tedious but vital clerical and proofreading tasks and a great deal of data entry. This work was mainly done by students in the University of Michigan Undergraduate Research Opportunities Program (UROP) and Work-Study Program. Almost everything was done or checked by two people to cut down on errors. We thank the following for their contributions: Richard Algra, Jena Baker, Jay Beeber, Charles Boulard, Luis Buitragn, Omar Cantu, Richard Carrera, Jean Chang, Scott Cramer, Raffy Davessia, Chaitanya Diwadkar, Michael Dojka, Adam R. Duncan, Dan Durda, Nicolas Fernandez, Rafael Francisco, Benjamin Graetz, Christopher Groesbeck, Margaret Grunow, Eric Hall, Jennifer Hippert, Angela Holt, Jason Hurley, Daniel Kocevski, Julie Lanyon (for last-minute herioc efforts), Madelene Means, Dina Mirijanian, Rafael Jose Mora, Megan Nesbitt, Thuyduong Nguyen, Jeremy J. Ortwine, Peter Rose, Erika Sandor, Elizabeth Sturgis-Doutre, Naomi Taylor, Joan Wang, A. White, Mark Wilson, Sherry Winkelman, and Joei Wroten. Names of others were lost in the mists of time, since neither UROP nor our project maintained complete records, but we are also grateful for the contributions of AB, SB, KJ, BL, SL, JHM, DN, Felipe F, SRP, CDR and JES, with apologies.

The earlier work of Wayne Fullerton, who produced the computer-generated plots of the HD stars to Schmidt scale for the whole sky, and of D. J. MacConnell, who did much early planning, observing, and training of observers, is still contributing to the success of the project.

Thanks also to the following observers, who took the high-quality plates so vital to good results: Klaus Czuia, Arturo Gomez, Gabriel Martin, Daniel Muturana, Mauricio Navarrete, and Mario Zemelman. We gratefully acknowledge the staff of the Cerro Tololo Inter-American Observatory for their help and cooperation during the 11 years that the southern survey was under way.

I am indebted to Robert F. Garrison for again kindly providing unpublished spectral types for most of the stars too overexposed to classify on Michigan plates.

The Goddard Space Flight Center has been very helpful, distributing both tape and CD-ROM versions of Volume 1, Volume 2, Volume 3, and Volume 4 of the Michigan Spectral Catalogue for us. Also Goddard's SkyView utility was very useful in identifing stars which were either on plates which had lost the matching Fullerton plots, or which were so closely spaced that identification from the plots was difficult.

We are also deeply grateful to Francois Ochsenbein and the Centre de Données Stellaires de Strasbourg for furnishing an extensive tape, which not only provided the more accurate values of right ascension and declination used in this catalogue, from the Proper Motion Catalogue, but also the CPD and SAO numbers and indication of the existence of the stars in several other catalogues, including an indication of all visual doubles. Also thanks to them for providing improved magnitudes for nearly all of the stars in this volume.

Many other people, too numerous to mention, have aided this project in various ways, and we thank everyone involved.

Finally we are especially grateful to the National Science Foundation for its continuing wholehearted support of this research, which has made the project possible. This material is based upon work supported by the National Science Foundation under Grant Numbers 8913683 and 9422318. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

# III. Spectral Classification

## A. Standards

The similarity in resolution of our spectra to that of the original work by Morgan and Keenan [MKK] allowed us to classify on a system which is a good approximation to the MK system. We used MK standards when they were available and supplemented with others as necessary. (See Tables 1-3). Objective-prism classification differs from slit classification in that often the spectrum is not of optimum density. Almost all of our standards had from 4 to 8 widely varying exposures so a fairly good match could almost always be found with one of the 3 exposures we had of each program star. Because the appearance of the hydrogen wings varies strongly with exposure, Houk did not rely on memory but directly compared virtually all the B and A stars with one or more standards. Many stars of later type were similarly compared; it is estimated that nearly half of the classifications in the catalogue were made by direct comparison with standards. This procedure will also be followed in future volumes to avoid any drift in the system.

The primary standards are listed in Table 1 below. The MK standards were supplemented by types by Bidelman in order to get an adequate representation of supergiants. Table 2 lists 20 other stars used as standards for which plates already were available at Michigan or which were sought out in the course of the classification to fill gaps in the primary standard grid.

The vast majority of the standard spectra fit very well into a consistent scheme, but a few did not and these 5 are listed in Table 3. We do *not* suggest that other classifiers use the types we have assigned as these are based only on one plate. Others may well come to different conclusions. If we are wrong about these stars, then the early G dwarfs in the catalogue may be systematically slightly late since several standards are involved.

## Table 1 Primary Table of Standards

| | Name | HR No. | HD No. | Spectral Type | Source |
|---|---|---|---|---|---|
| | $\tau$ CMa | 2782 | 57061 | O9 Ib | † MK (1973) |
| | 16 Sgr | 6823 | 167263 | O9 II | J+M (1953) |
| * | $\iota$ Ori | 1899 | 37043 | O9 III | † MK (1973) |
| | — | — | 52266 | O9 V | J+M (1953) |
| | — | 6347 | 154368 | O9.5 Iab | B (1954) |
| | $\zeta$ Ori | 1948 | 37742 | O9.5 Ib | J+M (1953) |
| | $\delta$ Ori | 1852 | 36486 | O9.5 II | J+M (1953) |
| | $\sigma$ Ori | 1931 | 37468 | O9.5 V | † MK (1973) |
| ** | 15 Sgr | 6822 | 167264 | B0 Ia | J+M (1953) |
| ** | — | 6219 | 150898 | B0 Iab | B (1954) |
| ** | — | 2479 | 48434 | B0 III | J+M (1953) |
| | $\delta$ Sco | 5953 | 143275 | B0.3 IV [B0.5 IV] | † MK (1953) [H,G,S (1969)] |
| | $\tau$ Sco | 6165 | 149438 | B0 V | † MK (1973) |
| ** | $\kappa$ Ori | 2004 | 38771 | B0 .5 Ia | † MK (1973) |
| ** | — | 6142 | 148688 | B1 Ia | B (1954) |
| * | $\rho$ Leo | 4133 | 91316 | B1 Ib | J+M (1953) |
| * | $\sigma$ Sco | 6084 | 147165 | B1 III | J+M (1953) |
| ** | $\omega^1$ Sco | 5993 | 144470 | B1 V | † MK (1973) |
| ** | $\chi^2$ Ori | 2135 | 41117 | B2 Ia | † MK (1973) |
| | $\epsilon$ CMa | 2618 | 52089 | B2 II | J+M (1953) |
| ** | $\pi^4$ Ori | 1552 | 30836 | B2 III | J+M (1953) |
| | $\gamma$ Peg | 39 | 886 | B2 IV | † MK (1973) |
| | 22 Sco | 6141 | 148605 | B2 V | † MK (1973) |
| | 3 Gem | 2173 | 42087 | B2.5 Ib | J+M (1953) |
| | $\sigma$ Sgr | 7121 | 175191 | B2.5 V | † MK (1973) |
| | $o^2$ CMa | 2653 | 53138 | B3 Ia | † MK (1973) |
| ** | — | 3654 | 79186 | B3 Ia | B (1954) |
| ** | $\kappa$ Cru | — | 111973 | B3 Iab | B (1954) |
| | $\iota$ Cma | 2596 | 51309 | B3 II | J+M (1953) |
| | $\nu$ Ori | 2159 | 41753 | B3 V | J+M (1953) |
| | — | 6450 | 157038/9 | B4 Ia | B (1954) |
| * | $\eta$ CMa | 2827 | 58350 | B5 Ia | † MK (1973) |
| ** | — | 3456 | 74371 | B5 Iab | B (1954) |
| ** | 67 Oph | 6714 | 164353 | B5 Ib | J+M (1953) |
| * | $\tau$ Ori | 1735 | 34503 | B5 III | J+M (1953) |
| | $\iota$ Aql | 7447 | 184930 | B5 III | J+M (1953) |
| ** | $\kappa$ Hya | 3849 | 83754 | B5 V | J+M (1953) |
| | $\psi^2$ Aqr | 8858 | 219688 | B5 V | J+M (1953) |
| | — | — | 183143 | B7 Ia | J+M (1953) |
| ** | — | 3708 | 80558 | B7 Iab | B (1954) |
| ** | $\beta$ Ori | 1713 | 34085 | B8 Ia | † MK (1973) |
| ** | $\gamma$ CMa | 2657 | 53244 | B8 II | J+M (1953) |
| | 18 Tau | 1144 | 23324 | B8 V | † MK (1973) |
| ** | — | 4338 | 96919 | B9 Ia | B (1954) |
| | — | 1804 | 35600 | B9 Ib | J+M (1953) |
| | $\gamma$ Lyr | 7178 | 176437 | B9 III | J+M (1953) |
| | 134 Tau | 2010 | 38899 | B9 IV | J+M (1953) |
| ** | — | 4169 | 92207 | A0 Ia | B (1954) |
| ** | 13 Mon | 2385 | 46300 | A0 Ib | J+M (1953) |
| * | $\gamma$ Gem | 2421 | 47105 | A0 IV | J+M (1953) |
| | $\gamma$ UMa | 4554 | 103287 | A0 V | † MK (1973) |
| ** | — | 4876 | 111613 | A1 Ia | B (1954) |
| | $\iota$ Ser | 5842 | 140159 | A1 V | J+M (1953) |
| | $\beta$ Ser A | 5867 | 141003 | A2 IV | J+M (1953) |
| | $\beta$ Eri | 1666 | 33111 | A3 III | J+M (1953) |
| ** | $\beta$ Leo | 4534 | 102647 | A3 V | J+M (1953) |
| | $\alpha$ PsA | 8728 | 216956 | A3 V | † MK (1973) |
| | $\delta$ Leo | 4357 | 97603 | A4 V | J+M (1953) |
| ** | — | 825 | 17378 | A5 Ia | J+M (1953) |
| ** | — | 2874 | 59612 | A5 Ib | J+M (1953) |
| * | $o$ Sco | 6081 | 147084 | A5 II | † MK (1973) |
| ** | — | 3739 | 81471 | A7 Iab | B (1954) |
| ** | — | 6144 | 148743 | A7 Ib | B (1951) |
| | $\theta^2$ Tau | 1412 | 28319 | A7 III | J+M (1953) |
| | 21 LMi | 3974 | 87696 | A7 V | J+M (1953) |
| | $\gamma$ Her | 6095 | 147547 | A9 III | J+M (1953) |

| | Name | HR No. | HD No. | Spectral Type | Source |
|---|---|---|---|---|---|
| ** | — | 4110 | 90772 | F0 Ia | B (1954) |
| | $\alpha$ Lep | 1865 | 36673 | F0 Ib | † MK (1973) |
| | $\zeta$ Leo | 4031 | 89025 | F0 III | † MK (1973) |
| | $\mu$ Cet | 813 | 17094 | F0 IV | J+M (1953) |
| | $\rho$ Gem | 2852 | 58946 | F1A9 [F0 V] | G, unpubl. [J+M (1953)] |
| ** | 89 Her | 6685 | 163506 | F2 Ia | J+M (1953) |
| | — | 3496 | 75276 | F2 Iab | B (1954) |
| ** | $\nu$ Agl | 7387 | 182835 | F2 Ib | J+M (1953) |
| ** | $\nu$ Her | 6707 | 164136 | F2 II | J+M (1953) |
| * | 14 Ari | 623 | 13174 | F2 III | J+M (1953) |
| * | $\sigma$ Boo | 5447 | 128167 | F2 V | J+M (1953) |
| | 46 Tau | 1309 | 26690 | F3 IV/V [F3 V] | M, unpubl. [J+M (1953)] |
| ** | — | 2957 | 61715 | F4 Iab | B (1951) |
| ** | — | — | 172052 | F5 Ib | B (1951) |
| * | 41 Cyg | 7834 | 195295 | F5 II | J+M (1953) |
| * | $\beta$ Del | 7882 | 196524 | F5 III | B (1951) |
| | 45 Boo | 5634 | 134083 | F5 V | J+M (1953) |
| | — | 7308 | 180583 | F6 II | B (1951) |
| | — | 6577 | 160365 | F6 III | † MK (1973) |
| | $\alpha$ Tri | 544 | 11443 | F6 IV | † MK (1973) |
| ** | $\gamma$ Ser | 5933 | 142860 | F6 V | J+M (1953) |
| | $\iota$ Psc | 8969 | 222368 | F7 V | J+M (1953) |
| ** | $\delta$ CMa | 2693 | 54605 | F8 Ia | J+M (1953) |
| ** | $\gamma^1$ Nor | 6058 | 146143 | F8 Iab | B (1954) |
| ** | 11 Pup | 3102 | 65228 | F8 II | B (1951) |
| | $\upsilon$ Peg | 8905 | 220657 | F8 IV | J+M (1953) |
| | $\beta$ Vir | 4540 | 102870 | F9 V [F8 V] | † MK (1973) [J+M (1953)] |
| ** | — | 4511 | 101947 | G0 Ia | B (1954) |
| | — | 8752 | 217476 | G5 var 0 [G0 Ia] | MK (1973) [J+M (1953)] |
| | $\beta$ Aqr | 8232 | 204867 | G0 Ib | † MK (1973) |
| * | 31 Com | 4883 | 111812 | G0 III | † MK (1973) |
| * | $\eta$ Boo | 5235 | 121370 | G0 IV | J+M (1953) |
| | $\epsilon$ Leo | 3873 | 84441 | G1 II [G0 II] | MK (1973) [J+M (1953)] |
| | — | — | 27836 | G1 V | † MK (1973) |
| ** | $\zeta$ Mon | 3188 | 67594 | G2 Ib | † MK (1973) |
| | Sun (Uranus) | — | — | G2 V | † MK (1973) |
| | $\xi$ Pup | 3045 | 63700 | G3 Ib | B (1951) |
| ** | 9 Peg | 8313 | 206859 | G5 Ib | † MK (1973) |
| * | 25 Gem | 2453 | 47731 | G5 Ib | J+M (1953) |
| * | $\omega$ Gem | 2630 | 52497 | G5 II | J+M (1953) |
| | — | 1327 | 27022 | G4 III [G5 III] | MK (1973) [J+M (1953)] |
| | $\mu$ Her | 6623 | 161797 | G5 IV | MK (1973) |
| ** | $\kappa^1$ Cet | 996 | 20630 | G5 V | J+M (1953) |
| ** | $\epsilon$ Gem | 2473 | 48329 | G8 Ib | † MK (1973) |
| | $\zeta$ Cyg | 8115 | 202109 | G8 II CN 1 [G8 II] | † MK (1973) [J+M (1953)] |
| | $\eta$ Psc | 437 | 9270 | G8 III | J+M (1953) |
| | $\kappa$ Gem | 2985 | 62345 | G8 IIIa [G8 III] | † MK (1973) [J+M (1953)] |
| | $\beta$ Aql | 7602 | 188512 | G8 IV | † MK (1973) |
| | $\xi$ Boo (A) | 5544 | 131156 | G8 V | J+M (1953) |
| ** | 12 Peg | 8321 | 207089 | K0 Ib | MK (1973) |
| | $\theta^1$ Tau | 1411 | 28307 | K0 III | J+M (1953) |
| | $\delta$ Eri | 1136 | 23249 | K0 IV | J+M (1953) |
| * | 54 Psc | 166 | 3651 | K0 V | J+M (1953) |
| | $\zeta$ Cep | 8465 | 210745 | K1.5 Ib | † MK (1973) |
| | — | 2334 | 45416 | K1 II | J+M (1953) |
| | 1 Peg | 8173 | 203504 | K1 III | MK (1973) |
| | $\gamma$ Cep | 8974 | 222404 | K1 IV | MK (1973) |
| | 107 Psc | 493 | 10476 | K1 V | J+M (1953) |
| | $\epsilon$ Peg | 8308 | 206778 | K2 Ib | † MK (1973) |
| | 56 Ori | 2037 | 39400 | K1.5 IIb [K2 II] | † MK (1973) [J+M (1953)] |
| ** | $\sigma$ Oph | 6498 | 157999 | K2 II [K3 II] | † MK (1973) [M,C,W (1955)] |
| ** | $\beta$ Oph | 6603 | 161096 | K2 III | † MK (1973) |
| | $\alpha$ Ari | 617 | 12929 | K2 IIIab | † MK (1973) |
| | $\alpha$ Ser | 5854 | 140573 | K2 V | † MK (1973) |
| | — | 6806 | 166620 | K2 III CN 1.5 | J+M (1953) |
| ** | $o^1$ CMa | 2580 | 50877 | K2.5 Iab [K3 Iab] | † MK (1973) [J+M (1953)] |
| | $\eta$ Per A | 834 | 17506 | K3-Ib-IIa [K3 Ib] | † MK (1973) [J+M (1953)] |
| | $\theta$ Del | 7892 | 196725 | K3 Ib | B (1951) |
| * | $\gamma$ Aql | 7525 | 186791 | K2 II | † MK (1973) |
| | $\pi$ Her | 6418 | 156283 | K3 IIab | † MK (1973) |
| * | $\delta$ And | 165 | 3627 | K3 III | † MK (1973) |
| ** | $\beta$ Cnc | 3249 | 69267 | K4 III | † MK (1973) |
| | $\xi$ Cyg | 8079 | 200905 | K4.5 Ib-II [K5 Ib] | † MK (1973) [J+M (1953)] |
| | $\alpha$ Tau | 1457 | 29139 | K5 III | † MK (1973) |
| ** | $\gamma$ Dra | 6705 | 164058 | K5 III | † MK (1973) |
| | — | — | 154363 | K5 V | J+M (1953) |
| | $\nu$ Gem | 2905 | 60522 | M0 III | MK (1973) |
| | 6 Gem | 2197 | 42543 | M1-M2 Ia-Iab [M1 Ia] | † MK (1973) [J+M (1953)] |
| | $\alpha$ Ori | 2061 | 39801 | M1-M2 Ia-Ib [M2 Iab] | † MK (1973) [J+M (1953)] |
| ** | 119=CE Tau | 1845 | 36389 | M2 Iab-Ib [M2 Ib] | † MK (1973) [J+M (1953)] |
| * | — | — | 95735 | M2 V | J+M (1953) |
| | $\mu$ Gem | 2286 | 44478 | M3 IIIab | † MK (1973) |
| | $\eta$ Gem | 2216 | 42995 | M3 III | MKK (1943) |
| | 45=RZ Ari | 867 | 18191 | M6 III | † MK (1973) |
| ** | — | — | 207076 | M7 III | MK (1973) |

* in First Atlas only
** in Second Atlas

(A dagger(†) in front of this reference indicates that the spectral type has undergone re-examination by Morgan for self-consistency).

# Table 2 Secondary Standards

| Name | HR No. | HD No. | Spectral Type | Source |
|---|---|---|---|---|
| — | — | 93619 | B1 Iab | H+C (1975) |
| — | 2360 | 45796 | B6 V | H,G,S (1969) |
| — | 3898 | 85355 | B7 III | H,G,S (1969) |
| — | — | 149019 | B9/A0 Iab | H+C (1975) |
| — | 4218 | 93526 | A0 III | CCJJ (1969) |
| — | 3981 | 87887 | A0 III | CCJJ (1969) |
| $o$ Peg | 8641 | 214994 | A1 IV | CCJJ (1969) |
| — | — | 2692/3 | A3 Ia | H+C (1975) |
| $\tau$ Peg | 8880 | 220061 | A5 IV | H+C (1975) |
| $\sigma^2$ Tau | 1479 | 29488 | A5 V | CCJJ (1969) |
| — | — | 96746 | G2 Iab | H+C (1975) |
| $\delta$ CrB | 5889 | 141714 | G5 III/IV | R (1952) |
| $\theta$ Psc | 8916 | 220954 | K1 III | R (1952) |
| — | — | 184467 | K1 V | R (1955) |
| — | 753 | 16160 | K3 V | R (1955) |
| — | 6005 | 144889 | K4 III | R (1955) |
| — | 7633 | 189276 | K5 II/III | R (1952) |
| — | — | 79210/1 | M0 V + M0 V | R (1952) |
| — | 4278 | 5129 | M2 III | R (1955) |
| — | 4333 | 96813 | M4 III | H+C (1975) |

# Table 3 Revised Standards

| Name | HR No. | HD No. | Spectral Type Used | Standard Spec. Type | Source |
|---|---|---|---|---|---|
| * $\beta$ Com | 4983 | 114710 | G2 V | G0 V | †MK (1973) |
| $\zeta$ Her | 6212 | 150680 | G3 IV | G1 IV | †MK (1973) |
| $\xi$ Pup | 3045 | 63700 | G3 Iab/Ib | G3 Ib | J-M (1953) |
| 85 Peg | 9088 | 224930 | G3/5 V | G2 V | M,H,J (1953) |
| | | | | G3 V | R(1955) |
| $\pi$ Leo | 3950 | 86663 | M1 III | M2 IIIab[M2 III] | †MK (1973) |


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R (1952) Roman, N. G. 1952, *Ap. J.*,**116**,122.
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## B. Spectral Qualities and Averaging

At the time each spectrum was classified it was assigned a quality ranging from 1 to 4. Quality 1 spectra are of near-optimum exposure and unoverlapped by other spectra. Quality 2 spectra may be slightly under or overexposed or slightly overlapped. An error analysis shows that quality 2 types are very nearly as accurate as quality 1's. Quality 3 spectra are usually quite overlapped or underexposed and quality 4 are worse, though still probably better than the HD type. About three quarters of the spectra have qualities of 1 or 2, and it is recommended that statistical studies be restricted to these stars when practicable. About 9% of the stars were classified independently on two or more plates. A total of 34,085 independent spectra were classified to yield the 30,235 spectral types by Houk in this catalogue. These multiple classifications for a single star were combined to produce a single spectral type, in most cases via a computer program. When a single classification was of quality 1 or 2, any quality 3 or 4 classifications were discarded and the quality 1 or 2 classification was used. These cases are not designated as averages in the catalogue. When more than one quality 1 or 2 classification was present, any quality 3 or 4 classifications were discarded and an average spectral type was formed from the quality 1 or 2 classifications. If only quality 3 or 4 classifications were available, they were averaged to form a single spectral type. To form the averages the temperature and luminosity types were converted to numerical codes. These codes were then combined in a weighted average and reconverted to normal spectral notation. Quality 1's were assigned weight 1.5 and quality

2's weight 1. Likewise, when no quality 1 or 2 classifications were available, quality 3's were assigned weight 1.5 and quality 4's weight 1. In the numerical codes the temperature types that are not used in the present classification system (Fl, F4, F9, G4, G7, G9, K6, K7, K8, and K9) were treated as non-existent. For example, the difference on the numerical scale between K5 and M0 is the same as that between M0 and Ml. The types O9.5, B0.5, and B9.5 were treated as half-temperature subtypes. Luminosity type Iab was also treated as a half type, but Ia and Ib were treated as full luminosity types. Cases in which one or more of the classifications to be averaged were peculiar could not be handled by the computer and were averaged by hand, sometimes after reexamining the spectra. Whenever the classification used in the catalogue is an average, the quality assigned it is the highest of the qualities used in forming the average and the quality is prefixed with an "A". The plate codes (see section IV) of all plates used to form the average are included in the catalogue.

## C. Notation

A major deviation from normal notation in the catalogue is that hyphenated types (ex., B8-9 IV-V) were not used. The hyphen was avoided because it might be thought to imply a type intermediate between those given, whereas in this catalogue often one type is as likely as the other and the double type is an indication of uncertainty. Therefore we used the slash (B8/9 IV/V). In general, the slashed spectra of quality 1 and spectral type later than B are probably truly intermediate. Note that many of the slashes were the result of the averaging process.

The other major innovation has been in the notation for spectra of peculiar stars such as weak-line stars and strong or weak CN stars. These will be discussed in detail in part E below. The general idea is to indicate the degree of the peculianty by giving 'normal' temperature or luminosity types determined from different lines, such as hydrogen line vs. metal line, or CN vs. Sr. With this scheme there is no need to introduce a verbal (strong, moderate, weak) or numerical scale which requires peculiar 'standards' for its definition.

Uncertain types or uncertain parts of spectral types were enclosed in parentheses - ex., AO (V). The usual convention of denoting broad-lined stars with 'n', very broad-lined stars with 'nn', and sharp-lined stars with 's' was followed. Most of the broad or sharp-lined stars are of type B or A. In general the spectral notation is that traditionally used in MK classification.

## D. Classification Criteria

Nearly all the temperature and luminosity criteria outlined by Morgan, Keenan, and Kellman [MKK] and Johnson and Morgan [JM] are applicable to our spectra, so the criteria will not be outlined again here. A few problem areas are discussed in part E. Almost all the spectral lines labeled in our *Atlas* [HIR] and *Second Atlas* [HN] are temperature and luminosity criteria. In addition to these and other MK criteria, the general appearance of the spectrum was an important factor in arriving at the final spectral type. Much of the classifier's previous experience had been with low-dispersion spectra where the overall appearance of the spectrum was of paramount interest. This approach was carried over into the present work as much as possible, and the unknown and standard spectra were considered as a whole in getting the best match.

## E. Problems, Notation, and Miscellaneous Comments

### O Stars

There are 22 O stars in the catalogue. Many O stars occur in tight clusters where the overlap problems on objective prism plates are so bad that they preclude discovery or at least lower the quality of the type given. Because of such classification uncertainties Walborn's system [W] of designating Of stars was not used for the few found. However, since the lines in emission are listed in the remarks, such types may be estimated.

### B Stars

There are about 3000 B stars. The main classification problem was luminosity separation of giants and dwarfs for the mid-B stars. Even for good quality spectra, the differences are subtle on our plates. For example, compare $\pi$ Ori and $\kappa$ Hya on the B5 sheet of the *Atlas*. An area which may have been somewhat inadequately covered is the problem of moderately He-rich or He-poor stars. Only fairly strong cases would have been noticed. B stars are not designated as 'e' unless the emission is above continuum level. When a line is totally, partially, or possibly filled in, a remark is made to that effect. Finally, a matter of notation: although most peculiar Si stars are really of type B, all such peculiar stars were designated Ap stars. Any exceptionally early cases have remarks.

### A Stars

There are about 5800 A stars including $\approx$ 300 Am and Ap stars. The notation used for the Am stars (ex., A2mA5-F0) gives three types. The first gives the type indicated by the Ca K line strength. The second, and least accurate, gives the type indicated by the hydrogen lines. The problem here is that in Am stars the hydrogen wings are suppressed. Hence comparing with ordinary dwarf standards gives too late a type. The third type is that indicated by the metal strength. Am stars have giant-like metals, and giant standards were used to get this type. For the Ap stars the elements (ex., ApCrEuSr) are listed in order of the strengths of the lines. Ap stars of the HgMn type are not usually detected at the resolution used here.

### F Stars

There are nearly 7300 F stars. Note that peculiar stars are all called 'Ap' even though a few are as late as FO or F2. There are a very few unusually late metallic-line stars called Fm which have G bands but also have line strengths (strong Sr $\lambda$4077 and $\lambda$4150, $\lambda 4416 << \lambda 4481$) similar to Am stars. There is a larger intermediate group which is called 'Fm $\delta$Del' since the characteristics are more similar to Am's than Ap's.

### G Stars

There are about 6100 G stars. The following notation is used for weak-metal stars (ex., G5wFO): temperature type based on the H lines followed by a 'w' and then the type based on the metal lines. Sometimes a luminosity type is also included. The difference between the two types indicates the degree of metal weakening. This notation breaks down in the case of extremely metal-weak or early stars where no metal type can be derived. For these the H-line type followed by a 'w' is given in the catalogue accompanied by a remark in the back of the volume. Stars with no G-band or a very weak G-band are given no special designation but the type is followed by a 'p' and a remark is included. A similar procedure is followed for stars with strong CH.

### K Stars

There are about 7600 K stars including stars having noticeably weak or strong CN. In the catalogue the CN strength is indicated by a 'pseudo-luminosity' as determined from the CN break and CN band strength (ex., K2 IIICNII and K1 IIICNIV). Stars which showed a strong Ba $\lambda$4554 line are designated with a 'p' and 'Ba' (ex., KOp Ba). These stars usually also have strong Sr and strong CN. In some cases C2 bands can be seen. The K spectra were often too faint at the blue end for the Sr $\lambda 4077/\lambda 4063$ ratio to be observed. In such cases the luminosity is determined from the CN and is parenthesized. No such spectrum is ever assigned a quality higher than 3.

### M and C Stars

There are about 700 M stars and 20 C stars. C stars were not assigned subtypes.

### Emission Stars and Other Miscellaneous Types

Stars which showed hydrogen lines in emission are designated with an 'e'. A remark usually indicates what lines were seen in emission. Following the traditional practice, stars with Ca H + K but not hydrogen in emission are designated with a 'p'. All of these stars have remarks indicating that Ca H + K are in emission.

Wolf-Rayet stars were classified 'WN' or 'WC'. No attempt was made to subdivide the Wolf-Rayet stars further.

The type 'NEBULA' includes any spectrum, either emission or continuous, which looked extended rather than stellar. Thus it includes H II regions, planetary nebulae, and globular clusters. When the nebulae were identified on the tape provided by the Centre de Données Stellaires de Strasbourg, these identifications were included in the remarks.

# IV. Description of Catalogue

Column:

1. HD number
2. Spectral type
3. Average indicated
   Quality: 1 (best) to 4 (worst)
   Remarks code: V,B,L,R,D
4. Photographic magnitude if not otherwise indicated
5. $\alpha_{1900}$ from Centre de Données Stellaires de Strasbourg
6. $\delta_{1900}$ from Centre de Données Stellaires de Strasbourg
7. $\Delta\alpha = 100$ yr. precession in $\alpha$
8. $\Delta\delta = 100$ yr. precession in $\delta$
9. Galactic longitude (*'l'*)
10. Galactic latitude (*'b'*)
11. DM or CSI number
12. SAO number
13. Plate Codes

Further explanation of some columns in the catalogue:

*Column 1.* HD number. All stars in the Henry Draper Catalogue having $\delta_{1900}$ south of (and including) $+5°.00$ and north of $-12°.00$ are included, whether a new spectral type is available or not. It seemed unnecessary and unwise to introduce a consecutive running number since all the stars in these volumes will be HD stars. Note that due to an error in the HD Catalogue, HD numbers 91169 and 109005 represent the same star. It has been listed twice in the volume for the user's convenience.

*Column 2.* Spectral type. A dagger (†) in front of the type indicates it is taken from another source. For each such type there is a remark in the back of the volume. For an explanation of spectral notation please read section III above.

*Column 3.* If the spectral type is the average from two or more plates (see plate code column 13), then an A indicates this (see section III ). See section III B for a description of the quality, and Section V below for a description of the remark codes.

*Column 4.* Unless otherwise noted, the magnitude given is photographic, and was supplied by the Centre de Données Stellaires de Strasbourg. Other magnitudes are noted by V (Visual) or B (Blue). Magnitudes from the HD catalogue were only used if no other magnitude was available. ***** in the magnitude column indicates the star is a variable with an amplitude equal to or greater than 1.0 magnitude. All known variables are indicated by a 'V' in the remarks column, and for small amplitude variables the maximum magnitude, as given in the Variable Star Catalogue, is listed.

*Column 5-8.* The coordinates given are based on the Epoch 2000 coordinates supplied by Strasbourg, from the proper motion catalogue. Following tradition and to maintain consistency with previous volumes, we list the Epoch 1900 coordinates and the precession to 2000.

*Column 11.* The declination zone of Volume 5 is north of the dividing line between the CoD catalogue in the south and the BD(SD) catalogue in the north. Therefore these numbers are from the BD catalogue. For stars with out a DM number, the CSI number is listed (CSI - Catalogue of Stellar Indentification - maintained by Centre de Données Stellaires de Strasbourg). These numbers are indicated by a 'C' preceeding the number.

*Column 13.* Plate Code(s). Each plate has been assigned an identification code. By use of Table 4, knowing the plate code, the plate number and date the plate was taken can be obtained. These columns also serve to indicate the number of plates used in obtaining the average spectral type given. Plates whose codes start with 3 or 4 are the short-exposure plates of $3^m + 1^m$ or $4^m + 1^m$ exposure, respectively. Codes starting with 8 or 9 are $20^m$ exposures at slightly different centers which are used only for stars not on the main plate.

# Table 4 Plate List

| Plate Code | Plate Number | Date | Plate Code | Plate Number | Date | Plate Code | Plate Number | Date |
|---|---|---|---|---|---|---|---|---|
| YE | 1334 | Dec. 2/3 '67 | ZH | 1323 | Dec. 1/2 '67 | ZL | 1355 | Dec. 3/4 '67 |
| ZN | 1325 | Dec. 1/2 '67 | ZO | 1326 | Dec. 1/2 '67 | ZP | 17304 | Dec. 12/13 '74 |
| ZQ | 1327 | Dec. 1/2 '67 | ZR | 1344 | Dec. 2/3 '67 | ZS | 1328 | Dec. 1/2 '67 |
| ZT | 1345 | Dec. 2/3 '67 | ZU | 1346 | Dec. 2/3 '67 | ZV | 1331 | Dec. 1/2 '67 |
| ZW | 1347 | Dec. 2/3 '67 | ZX | 1332 | Dec. 1/2 '67 | ZZ | 1348 | Dec. 2/3 '67 |
| AAA | 3563 | Jan. 16/17 '69 | AAB | 15546 | Jan. 24/25 '74 | AAD | 15547 | Jan. 24/25 '74 |
| AAE | 17291 | Dec. 11/12 '74 | ABF | 3565 | Jan. 16/17 '69 | ABG | 3600 | Jan. 21/22 '69 |
| ABH | 3615 | Jan. 22/23 '69 | ABI | 20232 | Dec. 27/28 '76 | ABJ | 21732 | June 1/2 '78 |
| ABM | 7915 | Jan. 30/31 '71 | ABN | 4759 | July 7/8 '69 | ABQ | 4819 | July 15/16 '69 |
| ABR | 7880 | Jan. 27/28 '71 | ABS | 7881 | Jan. 27/28 '71 | ABT | 4582 | June 15/16 '69 |
| ABU | 8454 | Mar. 29/30 '71 | ABX | 8455 | Mar. 29/30 '71 | ABY | 6117 | Mar. 10/11 '70 |
| ACA | 8456 | Mar. 29/30 '71 | ACB | 8457 | Mar. 29/30 '71 | ACC | 8458 | Mar. 29/30 '71 |
| ACH | 4594 | June 16/17 '69 | ACI | 4739 | July 5/6 '69 | ACN | 16551 | Aug. 11/12 '74 |
| ACR | 4740 | July 5/6 '69 | ACS | 4596 | June 16/17 '69 | ACT | 4597 | June 16/17 '69 |
| ACU | 4574 | June 15/16 '69 | ACV | 4595 | June 16/17 '69 | ADE | 8428 | Mar. 26/27 '71 |
| ADL | 6114 | Mar. 10/11 '70 | ADR | 2505 | June 23/24 '68 | ADY | 13522 | May 31/June 1 '73 |
| ADZ | 2503 | June 23/24 '68 | AEC | 2504 | June 23/24 '68 | AEE | 16550 | Aug. 11/12 '74 |
| AEF | 4579 | June 15/16 '69 | AEH | 4580 | June 15/16 '69 | AEJ | 4760 | July 7/8 '69 |
| AEK | 4761 | July 7/8 '69 | AEN | 4577 | June 15/16 '69 | AFD | 4817 | July 15/16 '69 |
| AFH | 4818 | July 15/16 '69 | AFI | 4820 | July 15/16 '69 | AFJ | 4821 | July 15/16 '69 |
| AFM | 4762 | July 7/8 '69 | AFN | 13567 | June 2/3 '73 | AFV | 1329 | Dec 1/2 '67 |
| AFW | 7253 | Aug. 28 '70 | AFX | 7254 | Aug. 28 '70 | AFY | 7276 | Aug. 30 '70 |
| AFZ | 7256 | Aug. 28 '70 | AGA | 7257 | Aug. 28 '70 | AGB | 7258 | Aug. 28 '70 |
| AGC | 1208 | Nov. 19/20 '67 | AGD | 1209 | Nov. 19/20 '67 | AGE | 1210 | Nov. 19/20 '67 |
| AGF | 1315 | Nov. 30/Dec. 1 '67 | AGG | 1309 | Nov. 30/Dec. 1 '67 | AGH | 1308 | Nov. 30/Dec. 1 '67 |
| AGI | 13569 | June 2/3 '73 | AGJ | 17307 | Dec. 12/13 '74 | AGK | 7255 | Aug. 28 '70 |
| AGL | 1330 | Dec. 1/2 '67 | AGM | 1300 | Nov. 30/Dec. 1 '67 | AGN | 1304 | Nov. 30/Dec. 1 '67 |
| AGO | 1305 | Nov. 30/Dec. 1 '67 | AGP | 1306 | Nov. 30/Dec. 1 '67 | AGQ | 1307 | Nov. 30/Dec. 1 '67 |
| AGR | 1317 | Dec. 1/2 '67 | AGS | 17309 | Dec. 12/13 '74 | AGT | 1312 | Nov. 30/Dec. 1 '67 |
| AGU | 1311 | Nov. 30/Dec. 1 '67 | AGV | 1301 | Nov. 30/Dec. 1 '67 | AGW | 1219 | Nov. 20/21 '67 |
| AGX | 1220 | Nov. 20/21 '67 | AGY | 1227 | Nov. 20/21 '67 | AGZ | 1302 | Nov. 30/Dec. 1 '67 |
| AHA | 1229 | Nov. 21/22 '67 | AHB | 1303 | Nov. 30/Dec. 1 '67 | AHC | 9713 | Oct. 14/15 '71 |
| AHD | 16790 | Aug. 17/18 '74 | AHE | 16789 | Aug. 17/18 '74 | AHF | 16792 | Aug. 17/18 '74 |
| AHG | 17294 | Dec. 12/13 '74 | AHH | 7914 | Jan. 30/31 '71 | AHI | 7911 | Jan. 30/31 '71 |
| AHJ | 17178 | Dec. 5/6 '74 | AHK | 16793 | Aug. 17/18 '74 | AHL | 16795 | Aug. 17/18 '74 |
| AHM | 16796 | Aug. 17/18 '74 | AHN | 9526 | Sept. 21/22 '71 | AHO | 1310 | Nov. 30/Dec. 1 '67 |
| AHP | 7272 | Aug. 29 '70 | AHQ | 7273 | Aug. 29 '70 | AHR | 1316 | Nov. 30/Dec. 1 '67 |
| AHS | 3469 | Jan. 8/9 '69 | AHT | 3493 | Jan. 11/12 '69 | AHU | 3474 | Jan. 9/10 '69 |
| AHV | 3470 | Jan. 8/9 '69 | AHW | 9714 | Oct. 14/15 '71 | AHX | 3475 | Jan. 9/10 '69 |
| AHY | 3494 | Jan. 11/12 '69 | AHZ | 3477 | Jan. 9/10 '69 | AIA | 3476 | Jan. 9/10 '69 |
| AIB | 3512 | Jan. 13/14 '69 | AIC | 17265 | Dec. 11/12 '74 | AID | 17292 | Dec. 11/12 '74 |
| AIE | 17176 | Dec. 5/6 '74 | AIF | 3478 | Jan. 9/10 '69 | AIG | 17175 | Dec. 5/6 '74 |
| AIH | 5867 | Feb. 4/5 '70 | AII | 3616 | Jan. 22/23 '69 | AIJ | 3561 | Jan. 16/17 '69 |
| AIK | 5866 | Feb. 4/5 '70 | AIL | 7910 | Jan. 30/31 '71 | AIM | 7912 | Jan. 30/31 '71 |
| AIN | 7894 | Jan. 28/29 '71 | AIO | 6131 | Mar. 12/13 '70 | AIP | 6132 | Mar. 12/13 '70 |
| AIQ | 8314 | Mar. 20/21 '71 | AIR | 8315 | Mar. 20/21 '71 | AIS | 8316 | Mar. 20/21 '71 |
| AIT | 8328 | Mar. 21/22 '71 | AIU | 8329 | Mar. 21/22 '71 | AIV | 8327 | Mar. 21/22 '71 |
| AIW | 9715 | Oct. 14/15 '71 | AIX | 9716 | Oct. 14/15 '71 | AIY | 9527 | Sept. 21/22 '71 |
| AIZ | 9566 | Sept. 23/24 '71 | AJA | 6145 | Mar. 13/14 '70 | AJB | 7284 | Aug. 30 '70 |
| AJC | 7285 | Aug. 30 '70 | AJD | 16852 | Aug. 25/26 '70 | AJE | 7286 | Aug. 30 '70 |
| AJF | 21734 | June 1/2 '70 | AJG | 18239 | May 5/6 '75 | AJH | 18240 | May 5/6 '75 |
| AJI | 17180 | Dec. 5/6 '74 | AJJ | 20224 | Dec. 22/23 '76 | AJK | 15585 | Jan. 28/29 '74 |
| AJL | 7916 | Jan. 30/31 '71 | AJM | 6135 | Mar. 12/13 '70 | AJN | 3545 | Jan. 15/16 '69 |
| AJO | 3490 | Jan. 11/12 '69 | AJP | 3508 | Jan. 13/14 '69 | AJQ | 3509 | Jan. 13/14 '69 |
| AJR | 3523 | Jan. 14/15 '69 | AJS | 3510 | Jan. 13/14 '69 | AJT | 6133 | Mar. 12/13 '70 |
| AJU | 3511 | Jan. 13/14 '69 | AJV | 3544 | Jan. 15/16 '69 | AJW | 7895 | Jan. 28/29 '71 |
| AJX | 6134 | Mar. 12/13 '70 | AJY | 7897 | Jan. 28/29 '71 | AJZ | 6124 | Mar. 11/12 '70 |
| AKA | 3633 | Jan. 24/25 '69 | AKB | 3489 | Jan. 11/12 '69 | AKC | 3481 | Jan. 10/11 '69 |
| AKD | 3612 | Jan. 22/23 '69 | AKE | 3488 | Jan. 1/2 '69 | AKF | 3482 | Jan. 10/11 '69 |
| AKG | 8320 | Mar. 20/21 '71 | AKH | 3471 | Jan. 8/9 '69 | AKI | 3495 | Jan. 12/13 '69 |
| AKJ | 6136 | Mar. 12/13 '70 | AKK | 8170 | Mar. 1/2 '71 | AKL | 8313 | Mar. 20/21 '71 |
| AKM | 8152 | Feb. 28/Mar. 1 '71 | AKN | 8149 | Feb. 28/Mar. 1 '71 | AKO | 8148 | Feb. 28/Mar. 1 '71 |
| AKP | 8169 | Mar. 1/2 '71 | AKQ | 7920 | Jan. 30/31 '71 | AKR | 8104 | Feb. 25/26 '71 |
| AKS | 8171 | Mar. 1/2 '71 | AKT | 8153 | Feb. 28/Mar. 1 '71 | AKU | 18199 | May 4/5 '75 |
| AKV | 3562 | Jan. 16/17 '69 | AKW | 8154 | Feb. 28/Mar. 1 '71 | AKX | 3487 | Jan. 11/12 '69 |
| AKY | 6146 | Mar. 13/14 '70 | AKZ | 4602 | June 16/17 '69 | ALA | 6147 | Mar. 13/14 '70 |
| ALB | 8150 | Feb. 28/Mar. 1 '71 | ALC | 8151 | Feb. 28/Mar. 1 '71 | ALD | 6137 | Mar. 12/13 '70 |
| ALE | 6138 | Mar. 12/13 '70 | ALF | 8337 | Mar. 21/22 '71 | ALG | 18241 | May 5/6 '75 |
| ALH | 20710 | June 14 '77 | ALI | 13158 | April 25/26 '73 | ALJ | 8136 | Feb. 27/28 '71 |
| ALK | 4783 | July 14/15 '69 | ALL | 6125 | Mar. 11/12 '70 | ALM | 6126 | Mar. 11/12 '70 |
| ALN | 4641 | June 18/19 '69 | ALO | 16613 | Aug. 13/14 '74 | ALP | 4752 | July 7/8 '69 |
| ALQ | 4643 | June 18/19 '69 | ALR | 4642 | June 18/19 '69 | ALS | 4621 | June 17/18 '69 |
| ALT | 16612 | Aug. 13/14 '74 | ALU | 4622 | June 17/18 '69 | ALV | 4598 | June 16/17 '69 |
| ALW | 16771 | Aug. 17/18 '74 | ALX | 4784 | July 14/15 '69 | ALY | 4806 | July 15/16 '69 |
| ALZ | 20685 | June 13/14 '77 | AMA | 4807 | July 15/16 '69 | AMB | 4808 | July 15/16 '69 |
| AMC | 4785 | July 14/15 '69 | AMD | 4809 | July 15/16 '69 | AME | 4810 | July 15/16 '69 |
| AMF | 4788 | July 14/15 '69 | AMG | 16773 | Aug. 17/18 '74 | AMH | 13571 | June 2/3 '73 |
| AMI | 4794 | July 14/15 '69 | AMJ | 4793 | July 14/15 '69 | AMK | 20724 | July 14 '77 |
| AML | 9737 | Oct. 15/16 '71 | AMM | 9669 | Oct. 12/13 '71 | AMN | 9668 | Oct. 12/13 '71 |
| AMO | 9667 | Oct. 12/13 '71 | AMP | 9738 | Oct. 15/16 '71 | AMQ | 9717 | Oct. 14/15 '71 |
| AMR | 9661 | Oct. 11/12 '71 | AMS | 9567 | Sept. 23/24 '71 | AMT | 17266 | Dec. 11/12 '74 |
| AMU | 3520 | Jan. 14/15 '69 | AMV | 17268 | Dec. 11/12 '74 | AMW | 3517 | Jan. 14/15 '69 |
| AMX | 8173 | Mar. 1/2 '71 | AMY | 3543 | Jan. 15/16 '69 | AMZ | 8317 | Mar. 20/21 '71 |
| ANA | 13151 | April 25/26 '73 | ANB | 3522 | Jan. 14/15 '69 | ANC | 20231 | Dec. 27/28 '76 |
| AND | 8331 | Mar. 21/22 '71 | ANE | 17270 | Dec. 11/12 '74 | ANF | 10889 | April 9/10 '72 |
| ANG | 8330 | Mar. 21/22 '71 | ANH | 8353 | Mar. 22/23 '71 | ANI | 3521 | Jan. 14/15 '69 |
| ANJ | 20211 | Dec. 20/21 '76 | ANK | 3611 | Jan. 22/23 '69 | ANL | 17345 | Dec. 14/15 '74 |
| ANM | 8350 | Mar. 22/23 '71 | ANN | 8351 | Mar. 22/23 '71 | ANO | 8352 | Mar. 22/23 '71 |
| ANP | 10988 | April 15/16 '72 | ANQ | 10990 | April 15/16 '72 | ANR | 3519 | Jan. 14/16 '69 |
| ANS | 3498 | Jan. 12/13 '69 | ANT | 3497 | Jan. 12/13 '69 | ANU | 3518 | Jan. 14/15 '69 |
| ANV | 3537 | Jan. 15/16 '69 | ANW | 3496 | Jan. 12/13 '69 | ANX | 4792 | July 14/15 '69 |
| ANY | 8332 | Mar. 21/22 '71 | ANZ | 4790 | July 14/15 '69 | AOA | 4813 | July 15/16 '69 |
| AOB | 17436 | Dec. 19/20 '74 | AOC | 20210 | Dec. 20/21 '76 | AOD | 10868 | April 8/9 '72 |
| AOE | 4644 | June 18/19 '69 | AOF | 18169 | May 3/4 '75 | AOG | 4645 | June 18/19 '69 |
| AOH | 4646 | June 18/19 '69 | AOI | 4755 | July 7/8 '69 | AOJ | 4647 | June 18/19 '69 |
| AOK | 20688 | June 13 '77 | AOL | 4603 | June 16/17 '69 | AOM | 7252 | Aug. 28 '70 |
| AON | 7275 | Aug. 30 '70 | AOO | 8239 | Mar. 5/6 '71 | AOP | 16718 | Aug. 16/17 '74 |
| AOQ | 7279 | Aug. 30 '70 | AOR | 4624 | June 17/18 '69 | AOS | 16712 | Aug. 16/17 '74 |
| AOT | 16727 | Aug. 16/17 '74 | AOU | 7291 | Aug. 31 '70 | AOV | 16767 | Aug. 17/18 '74 |
| AOW | 7278 | Aug. 30 '70 | AOX | 9653 | Oct. 11/12 '71 | AOY | 9666 | Oct. 12/13 '71 |
| AOZ | 9733 | Oct. 12/13 '71 | APA | 4757 | July 7/8 '69 | APB | 13591 | June 3/4 '73 |
| APC | 7243 | Aug. 24 '70 | APD | 13570 | June 2/3 '73 | APE | 7290 | Aug. 31 '70 |
| APF | 7292 | Aug. 31 '70 | APG | 7293 | Aug. 31 '70 | APH | 7277 | Aug. 30 '70 |
| API | 9648 | Oct. 11/12 '71 | APJ | 7280 | Aug. 30 '70 | APK | 9664 | Oct. 12/13 '71 |

| Plate Code | Plate Number | Date | Plate Code | Plate Number | Date | Plate Code | Plate Number | Date |
|---|---|---|---|---|---|---|---|---|
| APL | 9665 | Oct. 12/13 '71 | APM | 4625 | June 17/18 '69 | APN | 4626 | June 17/18 '69 |
| APO | 13547 | June 1/2 '73 | APP | 16686 | Aug. 15/16 '74 | APQ | 16688 | Aug. 15/16 '74 |
| APR | 16690 | Aug. 15/16 '74 | APS | 5015 | Aug. 12/13 '69 | APT | 5016 | Aug. 12/13 '69 |
| APU | 4811 | July 15/16 '69 | APV | 4789 | July 14/15 '69 | APW | 4812 | July 15/16 '69 |
| APX | 13551 | June 1/2 '73 | APY | 13552 | June 1/2 '73 | APZ | 13572 | June 2/3 '73 |
| AQA | 9776 | Oct. 20/21 '71 | AQB | 9777 | Oct. 20/21 '71 | AQC | 9778 | Oct. 20/21 '71 |
| AQD | 9729 | Oct. 15/16 '71 | AQE | 9730 | Oct. 15/16 '71 | AQF | 9649 | Oct. 11/12 '71 |
| AQG | 9650 | Oct. 11/12 '71 | AQH | 9651 | Oct. 11/12 '71 | AQI | 9652 | Oct. 11/12 '71 |
| AQJ | 10893 | April 9/10 '72 | AQK | 10895 | April 9/10 '72 | AQL | 8251 | Mar. 6/7 '71 |
| AQM | 8252 | Mar. 6/7 '71 | AQN | 8253 | Mar. 6/7 '71 | AQO | 13274 | May 5/6 '73 |
| AQP | 13559 | June 2/3 '73 | AQQ | 13560 | June 2/3 '73 | AQR | 13561 | June 2/3 '73 |
| AQS | 20690 | June 13 '77 | AQT | 13562 | June 2/3 '73 | AQU | 13563 | June 2/3 '73 |
| AQV | 20742 | June 16 '77 | AQW | 7251 | Aug. 28 '70 | AQX | 20728 | June 14 '77 |
| AQY | 18377 | May 15/16 '75 | AQZ | 20747 | June 18 '77 | ARA | 9800 | Oct. 21/22 '71 |
| ARB | 9799 | June 13 '77 | ARC | 13574 | June 2/3 '73 | ARD | 13553 | June 1/2 '73 |
| ARE | 20705 | June 13 '77 | ARF | 13573 | June 2/3 '73 | ARG | 13607 | June 3/4 '73 |
| ARH | 20707 | June 13 '77 | ARI | 10891 | April 9/10 '72 | ARJ | 18242 | May 5/6 '75 |
| ARK | 18243 | May 5/6 '75 | ARL | 20694 | June 13 '77 | ARM | 11038 | April 22/23 '72 |
| ARN | 16715 | Aug. 16/17 '74 | ARO | 20741 | June 16 '77 | ARP | 7250 | Aug. 28 '70 |
| ARQ | 9801 | Oct. 21/22 '71 | ARR | 13608 | June 3/4 '73 | ARS | 19958 | Aug. 27/28 '76 |
| ART | 9731 | Oct. 15/16 '71 | ARU | 9732 | Oct. 15/16 '71 | ARV | 18200 | May 4/5 '75 |
| ARW | 6148 | Mar. 13/14 '70 | ARX | 20862 | Aug. 15 '77 | ARY | 4623 | June 17/18 '69 |
| ARZ | 7249 | Aug. 28 '70 | ASA | 8155 | Feb. 28/Mar. 1 '71 | ASB | 13550 | June 1/2 '73 |
| ASC | 7244 | Aug. 24 '70 | ASE | 9789 | Oct. 20/21 '71 | 3AJH | 10688 | Mar. 19/20 '72 |
| 3ALB | 10687 | Mar. 19/20 '72 | 3ALG | 10691 | Mar. 19/20 '72 | 3ALI | 10694 | Mar. 19/20 '72 |
| 3ANF | 10890 | April 9/10 '72 | 3AOD | 10869 | April 8/9 '72 | 4ZS | 17157 | Dec. 4/5 '74 |
| 4ZT | 17158 | Dec. 4/5 '74 | 4ZU | 17159 | Dec. 4/5 '74 | 4ZV | 17161 | Dec. 4/5 '74 |
| 4ZX | 17162 | Dec. 4/5 '74 | 4ZZ | 17163 | Dec. 4/5 '74 | 4AAB | 12310 | Jan. 3/4 '73 |
| 4AAD | 12312 | Jan. 3/4 '73 | 4ABG | 15536 | Jan. 23/24 '74 | 4ABH | 13167 | April 26/27 '73 |
| 4ABR | 13174 | April 27/28 '73 | 4ABX | 13177 | April 27/28 '73 | 4ABY | 13171 | April 26/27 '73 |
| 4ACS | 15741 | Feb. 15/16 '74 | 4ACU | 15844 | Feb. 22/23 '74 | 4ADL | 13168 | April 26/27 '73 |
| 4AFX | 16653 | Aug. 14/15 '74 | 4AGE | 16783 | Aug. 17/18 '74 | 4AGF | 17192 | Dec. 5/6 '74 |
| 4AGH | 17188 | Dec. 5/6 '74 | 4AGL | 12306 | Jan. 3/4 '73 | 4AGP | 13966 | Oct. 3/4 '73 |
| 4AGS | 12308 | Jan. 3/4 '73 | 4AGT | 17191 | Dec. 5/6 '74 | 4AGU | 17165 | Dec. 4/5 '74 |
| 4AGW | 16787 | Aug. 17/18 '74 | 4AGY | 16755 | Aug. 16/17 '74 | 4AHA | 13962 | Oct. 3/4 '73 |
| 4AHC | 16781 | Aug. 17/18 '74 | 4AHD | 16782 | Aug. 17/18 '74 | 4AHE | 16788 | Aug. 17/18 '74 |
| 4AHF | 16791 | Aug. 17/18 '74 | 4AHG | 16847 | Aug. 25/26 '74 | 4AHH | 15537 | Jan. 23/24 '74 |
| 4AHI | 17195 | Dec. 5/6 '74 | 4AHJ | 17179 | Dec. 5/6 '74 | 4AHK | 16794 | Aug. 17/18 '74 |
| 4AHL | 16797 | Aug. 17/18 '74 | 4AHM | 13975 | Oct. 4/5 '73 | 4AHN | 13976 | Oct. 4/5 '73 |
| 4AHP | 13977 | Oct. 4/5 '73 | 4AHQ | 17169 | Dec. 5/6 '74 | 4AHR | 15721 | Feb. 15/16 '74 |
| 4AHS | 13987 | Oct. 6/7 '73 | 4AHT | 17193 | Dec. 5/6 '74 | 4AHU | 13988 | Oct. 6/7 '73 |
| 4AHV | 13989 | Oct. 6/7 '73 | 4AHW | 16849 | Aug. 25/26 '74 | 4AHX | 13991 | Oct. 6/7 '73 |
| 4AHY | 17194 | Dec. 5/6 '74 | 4AHZ | 17172 | Dec. 5/6 '74 | 4AIA | 17171 | Dec. 5/6 '74 |
| 4AIB | 17183 | Dec. 5/6 '74 | 4AIC | 16848 | Aug. 25/26 '74 | 4AID | 15604 | Feb. 1/2 '74 |
| 4AIE | 12303 | Jan. 3/4 '73 | 4AIF | 17173 | Dec. 5/6 '74 | 4AIG | 17174 | Dec. 5/6 '74 |
| 4AIH | 17182 | Dec. 5/6 '74 | 4AII | 15705 | Feb. 14/15 '74 | 4AIJ | 15719 | Feb. 15/16 '74 |
| 4AIK | 17234 | Dec. 8/9 '74 | 4AIL | 15846 | Feb. 23/24 '77 | 4AIM | 15704 | Feb. 14/15 '74 |
| 4AIN | 15515 | Jan. 21/22 '74 | 4AIO | 13360 | May 21/22 '73 | 4AIP | 13361 | May 21/22 '73 |
| 4AIQ | 15852 | Feb. 23/24 '74 | 4AIR | 15853 | Feb. 23/24 '74 | 4AIS | 15711 | Feb. 14/15 '74 |
| 4AIU | 15851 | Feb. 23/24 '74 | 4AIV | 15849 | Feb. 23/24 '74 | 4AIW | 16850 | Aug. 25/26 '74 |
| 4AIX | 16851 | Aug. 25/26 '74 | 4AIZ | 17220 | Dec. 8/9 '74 | 4AJA | 13264 | May 5/6 '73 |
| 4AJB | 17225 | Dec. 8/9 '74 | 4AJC | 17226 | Dec. 8/9 '74 | 4AJD | 16853 | Aug. 25/26 '74 |
| 4AJE | 17227 | Dec. 8/9 '74 | 4AJF | 26559 | Feb. 29/Mar. 1 '84 | 4AJG | 15518 | Jan. 21/22 '74 |
| 4AJI | 17181 | Dec. 5/6 '74 | 4AJJ | 17285 | Dec. 11/12 '74 | 4AJK | 15519 | Jan. 21/22 '74 |
| 4AJL | 15775 | Feb. 18/19 '74 | 4AJN | 15720 | Feb. 15/16 '74 | 4AJO | 17235 | Dec. 8/9 '74 |
| 4AJP | 17236 | Dec. 8/9 '74 | 4AJQ | 17237 | Dec. 8/9 '74 | 4AJR | 17240 | Dec. 8/9 '74 |
| 4AJS | 17238 | Dec. 8/9 '74 | 4AJT | 13362 | May 21/22 '73 | 4AJU | 17239 | Dec. 8/9 '74 |
| 4AJV | 17241 | Dec. 8/9 '74 | 4AJW | 15516 | Jan. 21/22 '74 | 4AJX | 15517 | Jan. 21/22 '74 |
| 4AJY | 13211 | May 2/3 '73 | 4AJZ | 13212 | May 2/3 '73 | 4AKA | 15848 | Feb. 23/24 '74 |
| 4AKB | 17233 | Dec. 8/9 '74 | 4AKC | 17231 | Dec. 8/9 '74 | 4AKD | 15847 | Feb. 23/24 '74 |
| 4AKE | 17230 | Dec. 8/9 '74 | 4AKF | 17232 | Dec. 8/9 '74 | 4AKG | 13263 | May 5/6 '73 |
| 4AKH | 17170 | Dec. 5/6 '74 | 4AKI | 17228 | Dec. 8/9 '74 | 4AKJ | 13210 | May 2/3 '73 |
| 4AKK | 15708 | Feb. 14/15 '74 | 4AKL | 15706 | Feb. 14/15 '74 | 4AKM | 15714 | Feb. 14/15 '74 |
| 4AKN | 15710 | Feb. 14/15 '74 | 4AKO | 15709 | Feb. 14/15 '74 | 4AKP | 15707 | Feb. 14/15 '74 |
| 4AKQ | 10689 | Mar. 19/20 '72 | 4AKR | 26560 | Feb. 29/Mar. 1 '74 | 4AKT | 13399 | May 24/25 '73 |
| 4AKU | 10690 | Mar. 19/20 '72 | 4AKV | 17186 | Dec. 5/6 '74 | 4AKW | 13262 | May 5/6 '73 |
| 4AKX | 17229 | Dec. 8/9 '74 | 4AKY | 13265 | May 5/6 '73 | 4AKZ | 16713 | Aug. 16/17 '74 |
| 4ALA | 13266 | May 5/6 '73 | 4ALB | 15540 | Jan. 23/24 '74 | 4ALC | 15713 | Feb. 14/15 '74 |
| 4ALD | 13213 | May 2/3 '73 | 4ALE | 13214 | May 2/3 '73 | 4ALF | 13215 | May 2/3 '73 |
| 4ALJ | 13455 | May 27/28 '73 | 4ALK | 13456 | May 27/28 '73 | 4ALL | 13216 | May 2/3 '73 |
| 4ALN | 20776 | June 21 '77 | 4ALO | 18326 | May 11/12 '75 | 4ALP | 15808 | Feb. 20/21 '74 |
| 4ALQ | 15809 | Feb. 20/21 '74 | 4ALS | 15785 | Feb. 18/19 '74 | 4ALT | 21778 | June 7/8 '78 |
| 4ALU | 15810 | Feb. 20/21 '74 | 4ALW | 16772 | Aug. 17/18 '74 | 4ALY | 13270 | May 5/6 '73 |
| 4ALZ | 13458 | May 27/28 '73 | 4AMA | 13271 | May 5/6 '73 | 4AMC | 13273 | May 5/6 '73 |
| 4AMF | 20717 | June 14 '77 | 4AMG | 16774 | Aug. 17/18 '74 | 4AMH | 20752 | June 19 '77 |
| 4AMI | 20703 | June 13 '77 | 4AML | 17216 | Dec. 8/9 '74 | 4AMN | 17214 | Dec. 8/9 '74 |
| 4AMO | 17213 | Dec. 8/9 '74 | 4AMP | 17217 | Dec. 8/9 '74 | 4AMQ | 17218 | Dec. 8/9 '74 |
| 4AMS | 17222 | Dec. 8/9 '74 | 4AMU | 17287 | Dec. 11/12 '74 | 4AMV | 17269 | Dec. 11/12 '74 |
| 4AMW | 17272 | Dec. 11/12 '74 | 4AMX | 13401 | May 24/25 '73 | 4AMY | 17290 | Dec. 11/12 '74 |
| 4AMZ | 15731 | Feb. 15/16 '74 | 4ANB | 17289 | Dec. 11/12 '74 | 4ANC | 17325 | Dec. 13/14 '74 |
| 4AND | 17374 | Dec. 16/17 '74 | 4ANE | 17271 | Dec. 11/12 '74 | 4ANH | 17372 | Dec. 16/17 '74 |
| 4ANI | 17288 | Dec. 11/12 '74 | 4ANL | 17368 | Dec. 16/17 '74 | 4ANM | 17369 | Dec. 16/17 '74 |
| 4ANN | 17370 | Dec. 16/17 '74 | 4ANO | 17371 | Dec. 16/17 '74 | 4ANS | 17277 | Dec. 11/12 '74 |
| 4ANT | 17276 | Dec. 11/12 '74 | 4ANV | 17273 | Dec. 11/12 '74 | 4ANY | 17375 | Dec. 16/17 '74 |
| 4ANZ | 20750 | June 19 '77 | 4AOA | 20751 | June 19 '77 | 4AOB | 13400 | May 24/25 '73 |
| 4AOC | 17327 | Dec. 13/14 '74 | 4AOE | 20714 | June 14 '77 | 4AOG | 16759 | Aug. 17/18 '74 |
| 4AOL | 16714 | Aug. 16/17 '74 | 4AOP | 18323 | May 11/12 '75 | 4AOQ | 16733 | Aug. 16/17 '74 |
| 4AOS | 20693 | June 13 '77 | 4AOT | 16768 | Aug. 17/18 '74 | 4AOY | 17263 | Dec. 11/12 '74 |
| 4APB | 16765 | Aug. 17/18 '74 | 4APC | 16766 | Aug. 17/18 '74 | 4APD | 20699 | June 13 '77 |
| 4APF | 18704 | Aug. 31 '70 | 4APJ | 16777 | Aug. 17/18 '74 | 4APK | 16778 | Aug. 17/18 '74 |
| 4APN | 16710 | Aug. 16/17 '74 | 4APO | 18174 | Aug. 15/16 '74 | 4APS | 16654 | Aug. 14/15 '74 |
| 4APT | 16655 | Aug. 14/15 '74 | 4APU | 20718 | June 14 '77 | 4APV | 20748 | June 17 '77 |
| 4APY | 18343 | May 11/12 '75 | 4APZ | 18344 | May 11/12 '75 | 4AQA | 20754 | June 19 '77 |
| 4AQB | 20755 | June 19 '77 | 4AQD | 18348 | May 11/12 '75 | 4AQG | 18710 | Aug. 10/11 '75 |
| 4AQI | 17262 | Dec. 11/12 '74 | 4AQQ | 20782 | June 21 '77 | 4AQS | 20691 | June 13 '77 |
| 4AQT | 20784 | June 21 '77 | 4AQU | 18229 | May 4/5 '95 | 4AQW | 18322 | May 11/12 '75 |
| 4AQX | 18376 | May 15/16 '75 | 4AQY | 20729 | June 14 '77 | 4ARB | 20032 | Oct. 22/23 '76 |
| 4ARC | 13554 | June 1/2 '73 | 4ARD | 20880 | Aug. 17 '77 | 4ARM | 20865 | Aug. 17 '77 |
| 4ARN | 18173 | May 3/4 '75 | 4ARV | 13269 | May 5/6 '73 | 4ARW | 13268 | May 5/6 '73 |
| 4ASA | 13267 | May 5/6 '73 | 4ASB | 20698 | June 13 '77 | 4ASC | 18335 | May 11/12 '75 |
| 9ALV | 4575 | June 15/16 '69 | 9ALZ | 4751 | July 7/8 '69 | 9ARC | 20726 | June 14 '77 |

# V. Description of Remarks

Further information about 4906 stars is given at the back of the catalogue. To aid the user in deciding whether to consult the remarks of a particular star, the following notation is used in Column 3 of the catalogue:

**B** indicates that the remark contains the HR (from The Bright Star Catalogue) number and the Bayer or Flamsteed designations where applicable. (1164 stars)

**L** indicates that information from the astronomical literature is given. Remarks designated O (other) in previous Volumes are now included as L remarks. In most cases individual literature references are not given; references systematically searched are listed at the end of this section. Remarks were generally limited to those relevant to the spectral appearance, such as rotation, variablity, and duplicity, and generally have included only information about the star which might affect the spectral classification. However, for the first time proper motions of LHS stars are given. The entry 'Emission Catalogue' refers to Wackerling's catalogue. (1121 stars)

**R** 846 of the stars in the remarks section have remarks of this type. All 'R' remarks were written by NH in the course of the spectral classification and all are related in some way to the spectrum. The other remark types (i.e. V,D etc.) were not available to NH during classification. The symbols and notation are self-explanatory. We discuss some of the more frequent types of 'R' remarks.

283 stars in the catalogue have composite spectra or possibly composite spectra and each of these has a remark so that it can be easily differentiated from known double stars which also sometimes have two types listed in the catalogue.

In 290 cases the fact that the star was visually double was deduced from the appearance of the spectrum. Most of these clearly showed early and late components. The rest were suspected to be double because they were fuzzy, double-lined, or closely overlapped. The following data were listed (taken from [IDS], prior to 1996; from 1996 on [WDS] was used): position angle p, angular distance d, and magnitudes of components. Sometimes a rough spectral type for the secondary component is also listed in the remarks, but often only a single type is listed in the catalogue, and it may actually be an average of the two components in some cases.

Remarks are made for all stars ($\approx 75$) showing emission or filled-in lines, and the lines in emission are identified in the remark. For nebulae the lines in emission are often not listed.

The great majority of Am stars do not have remarks, but $\approx 50$ do. Similarly some 40 of the Ap stars have 'R' remarks. For both Am and Ap stars these are mainly weak or questionable cases, and the spectral type listed in the catalogue may not indicate the possible metallic-line or peculiar nature of the star. Unusual and extremely strong cases are also included among the remarks.

About 20 of the 'R' remarks pertain to fuzzy or closely overlapped spectra some of which are probably new visual doubles.

About 40 of the weak-metal stars have 'R' remarks. In many cases the spectral type indicated by the G band is given to supplement the H-line and metallic-line types given in the catalogue. Slight or questionable and extreme cases are also noted.

Other smaller categories of 'R' remarks include: substantial disagreements with the HD catalogue, mainly with respect to spectral types; possible Fm $\delta$ Del types; stars with strong CH - these are not indicated in the catalogue spectral types; star with weak CH, strong CN or weak CN.

**D** The Centre de Données Stellaires de Strasbourg provided a listing of visual double stars from the Index Catalogue of Double Stars (commonly referred to as the Lick Catalogue). Remarks beginning 'undetected visual double' were included for doubles not discovered in the course of the spectral classification, the others having 'R' remarks. 'D' remarks were included for the 1904 doubles having a separation of $< 30$" and a $\Delta$ magnitude of $< 4.0$ mag, since for these the spectral appearance, and hence the assigned spectral type might be affected.

**V** All variables (337 stars) are indicated by a 'V' remark. Each has a remark in the back of the catalogue giving variable star designation, type of variablity, magnitude range and period, when these are known.

**†** All spectral types in the catalogue taken from other sources are preceded by a dagger. Each such star has a remark giving the reason the star could not be classified on Michigan plates, and the source of the classification. Many are taken from the HD catalogue. Classifications of many bright stars were provided by R. F. Garrison, and are listed as 'Garrison types'. W. Warren provided types for stars that were overlapped on our plates, where available. These are listed as 'Warren types', and are followed by a number which indicates which references were used by Warren to obtain the type. Please see the references section. All stars that did not have a Garrison or Warren type were researched using the SIMBAD utility of the Centre de Données Stellaires de Strasbourg. Those stars with MK types on SIMBAD are listed as 'SIMBAD types'.

# References

References for the preface:


**CP** Cannon, A. J. and Pickering, E. C. 1918-24, 'The Henry Draper Catalogue', *Harvard Annals*, **91-99**

**HC** Houk, N. and Cowley, A. 1973, *Spectral Classification and Multicolour Photometry*, ed. Ch. Fehrenbach and B.E. Westerlund, (Dordrecht-Holland: Reidel Publishing Company), 70

**HIR** Houk, N., Irvine, N. J., and Rosenbush, D. 1974, *An Atlas of Objective-Prism Spectra*, (Ann Arbor: The University of Michigan)

**HN** Houk, N. and Newberry, M. V. 1984, *A Second Atlas of Objective-Prism Spectra*, (Ann Arbor: The University of Michigan)

**VOL1** Houk, N. and Cowley, A. 1975, *University of Michigan Catalogue of Two-Dimensional Spectral Types for the HD Stars, Volume 1*, (Ann Arbor: University of Michigan)

**VOL2** Houk, N. 1978, *Michigan Catalogue of Two-Dimensional Spectral Types for the HD Stars, Volume 2*, (Ann Arbor: University of Michigan)

**VOL3** Houk, N. 1982, *Michigan Catalogue of Two-Dimensional Spectral Types for the HD Stars, Volume 3*, (Ann Arbor: University of Michigan)

**VOL4** Houk, N. and Smith-Moore, M. 1988, *Michigan Catalogue of Two-Dimensional Spectral Types for the HD Stars, Volume 4*, (Ann Arbor: University of Michigan)

**JM** Johnson, H. L. and Morgan, W. W. 1953, *Ap. J.*, **117**, 313

**MKK** Morgan, W. W., Keenan, P. C., and Kellman, E. 1943, *An Atlas of Stellar Spectra*, (Chicago: Univ. of Chicago Press)

**MK** Morgan, W. W. and Keenan, P. C. 1973, *Ann Rev Astr and Ap.*, **11**, 29

**W** Walborn, N. R. 1971, *Ap. J. Suppl.*, **23**, 257


References for the Remarks:

**G** = general reference for the Catalogue
**L** = reference for L remarks
**V** = reference for V remarks
**B** = reference for B remarks
**D** = reference for D remarks
**†** = reference for † remarks
**W** = reference for Warren types
**S** = reference for SIMBAD types

**L** Bidelman, W. P. 1954, 'Catalogue and Bibliography of Emission-Line Stars of Types Later than B', *Ap. J. Suppl.*, **1**, 175

†**LG** Cannon, A. J. and Pickering, E. C. 1918-24, 'The Henry Draper Catalogue', *Harvard Annals*, **91-99**

**B** Hoffleit, D. 1982, *Catalogue of Bright Stars*, 4th ed., (New Haven: Yale University Observatory)

**IDS D** Jeffers, H. M., van den Bos, W. H., and Greeby, F. M. 1961, *Index Catalogue of Visual Double Stars*, (Mount Hamilton: University of California)

**V** Sumus, N. N., ed., 1990, *General Catalogue of Variable Stars*, 4th ed., (Moscow: Sternberg State Astronomical Institute)

**G** NASA Skyview *http://skyview.gsfc.nasa.gov*

**L** Luyten, W. J. 1955, *A Catalogue of 1849 Stars with Proper Motions Exceeding* $0''5$ *Annually* (LHS), Lund Press

†**GS** SIMBAD *http://cdsweb.u-strasbg.fr/Simbad.html/*

**L** Uesugi, A. and Fukuda, I. 1970, *A Catalog of Rotational Velocities of the Stars*, *Contr. Inst. Ap. and Kwasan Obs.*, Kyoto, No.189

**L** Wackerling, L. R. 1970, 'Catalogue of Early-Type Stars Whose Spectra Have Shown Emission Lines', Mem. R.A.S., **73**, 153

**WDS D** Worley, C. E. and Douglass, G. G. 1997, *A.& A. Suppl.*, **125**, 523

† **W 2** McCuskey 1949, *Ap. J.*, **109** 426

† **W 4** Wenzel 1951, Veroeffent. Sonnenberg, **5**, 1

† **W 5** Sharpless 1952, *Ap. J.*, **116**, 251

† **W 12** Hiltner and Iriarte 1955, *Ap. J.*, **122**, 185

† **W 13** Morgan, Code, and Whitford 1955, *Ap. J. Supp.*, **2**, 41

† **W 14** Johnson H.L. and Hiltner 1956, *Ap. J.*, **123**, 267

† **W 16** van P. Smith 1956, *Ap. J.*, **124**, 43

† **W 19** Hiltner 1956, *Ap. J. Supp.*, **2**, 389

† **W 21** Strand 1958, *Ap. J.*, **128**, 14

† **W 22** Kukarkin, et al. 1958, GCVS, 2nd edition

† **W 25** Hoag and Smith 1959, *PASP*, **71**, 32

† **W 26** Borgman 1960, *BAN*, **15**, 255

† **W 31** Buscombe 1962, Mt Stromlo Mim, 4

† **W 33** Shiukashvili 1968, *Abastumani Bull.*, **38**, 153

† **W 34** Rountree 1968, *Ap. J. Supp.*, **17**, 371

† **W 35** Guetter 1968, *PASP*, **80**, 197

† **W 36** Murphy 1969, *A. J.*, **74**, 1082

† **W 37** McClure 1970, *A. J.*, **75**, 41

† **W 41** Walborn 1972, *A. J.*, **77**, 312

† **W 42** Smith 1972, *Ap.J.*, **175**, 765

† **W 43** Chuadze 1973, *Abastumani Bull.*, **44**, 105

† **W 48** Blaauw, et al. 1976, *A.&A.S.*, **23**, 393