#324

UNIVERSITY OF MICHIGAN

CATALOGUE OF TWO-DIMENSIONAL SPECTRAL TYPES FOR THE HD STARS

GA-13I

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1. INTRODUCTION:

The documentation for this data set was originally on paper, kept in NSSDC's Data Set Catalogs (DSCs). The paper documentation in the Data Set Catalogs have been made into digital images, and then collected into a single PDF file for each Data Set Catalog. The inventory information in these DSCs is current as of July 1, 2004. This inventory information is now no longer maintained in the DSCs, but is now managed in the inventory part of the NSSDC information system. The information existing in the DSCs is now not needed for locating the data files, but we did not remove that inventory information.

The offline tape datasets have now been migrated from the original magnetic tape to Archival Information Packages (AIP's).

A prior restoration may have been done on data sets, if a requestor of this data set has questions; they should send an inquiry to the request office to see if additional information exists.

2. ERRATA/CHANGE LOG:

NOTE: Changes are made in a text box, and will show up that way when displayed on screen with a PDF reader.

When printing, special settings may be required to make the text box appear on the printed output.

Version	Date	Person	Page	Description of Change
01				
02				

3 LINKS TO RELEVANT INFORMATION IN THE ONLINE NSSDC INFORMATION SYSTEM:

http://nssdc.gsfc.nasa.gov/nmc/

[NOTE: This link will take you to the main page of the NSSDC Master Catalog. There you will be able to perform searches to find additional information]

4. CATALOG MATERIALS:

a. Associated Documents To find associated documents you will need to know the document ID number and then click here. http://nssdcftp.gsfc.nasa.gov/miscellaneous/documents/

b. Core Catalog Materials

REQ. AGENT	RAND NO.	ACQ. AGENT
DLB	RC4613	TNK

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This data set consists of one 1600,EBCDIC , 9 track tape containing 2 files of S360 data. The first file is blocked 100 logical records to one physical record and the second file is blocked 20 logical records to one physical record.

D-22266 C-17064

Note to users of the magnetic tape version of the University of Michigan Catalogue of Two-Dimensional Spectral Types for the HD Stars, Volume I, by Nancy Houk and Anne P. Cowley.

The tape differs from the printed catalogue in several ways:

1) The catalogue preface is not included on the tape. A copy is enclosed, and users are urged to read it before utilizing the tape.

2) On the catalogue tape the spectral types are entirely in upper case; those types which have letters which were converted to lower case in the printed catalogue are preceded by an asterisk.

3) For stars that were not classifiable, published spectral types mainly from the HD Catalogue, are given. On the tape these are preceded by a plus sign (+) whereas in the printed catalogue a dagger (†) is used.

4) On the remarks tape the vertical bars indicate that the letter immediately following each is put into lower case in the printed version.

5) The asterisks on the remarks tape indicate that the following word or abbreviation is converted to a symbol in the printed version. Most are self evident. An underscore preceded by an asterisk means "yield" or "yields".

Below are listed formats of the University of Michigan Spectral Catalogue Tape. 9 Track Unlabeled, 1600 BPI.

File 1

The main catalogue
Format FB (10700, 107)
Fixed Block
Block length 10700 bytes
Record length 107 bytes
Records are EBCDIC and explained on a separate sheet.
There are 36382 records in this file.

File 2

The Remarks
Format FB (8000, 400)
Block length 8000 bytes
Record length 400 bytes
Records are in EBCDIC and explained on separate sheet.
There are 4636 records in this file.

Tape Formats

File 1: Main Catalogue

FMT = FB (10700,107) 9 Track 1600 BPI EBCDIC Characters

Subject	Length	Col. start	Col. end
HD No.	6	1	6
	1	7	7
* or +	1	8	8
Spec. type	16	9	24
	1	25	25
A - Quality	2	26	27
	1	28	28
Remark	4	29	32
	1	33	33
[1]Magnitude	6	34	39
Remark (V)	1	40	40
	1	41	41
R.A. (1900) Hours	2	42	43
	1	44	44
R.A. (1900) Min.	4	45	48
	1	49	49
Dec. (1900) Deg.	3	50	52
	1	53	53
Dec. (1900) Min.	2	54	55
	1	56	56
Prec. ΔR.A.	5	57	61
	1	62	62
Prec. ΔDec.	3	63	65
	1	66	66

Subject	Length	Col. start	Col. end
ℓ (gal. long.)	5	67	71
	1	72	72
b (gal. lat.)	5	73	77
	1	78	78
Zone	3	79	81
	1	82	82
CPD	5	83	87
	1	88	88
Plate Code #1	3	89	91
	1	92	92
Plate Code #2	3	93	95
	1	96	96
Plate Code #3	3	97	99
	1	100	100
Plate Code #4	3	101	103
	1	104	104
Plate Code #5	3	105	107

File 2: Remarks

FMT = FB(8000,400) 9 track 1600 BPI EBCDIC Characters

Subject	Length	Col. start	Col. end
HD No.	6	1	6
	1	7	7
Remark	remainder of record	8	-

[1]Note: The original tape as received from U. Michigan had asterisks in columns 35-38 if no magnitude was given in the HD Catalogue. This has been changed to read 99.9 in these columns.

UNIVERSITY OF MICHIGAN CATALOGUE OF TWO-DIMENSIONAL SPECTRAL TYPES FOR THE HD STARS

VOLUME I

by Nancy Houk and Anne P. Cowley

Department of Astronomy
University of Michigan
Ann Arbor, Michigan

1975

I. *Introduction*

This is the first of several volumes in a program of systematic reclassification of the Henry Draper stars on the MK system and contains all HD stars south of and including $\delta_{1900} = -53°0$. 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° + 6° prisms yield a dispersion at Hγ of 108 A/mm, and the resolution is about 2A, comparable to that of the original MK system. 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 by the accompanying atlas in a pocket at the back of the volume. In order to maintain a uniform, consistent system, all the spectral classification was done by one person (NH). Over 170 standard stars were used. (See section III). The stars were identified using computer generated plots to the scale of the Schmidt Plates (see Houk, N., and Cowley, A., 1973, in *Spectral Classification and Multicolour Photometry* ed. Ch. Fehrenbach and B. E. Westerlund. (Dordrecht-Holland: Reidel Publishing Company), p. 70).

Of the 36,382 HD stars in the catalogue 34,886 or 96% were classifiable. Previously published types are listed for the 4% not classifiable on our plates. About 93% 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 15% of the stars classified independently on more than one plate. Both the internal and external errors, which are similar to those usually obtained in classification of slit spectra, will be published and discussed elsewhere. Nearly 13% 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.

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* (Harvard Annals **91-99**, 1918-24), upon which our work is largely based. The present project scarcely would have been possible without the *HD 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, being 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. He also directed the southern observing program from 1967 through 1969. We thank him for much advice and help, and especially for looking over and commenting on preliminary versions of the remarks to this catalogue.

We are indebted to D. J. MacConnell who has contributed in many ways. He was the chief observer from 1967 through 1969 and trained all but one of the succeeding observers, as well as planning the observing program and evaluating all the plates for quality through 1973. He and Wayne Fullerton also planned the production of computer-generated plots of the HD stars to Schmidt scale used for identification. He was often consulted during the course of the spectral classification, particularly with regard to classification of the peculiar stars.

Thanks go to F. D. Miller for taking over direction of the NSF grant for Schmidt observing in 1969 upon the departure of W. P. Bidelman, continuing through 1973, after which it was incorporated into the NSF grant for the HD star reclassification.

We thank the following observers (listed chronologically) for taking the splendid plates so vital to the success of the project: D. J. MacConnell, Paul Hoover, Arturo Gómez, Oscar Saá, Gaston Araya, Jon Thomas, Nelson Irvine, and Mario Zemelman.

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

We acknowledge the work of Dorrit Hoffleit and her assistants at Yale whose keypunched version of the HD Catalogue made this project feasible. We also are indebted to her for providing a compilation of known errata to the HD. These corrections have been incorporated into this volume without noting them individually.

For day-to-day help on all phases of the project we are deeply indebted to the following general assistants, whose work was of consistently high quality and who all went far beyond the call of duty, often under time pressure: Dorothy Fraquelli, Mark Hartoog, Nelson Irvine, and Richard Moore.

We are grateful to the programmers, who did fine work while laboring under the disadvantage of direction by one not familiar with computers and their ways. They were, in chronological order, Wayne Fullerton, Timothy Hathaway, and Ray Wallman. Mark Hartoog also wrote several very useful programs.

The sheer amount of data involved produced a plethora of tedious but vital clerical tasks and a great deal of keypunching, involving over 100,000 cards. This work was mainly done by students in the University of Michigan Work-Study Program, most of whom worked for one term. Almost everything was done or checked by two people to cut down on errors. A complete (we hope) list of those involved in this clerical and keypunching work follows, and we thank them all: Edward Arrizabalaga, Deborah Cresswell, Lynda Curtis, Deborah Dahlen, Ronald Downes, Dorothy Fraquelli, Kirk Hayden, Judith Karpen, Irene Kazieczko, Richard Moore, Weylin Moy, Heidi Ott, Daniel Roarty, Daniel Sell, Yvonne Sears, Garrett TerBerg, Julia Truettner, Mary Van Dusen, Raymond Wallman, Joan Weiner, Frank Weir, Laurel Widerkehr, and Cathy Wylie.

Special appreciation is due to four students who did some unpaid volunteer work: Ronald Downes, Judith Karpen, Cathy Wylie, and Deborah Cresswell.

We thank the Astronomy Department of the University of Michigan, both under former chairman O. C. Mohler and present chairman W. A. Hiltner, for continuing support, especially through contribution of office staff and facilities and for the computer funds for producing the HD plots. We thank W. A. Hiltner for arranging the IST financing mentioned below.

We also gratefully acknowledge the staff at the Cerro Tololo Inter-American Observatory for their help and cooperation over the 8 years that the southern survey program has been underway.

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

We would like to invite readers to send us errata for the first volume. You are also encouraged to notify us promptly of any errors found so that the magnetic tape version can be corrected from time to time. In addition, a list of corrections will be published in Volume 2.

Appreciation and acknowledgment is expressed to the 1962 class of the University of Michigan for establishing an Institute of Science and Technology Publishing Fund. This fund has aided in the publication of this work.

Finally, we are especially grateful to the National Science Foundation for continuing support for this research project through a series of grants.

II. *Spectral Classification*

A. Standards

The similarity in resolution of our spectra to that of the original work by Morgan and Keenan allowed us to classify on a system which is a good approximation to the MK system. We used MK standards when they were available, supplemented with others as necessary. 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 we 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 also so compared; it is estimated that nearly half of the classifications in the catalogue were made by direct comparison with standards. This may not have been necessary but the procedure will also be followed in future volumes to avoid any drift in the system. Another precaution taken was to reclassify independently all the stars which had been classified in the first 6 months ($\cong$5000) and use these second types in the catalogue. Consequently types for the early plate codes (approximately through AF: see section IV below) should be as reliable as those for stars classified later.

The primary standards are listed in Table 1 below. The MK standards were supplmented by types by Bidelman in order to get an adequate representation of supergiants. The source abbreviated †MK (1973) did not become available until nearly half the stars in this volume (through approximately plate code CZ) had been classified, so the type used up to that point is listed in brackets along with its source, when it differs from the new type. 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.

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 15% of the stars were classified independently on two or more plates. A total of 40,235 independent spectra were classified to yield the 34,886 spectral types 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.

Table 1

Primary Standards

	Name	HR No.	HD No.	Spectral Type	Source
	τ CMa	2782	57061	09 Ib	†MK (1973)
	16 Sgr	6823	167263	09 II	J+M (1953)
*	ι Ori	1899	37043	09 III	†MK (1973)
	----	----	52266	09 V	J+M (1953)
	----	6347	154368	09.5 Iab	B (1954)
	ζ Ori	1948	37742	09.5 Ib	J+M (1953)
	δ Ori	1852	36486	09.5 II	J+M (1953)
	σ Ori	1931	37468	09.5 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)
	δ Sco	5953	143275	B0.3 IV [B0.5 IV]	†MK (1973) [H,G,S (1969)]
	τ Sco	6165	149438	B0 V	†MK (1973)
	κ Ori	2004	38771	B0.5 Ia	†MK (1973)
*	----	6142	148688	B1 Ia	B (1954)
*	ρ Leo	4133	91316	B1 Ib	J+M (1953)
*	σ Sco	6084	147165	B1 III	J+M (1953)
*	ω^1Sco	5993	144470	B1 V	†MK (1973)
	χ^2Ori	2135	41117	B2 Ia	†MK (1973)
	ε CMa	2618	52089	B2 II	J+M (1953)
	π^4Ori	1552	30836	B2 III	J+M (1953)
	γ 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)
	σ Sgr	7121	175191	B2.5 V	†MK (1973)
	o^2CMa	2653	----	B3 Ia	†MK (1973)
	----	3654	79186	B3 Ia	B (1954)
	κ Cru	----	111973	B3 Iab	B (1954)
	ι CMa	2596	----	B3 II	J+M (1953)
	ν Ori	2159	----	B3 V	J+M (1953)
	----	6450	157038/9	B4 Ia	B (1954)
*	η CMa	2827	58350	B5 Ia	†MK (1973)
*	----	3456	74371	B5 Iab	B (1954)
*	67 Oph	6714	164353	B5 Ib	J+M (1953)
*	τ Ori	1735	34503	B5 III	J+M (1953)
	ι Aql	7447	184930	B5 III	J+M (1953)
*	κ Hya	3849	83754	B5 V	J+M (1953)
	ψ^2Aqr	8858	219688	B5 V	J+M (1953)
	----	----	183143	B7 Ia	J+M (1953)
	----	3708	80558	B7 Iab	B (1954)

* in accompanying atlas

Table 1 Continued

Primary Standards

	Name	HR No.	HD No.	Spectral Type	Source
	β Ori	1713	34085	B8 Ia	†MK (1973)
	γ 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)
	γ 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)
*	γ Gem	2421	47105	A0 IV	J+M (1953)
	γ UMa	4554	103287	A0 V	†MK (1973)
	----	4876	111613	A1 Ia	B (1954)
	ι Ser	5842	140159	A1 V	J+M (1953)
	β Ser A	5867	141003	A2 IV	J+M (1953)
	β Eri	1666	33111	A3 III	J+M (1953)
	β Leo	4534	102647	A3 V	J+M (1953)
	α PsA	8728	216956	A3 V	†MK (1973)
	δ 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)
	θ^2Tau	1412	28319	A7 III	J+M (1953)
	21 LMi	3974	87696	A7 V	J+M (1953)
	γ Her	6095	147547	A9 III	J+M (1953)
	----	4110	90772	F0 Ia	B (1954)
	α Lep	1865	36673	F0 Ib	†MK (1973)
	ζ Leo	4031	89025	F0 III	†MK (1973)
	μ Cet	813	17094	F0 IV	J+M (1953)
	ρ Gem	2852	58946	F1m A9 [F0 V]	G, unpubl. [J+M (1953)]
*	89 Her	6685	163506	F2 Ia	J+M (1953)
	----	3496	75276	F2 Iab	B (1954)
*	ν Agl	7387	182835	F2 Ib	J+M (1953)
*	ν Her	6707	164136	F2 II	J+M (1953)
*	14 Ari	623	13174	F2 III	J+M (1953)
*	σ 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)
*	β Del	7882	196524	F5 III	B (1951)
	45 Boo	5634	134083	F5 V	J+M (1953)

*in accompanying atlas

Table 1 Continued

Primary Standards

	Name	HR No.	HD No.	Spectral Type	Source
	----	7308	180583	F6 II	B (1951)
	----	6577	160365	F6 III	†MK (1973)
	α Tri	544	11443	F6 IV	†MK (1973)
	γ Ser	5933	142860	F6 V	J+M (1953)
	ι Psc	8969	222368	F7 V	J+M (1953)
	δ CMa	2693	54605	F8 Ia	J+M (1953)
	γ^1Nor	6058	146143	F8 Iab	B (1954)
	11 Pup	3102	65228	F8 II	B (1951)
	υ Peg	8905	220657	F8 IV	J+M (1953)
	β 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)]
	β Aqr	8232	204867	G0 Ib	†MK (1973)
*	31 Com	4883	111812	G0 III	†MK (1973)
*	η Boo	5235	121370	G0 IV	J+M (1953)
	ε Leo	3873	84441	G1 II [G0 II]	MK (1973) [J+M (1953)]
	----	----	27836	G1 V	†MK (1973)
	ζ Mon	3188	67594	G2 Ib	†MK (1973)
	Sun (Uranus)	---	----	G2 V	†MK (1973)
	ξ Pup	3045	63700	G3 Ib	B (1951)
	9 Peg	8313	206859	G5 Ib	†MK (1973)
*	25 Gem	2453	47731	G5 Ib	J+M (1953)
*	ω Gem	2630	52497	G5 II	J+M (1953)
	----	1327	27022	G4 III [G5 III]	MK (1973) [J+M (1953)]
	μ Her	6623	161797	G5 IV	MK (1973)
*	κ Cet	996	20630	G5 V	J+M (1953)
	ε Gem	2473	48329	G8 Ib	†MK (1973)
	ζ Cyg	8115	202109	G8 II CN 1 [G8 II]	†MK (1973) [J+M (1953)]
	η Psc	437	9270	G8 III	J+M (1953)
	κ Gem	2985	62345	G8 IIIa [G8 III]	†MK (1973) [J+M (1953)]
	β Aql	7602	188512	G8 IV	†MK (1973)
	ξ Boo (A)	5544	131156	G8 V	J+M (1953)
*	12 Peg	8321	207089	K0 Ib	MK (1973)
	θ^1Tau	1411	28307	K0 III	J+M (1953)
	δ Eri	1136	23249	K0 IV	J+M (1953)
*	54 Psc	166	3651	K0 V	J+M (1953)
	ζ Cep	8465	210745	K1.5 Ib	†MK (1973)
	----	2334	45416	K1 II	J+M (1953)
	1 Peg	8173	203504	K1 III	MK (1973)
	γ Cep	8974	222404	K1 IV	MK (1973)
	107 Psc	493	10476	K1 V	J+M (1953)
	ε Peg	8308	206778	K2 Ib	†MK (1973)
	56 Ori	2037	39400	K1.5 IIb [K2 II]	†MK (1973) [J+M (1953)]
	σ Oph	6498	157999	K2 II [K3 II]	†MK (1973) [M,C,W (1955)]
	β Oph	6603	161096	K2 III	†MK (1973)

* in accompanying atlas

Table 1 Continued

Primary Standards

	Name	HR No.	HD No.	Spectral Type	Source
	α Ari	617	12929	K2 IIIab	†MK (1973)
	α Ser	5854	140573	K2 III CN 1.5	†MK (1973)
	----	6806	166620	K2 V	J+M (1953)
*	o^1CMa	2580	50877	K2.5 Iab [K3 Iab]	†MK (1973) [J+M (1953)]
	η Per A	834	17506	K3-Ib-IIa [K3 Ib]	†MK (1973) [J+M (1953)]
	θ Del	7892	196725	K3 Ib	B (1951)
*	γ Aql	7525	186791	K2 II	†MK (1973)
	π Her	6418	156283	K3 IIab	†MK (1973)
*	δ And	165	3627	K3 III	†MK (1973)
	β Cnc	3249	69267	K4 III	†MK (1973)
	ξ Cyg	8079	200905	K4.5 Ib-II [K5 Ib]	†MK (1973) [J+M (1953)]
	α Tau	1457	29139	K5 III	†MK (1973)
	γ Dra	6705	164058	K5 III	†MK (1973)
	----	----	154363	K5 V	J+M (1953)
	ν Gem	2905	60522	M0 III	MK (1973)
	6 Gem	2197	42543	M1-M2 Ia-Iab [M1 Ia]	†MK (1973) [J+M (1953)]
	α 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)
	μ Gem	2286	44478	M3 IIIab	†MK (1973)
	η Gem	2216	42995	M3 III	MKK (1943)
	45=RZ Ari	867	18191	M6 - III:	†MK (1973)
	----	----	207076	M7 III:	MK (1973)

* in accompanying atlas

Sources

B (1951) Bidelman, W.P. 1951, Ap. J., 113, 304.

B (1954) Bidelman, W.P. 1954, Pub. A.S.P., 75, 226.

H,G,S (1969) Hiltner, W.A., Garrison, R.F., and Schild, R.E. 1969, Ap. J., 157, 313.

J+M (1953) Johnson, H.L., and Morgan, W.W. 1953, Ap. J., 117, 313.

M,C,W (1955) Morgan, W.W., Code, A.D., Whitford, A.E. 1955, Ap. J. Suppl., 2, 41.

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

(A dagger (†) in front of this reference indicates that the spectral type quoted is a dagger type, i.e., 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	C^2J^2 (1969)
----	3981	87887	A0 III	C^2J^2 (1969)
o Peg	8641	214994	A1 IV	C^2J^2 (1969)
----	----	92692/3	A3 Ia	H+C (1975)
τ Peg	8880	220061	A5 IV	H+C (1975)
σ^2Tau	1479	29488	A5 V	C^2J^2 (1969)
----	----	96746	G2 Iab	H+C (1975)
δ CrB	5889	141714	G5 III/IV	R (1952)
θ 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	95129	M2 III	R (1955)
----	4333	96813	M4 III	H+C (1975)

Sources

C^2J^2(1969) Cowley, A.P., Cowley, C.R., Jaschek, M., and Jaschek, C. 1969, A.J., 74, 375.

H+C (1975) Houk, N., and Cowley, A.P. 1975, University of Michigan Catalogue of Two-Dimensional Spectral Types for the HD Stars (Astronomy Dept., Univ. of Mich., Ann Arbor, Michigan).

H,G,S (1969) Hiltner, W.A., Garrison, R.F., and Schild, R.E. 1969, Ap. J., 157, 313.

R (1952) Roman, N.G. 1952, Ap. J., 116, 122.

R (1955) Roman, N.G. 1955, Ap. J. Suppl., 2, 195.

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 then they were averaged to form a single spectral type. To form these averages the temperature and luminosity types were converted to numerical codes. These codes were then combined in a weighted average and converted back 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 (F1, 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 M1. 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 where 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 re-examining 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 table.

Table 3

Revised Standards

Name	HR No.	HD No.	Spectral Type Used	Standard Spec. Type	Source
* β Com	4983	114710	G2 V	G0 V	†MK (1973)
ζ Her	6212	150680	G3 IV	G1 IV	†MK (1973)
ξ 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)
π Leo	3950	86663	M1 III	M2-IIIab [M2 III]	†MK (1973) [J+M (1953)]

* in accompanying atlas

Sources

M,H,J (1953) Morgan, W.W., Harris, D.L., and Johnson, H.L. 1953, Ap. J., 118, 92.

See bottom of primary and secondary standards table for other sources above.

C. Notation

A major deviation in the catalogue from normal notation is that hyphenated types (ex., B8-9 IV-V) were not used. They were avoided because it was felt that they 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 following spectral subtypes were never used: F1, F4, F9, G4, G7, G9, K6-9.

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 peculiarity 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., A0 (V)). The usual convention was followed of denoting broad lined stars with "n", very broad lined stars with "nn", and sharp lined stars with "s". Most of the broad or sharp lined stars are of type B or A.

Otherwise the spectral notation is generally that traditionally used in MK classification.

D. Classification Criteria

Nearly all the temperature and luminosity criteria outlined by Morgan, Keenan, and Kellman (*An Atlas of Stellar Spectra,* Chicago: Univ. of Chicago Press, 1943) and Johnson and Morgan (*Ap. J.*, **117**, 313, 1953) 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 the accompanying atlas in the back of this volume 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 over-all 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

1. *O Stars*

There are 66 O stars in the Catalogue. Because O stars and supergiants are of special interest to many, a complete list of those in Volume I will be published elsewhere soon. Many O stars occur in tight clusters where the overlap problems on objective-prism plates are so bad as to preclude discovery or at least to lower the quality of the type given. Because of such classification uncertainties Walborn's system (Walborn, N. R. 1971, *Ap. J. Suppl.*, **23**, 257) 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.

2. *B Stars*

There are about 5500 B stars. A detailed breakdown by temperature subtype and luminosity type for all stars in Volume I will be published elsewhere. 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 τ Ori and κ Hya on the B5 sheet of the accompanying 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.

3. *A Stars*
There are about 7000 normal A stars and nearly 1000 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., Ap CrEuSr) 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. Only the most extreme examples could be identified.

4. *F Stars*
There are nearly 7000 F stars. Note that peculiar stars are all called "Ap" even though a few are as late as F0 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 λ4077 and λ4150, λ4416 << λ4481) similar to Am stars. There is a larger intermediate group which in the atlas is called "Fp δ Del" (see A5 and F2 portions of atlas write-up). This was later changed in the catalogue to "Fm δ Del" since the characteristics are more similar to Am's then Ap's.

5. *G Stars*
There are about 4800 G stars. The following notation is used for weak-metal stars (ex., G5wF0); 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.

6. *K Stars*
There are about 7200 normal K stars and 260 stars having noticeably weak or strong CN. See the atlas for examples. 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 λ4554 line are designated with a 'p' and 'Ba' (ex., K0p Ba). These stars usually also have strong Sr and strong CN. In some cases C_2 bands can be seen. The K spectra were often too faint at the blue end for the Sr 4077/4063 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.

7. *M,S,C Stars*
There are about 1100 M stars, 37 C stars and 4 S stars. S stars, which are rare anyway, are rather inconspicuous on our plates unless they are well-exposed and of very late type, and it is extremely likely that most of the early ones were assigned M types. C stars were not assigned subtypes.

8. *Emission Stars and Other Miscellaneous Types*
Stars which showed hydrogen lines in emission are designated with an "e". A remark usually indicates that 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 in the HD, these identifications were included in the remarks.

IV. *Description of Catalogue*

Column 1. HD number
2. Spectral type
3a. Average indicated
b. Quality: 1 (best) to 4 (worst)
c. Remark code; B,L,O,R
4. Photographic magnitude from HD catalogue followed by 'V' if variable
5. α_{1900} from HD catalogue
6. δ_{1900} from HD catalogue
7. $\Delta\alpha$ = 100 yr. precession in α
8. $\Delta\delta$ = 100 yr. precession in δ
9. l = galactic longitude (formerly known as l^{II})
10. b = galactic latitude (formerly known as b^{II})
11. CPD number
12. a-e. Plate Codes

Further explanation of some columns in the catalogue:

Column 1 HD number. All stars in the Henry Draper Catalogue having δ_{1900} south of (and including) $-53°\ 00'$ 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 to be included in this and future volumes will be HD stars.

Column 2 Spectral type. A dagger in front of the type indicates that it is taken from another source. These classifications must not be confused with the "dagger types" discussed in section III. In each such case there is a remark in the back of the volume. For an explanation of spectral notation please read section III above.

Column 3a. If the spectral type given is an average from two or more plates (see last 4 columns, 12 b-e) then an A indicates this (see section III B).

3b. See section III B for a description of the Quality.

3c. See section V below for a description of the remarks codes.

Column 4 With a few exceptions the photographic magnitude is given exactly as it appears in the HD Catalogue. For the few stars whose magnitude is given to two decimal places, they are repeated in the present catalgue except when the second is a 0. On the magnetic tape of the HD Catalogue zeroes were added to all stars; it was impossible to retrieve the few actually having a meaningful 0 in the second decimal place in the HD Catalogue. A "V" after the magnitude indicates that the star is a known or suspected variable, and there is a remark in the back of the volume (see section V for details).

Column 7 Very near the south pole some of the precessions are larger than $-99^{m}.9$ and these are given in the remarks rather than in the table because of lack of space.

Column 12 a-e. Plate Code(s). Each plate has been assigned an identification code. By use of the table immediately below, knowing the plate code, the plate number and date can be obtained. These columns also serve to indicate the number of plates used in obtaining the average spectral type given.

Table 4

Code	Plate No.	Date	Code	Plate No.	Date	Code	Plate No.	Date
A	3245	Dec. 11/12, 68	AH	3301	Dec. 15/16, 68	BO	3298	Dec. 15/16, 68
B	5019	Aug. 12/13, 69	AI	3220	Dec. 8/9, 68	BP	3266	Dec. 12/13, 68
C	5020	Aug. 12/13, 69	AJ	7872	Jan. 27/28, 71	BQ	3299	Dec. 15/16, 68
D	3246	Dec. 11/12, 68	AK	3221	Dec. 8/9, 68	BR	3300	Dec. 15/16, 68
E	3268	Dec. 12/13, 68	AL	3529	Jan. 14/15, 69	BS	3253	Dec. 11/12, 68
F	3306	Dec. 16/17, 68	AM	8066	Feb. 22/23, 71	BT	9546	Sep. 22/23, 71
G	3307	Dec. 16/17, 68	AN	2211	May 21/22, 68	BU	5853	Feb. 3/4, 70
H	3291	Dec. 15/16, 68	AO	8067	Feb. 22/23, 71	BV	3304	Dec. 15/16, 68
I	3239	Dec. 10/11, 68	AP	7873	Jan. 27/28, 71	BW	3173	Nov. 29/30, 68
J	3263	Dec. 12/13, 68	AQ	3247	Dec. 11/12, 68	BX	3219	Dec. 8/9, 68
K	3252	Dec. 11/12, 68	AR	8071	Feb. 22/23, 71	BY	3296	Dec. 15/16, 68
L	5852	Feb. 3/4, 70	AS	3229	Dec. 9/10, 68	BZ	3163	Nov. 27/28, 68
M	3172	Nov. 29/30, 68	AT	7260	Aug. 28/29, 70	CA	5857	Feb. 3/4, 70
N	3297	Dec. 15/16, 68	AU	4607	June 16/17, 69	CB	3162	Nov. 27/28, 68
O	3149	Nov. 26/27, 68	AV	2470	June 20/21, 68	CC	3174	Nov. 29/30, 68
P	6109	Mar. 10/11, 70	AW	7266	Aug. 29/30, 70	CD	3161	Nov. 27/28, 68
Q	3267	Dec. 12/13, 68	AX	8379	Mar. 23/24, 71	CE	3160	Nov. 27/28, 68
R	3151	Nov. 26/27, 68	AY	7294	Aug. 31/Sep. 1, 70	CF	6112	Mar. 10/11, 70
S	6110	Mar. 10/11, 70	AZ	2144	May 18/19, 68	CG	3318	Dec. 16/17, 68
T	5851	Feb. 3/4, 70	BA	2208	May 21/22, 68	CH	3319	Dec. 16/17, 68
U	3302	Dec. 15/16, 68	BB	2283	May 28/29, 68	CI	2261	May 27/28, 68
V	5979	Feb. 12/13, 70	BC	3248	Dec. 11/12, 68	CJ	2210	May 21/22, 68
W	6111	Mar. 10/11, 70	BD	3249	Dec. 11/12, 68	CK	2418	June 4/5, 68
X	3241	Dec. 10/11, 68	BE	3262	Dec. 12/13, 68	CL	2419	June 4/5, 68
Y	3551	Jan. 15/16, 69	BF	3261	Dec. 12/13, 68	CM	2480	June 20/21, 68
Z	3531	Jan. 14/15, 69	BG	3222	Dec. 8/9, 68	CN	8019	Feb. 20/21, 71
AA	7874	Jan. 27/28, 71	BH	3260	Dec. 12/13, 68	CO	2250	May 24/25, 68
AB	2141	May 18/19, 68	BI	7269	Aug. 29/30, 70	CP	8064	Feb. 22/23, 71
AC	3264	Dec. 12/13, 68	BJ	7268	Aug. 29/30, 70	CQ	2251	May 24/25, 68
AD	3251	Dec. 11/12, 68	BK	10549	Mar. 15/16, 72	CR	2209	May 21/22, 68
AE	3265	Dec. 12/13, 68	BL	2559	July 3/4, 68	CS	2252	May 24/25, 68
AF	2260	May 27/28, 68	BM	3250	Dec. 11/12, 68	CT	8157	Feb. 28/Mar 1, 71
AG	3152	Nov. 26/27, 68	BN	7282	Aug. 30/31, 70	CU	2145	May 18/19, 68

Code	Plate No.	Date
CV	7259	Aug. 28/29, 70
CW	7267	Aug. 29/30, 70
CX	3240	Dec. 10/11, 68
CY	3242	Dec. 10/11, 68
CZ	3243	Dec. 10/11, 68
DA	3314	Dec. 16/17, 68
DB	3315	Dec. 16/17, 68
DC	4660	June 18/19, 69
DD	3332	Dec. 17/18, 68
DE	3333	Dec. 17/18, 68
DF	3550	Jan. 15/16, 69
DG	3150	Nov. 26/27, 68
DH	3530	Jan. 14/15, 69
DI	7885	Jan. 28/29, 71
DJ	8020	Feb. 20/21, 71
DK	5981	Feb. 12/13, 70
DL	7871	Jan. 27/28, 71
DM	3179	Nov. 30/Dec. 1, 68
DN	5970	Feb. 11/12, 70
DO	3592	Jan. 20/21, 69
DP	2142	May 18/19, 68
DQ	2483	June 21/22, 68
DR	8438	Mar. 27/28, 71
DS	2485	June 21/22, 68
DT	2484	June 21/22, 68
DU	2469	June 20/21, 68
DV	6101	Mar. 8/9, 70
DW	3295	Dec. 15/16, 68
DX	2146	May 18/19, 68
DY	2143	May 18/19, 68
DZ	8156	Feb. 28/Mar. 1, 71
EA	5860	Feb. 3/4, 70
EB	9726	Oct. 15/16, 71
EC	8099	Feb. 25/26, 71
ED	2486	June 21/22, 68
EE	8174	Mar. 1/2, 71
EF	8065	Feb. 22/23, 71
EG	8107	Feb. 25/26, 71
EH	8105	Feb. 25/26, 71
EI	8101	Feb. 25/26, 71
EJ	7907	Jan. 30/31, 71
EK	8108	Feb. 25/26, 71
EL	10467	Mar. 11/12, 72
EM	8159	Feb. 28/Mar. 1, 71
EN	8175	Mar. 1/2, 71
EO	8124	Feb. 26/27, 71
EP	2359	May 31/June 1, 68
EQ	11060	Apr. 23/24, 72
ER	2358	May 31/June 1, 68
ES	2556	July 3/4, 68
ET	4608	June 16/17, 69
EU	4609	June 16/17, 69
EV	2307	May 28/29, 68
EW	2360	May 31/June 1, 68
EX	2361	May 31/June 1, 68
EY	11587	Sep. 29/30, 72
EZ	4659	June 18/19, 69
FA	2558	July 3/4, 68
FB	2305	May 28/29, 68
FC	2481	June 20/21, 68
FD	8109	Feb. 25/26, 71
FE	2301	May 28/29, 68
FF	2279	May 27/28, 68
FG	2471	June 20/21, 68
FH	8160	Feb. 28/Mar. 1, 71
FI	2467	June 20/21, 68
FJ	3218	Dec. 8/9, 68
FK	8378	Mar. 23/24, 71
FL	13150	Apr. 25/26, 73
FM	3207	Dec. 7/8, 68
FN	9695	Oct. 13/14, 71
FO	11510	Sep. 10/11, 72
FP	3620	Jan. 22/23, 69
FQ	2102	May 15/16, 68
FR	8021	Feb. 20/21, 71
FS	8022	Feb. 20/21, 71
FT	3269	Dec. 12/13, 68
FU	10569	Mar. 16/17, 72
FV	8106	June 25/26, 71
FW	10551	Mar. 15/16, 72
FX	11495	Sep. 10/11, 72
FY	8068	Feb. 22/23, 71
FZ	13927	Sep. 30/Oct. 1, 73
GA	3208	Dec. 7/8, 68
GB	8069	Feb. 22/23, 71
GC	8070	Feb. 22/23, 71
GD	8176	Mar. 1/2, 71
GE	2468	June 20/21, 68
GF	2308	May 28/29, 68
GG	2309	May 28/29, 68
GH	13220	May 2/3, 73
GI	4599	June 16/17, 69
GJ	10498	Mar. 12/13, 72

Code	Plate No.	Date
GK	13221	May 2/3, 73
GL	8380	Mar. 23/24, 71
GM	8394	Mar. 24/25, 71
GN	8393	Mar. 24/25, 71
GO	4661	June 18/19, 69
GP	13389	May 23/24, 73
GQ	13253	May 4/5, 73
GR	13254	May 4/5, 73
GS	13255	May 4/5, 73
GT	2302	May 28/29, 68
GU	11529	Sep. 11/12, 72
GV	8395	Mar. 24/25, 73
GW	2472	June 20/21, 68
GX	9706	Oct. 14/15, 71
GY	2478	June 20/21, 68
GZ	2249	May 24/25, 68
HA	9728	Oct. 15/16, 71
HB	9707	Oct. 14/15, 71
HC	11505	Sep. 10/11, 72
HD	2213	May 21/22, 68
HE	9520	Sep. 21/22, 71
HF	11507	Sep. 10/11, 72
HG	11591	Sep. 29/30, 72
HH	2212	May 21/22, 68
HI	16505	Aug. 9/10, 74
HJ	11703	Oct. 10/11, 72
HK	2300	May 28/29, 68
HL	2354	May 31/June 1, 68
HM	2355	May 31/June 1, 68
HN	2356	May 31/June 1, 68
HO	2357	May 31/June 1, 68
HP	2336	May 29/30, 68
HQ	11503	Sep. 10/11, 72
HR	9542	Sep. 22/23, 71
HS	4600	June 16/17, 69
HT	2406	June 3/4, 68
HU	11706	Oct. 10/11, 72
HV	7281	Aug. 30/31, 70
3D	11725	Oct. 10/11, 72
3K	13928	Sep. 29/30, 73
3L	10475	Mar. 12/13, 72
3M	10458	Mar. 11/12, 72
3N	10531	Mar. 14/15, 72
3O	10532	Mar. 14/15, 72
3P	10453	Mar. 11/12, 72
3Q	10548	Mar. 15/16, 72
3R	10536	Mar. 14.15, 72
3S	10407	Mar. 9/10, 72
3U	10554	Mar. 16/17, 72
3V	10642	Mar. 18/19, 72
3W	10408	Mar. 9/10, 72
3Y	10457	Mar. 11/12, 72
3Z	10534	Mar. 14/15, 72
3AA	10410	Mar. 9/10, 72
3AB	10484	Mar. 12/13, 72
3AF	10490	Mar. 12/13, 72
3AG	10537	Mar. 14/15, 72
3AH	10586	Mar. 17/18, 72
3AJ	10461	Mar. 11/12, 72
3AL	10462	Mar. 11/12, 72
3AM	10422	Mar. 9/10, 72
3AO	10389	Mar. 7/8, 72
3AP	10409	Mar. 9/10, 72
3AR	10393	Mar. 7/8, 72
3AX	10395	Mar. 7/8, 72
3AZ	10492	Mar. 12/13, 72
3BA	10585	Mar. 16/17, 72
3BB	10611	Mar. 17/18, 72
3BP	10547	Mar. 15/16, 72
3BS	10474	Mar. 12/13, 72
3BU	10476	Mar. 12/13, 72
3BV	10477	Mar. 12/13, 72
3BW	10459	Mar. 11/12, 72
3BY	10546	Mar. 15/16, 72
3BZ	10481	Mar. 12/13, 72
3CA	10454	Mar. 11/12, 72
3CB	10480	Mar. 12/13, 72
3CC	10460	Mar. 11/12, 72
3CD	10479	Mar. 12/13, 72
3CE	10535	Mar. 14/15, 72
3CF	10455	Mar. 11/12, 72
3CG	10533	Mar. 14/15, 72
3CH	10538	Mar. 14/15, 72
3CI	10491	Mar. 12/13, 72
3CN	10485	Mar. 12/13, 72
3CP	10615	Mar. 17/18, 72
3CT	10525	Mar. 13/14, 72
3CU	10493	Mar. 12/13, 72
3DE	10588	Mar. 17/18, 72
3DF	10456	Mar. 11/12, 72
3DG	10555	Mar. 16/17, 72
3DH	10483	Mar. 12/13, 72
3DJ	10486	Mar. 12/13, 72

Code	Plate No.	Date
3DK	10517	Mar. 13/14, 72
3DM	10556	Mar. 16/17, 72
3DO	10610	Mar. 17/18, 72
3DP	10522	Mar. 13/14, 72
3DQ	10518	Mar. 13/14, 72
3DS	10519	Mar. 13/14, 72
3DT	10571	Mar. 16/17, 72
3DU	10521	Mar. 13/14, 72
3DY	10523	Mar. 13/14, 72
3DZ	10524	Mar. 13/14, 72
3EA	10411	Mar. 9/10, 72
3EC	10412	Mar. 9/10, 72
3ED	10520	Mar. 13/14, 72
3EE	10578	Mar. 16/17, 72
3EF	10616	Mar. 17/18, 72
3EG	10617	Mar. 17/18, 72
3EI	10413	Mar. 9/10, 72
3EK	10573	Mar. 16/17, 72
3EM	10631	Mar. 17/18, 72
3EN	10576	Mar. 16/17, 72
3FD	10574	Mar. 16/17, 72
3FH	10576	Mar. 16/17, 72
3FI	10630	Mar. 17/18, 72
3FK	10394	Mar. 7/8, 72
3FL	10482	Mar. 12/13, 72
3FP	10612	Mar. 17/18, 72
3FQ	10613	Mar. 17/18, 72
3FR	10414	Mar. 9/10, 72
3FS	10421	Mar. 9/10, 72
3FT	10478	Mar. 12/13, 72
3FU	10570	Mar. 16/17, 72
3FV	10614	Mar. 17/18, 72
3FY	10390	Mar. 7/8, 72
3GB	10391	Mar. 7/8, 72
3GC	10392	Mar. 7/8, 72
3GD	10579	Mar. 16/17, 72
3GE	10634	Mar. 17/18, 72
3GH	10583	Mar. 16/17, 72
3GI	10584	Mar. 16/17, 72
3GJ	10632	Mar. 17/18, 72
3GK	10398	Mar. 7/8, 72
3GM	10581	Mar. 16/17, 72
3GN	10580	Mar. 16/17, 72
3GP	10572	Mar. 16/17, 72
3GV	10397	Mar. 7/8, 72
3GW	11054	April 23/24, 72
3GY	11059	April 23/24, 72
3GZ	10633	Mar. 17/18, 72
3HS	10582	Mar. 16/17, 72
4A	11724	Oct. 10/11, 72
4B	16542	Aug. 10/11, 74
4C	16479	Aug. 7/8, 74
4E	11748	Oct. 13/14, 72
4F	16480	Aug. 7/8, 74
4G	16481	Aug. 7/8, 74
4H	16543	Aug. 10/11, 74
4I	11727	Oct. 10/11, 72
4J	11762	Oct. 14/15, 72
4K	11770	Oct. 14/15, 72
4R	12086	Dec. 10/11, 72
4T	11624	Oct. 2/3, 72
4X	11621	Oct. 2/3, 72
4AC	11763	Oct. 14/15, 72
4AD	11769	Oct. 14/15, 72
4AE	11747	Oct. 13/14, 72
4AI	13924	Sep. 30/31, 73
4AK	11744	Oct. 13/14, 72
4AN	16488	Aug. 8/9, 74
4AQ	11726	Oct. 10/11, 72
4AS	13922	Sep. 30/31, 73
4AT	11723	Oct. 10/11, 72
4AU	11578	Sep. 29/30, 72
4AV	16485	Aug. 8/9, 74
4AW	11707	Oct. 10/11, 72
4AY	11704	Oct. 10/11, 72
4BC	16482	Aug. 7/8, 74
4BD	11767	Oct. 14/15, 72
4BE	11761	Oct. 14/15, 72
4BF	11745	Oct. 13/14, 72
4BG	11746	Oct. 13/14, 72
4BH	16540	Aug. 10/11, 74
4BI	16539	Aug. 10/11, 74
4BJ	16541	Aug. 10/11, 74
4BK	13516	May 31/June 1, 73
4BL	16538	Aug. 10/11, 74
4BM	11768	Oct. 14/15, 72
4BN	11542	Sep. 11/12, 72
4BO	11764	Oct. 14/15, 72
4BQ	11765	Oct. 14/15, 72
4BR	11766	Oct. 14/15, 72
4BT	11512	Sep. 10/11, 72
4BX	11730	Oct. 10.11, 72
4CE	12085	Dec. 10/11, 72
4CH	13397	May 23/24, 73
4CJ	16487	Aug. 8/9, 74
4CK	11574	Sep. 29/30, 72
4CL	11498	Sep. 10/11, 72
4CM	16492	Aug. 8/9, 74
4CO	13243	May 3/4, 73
4CQ	16490	Aug. 8/9, 74
4CR	16486	Aug. 8/9, 74
4CS	11575	Sep. 29/30, 72

Code	Plate No.	Date
4CV	16478	Aug. 7/8, 74
4CW	11708	Oct. 10/11, 72
4CX	11728	Oct. 10/11, 72
4CY	11622	Sep. 29/30, 72
4CZ	11623	Sep. 29/30, 72
4DA	12080	Dec. 10/11, 72
4DB	12082	Dec. 10.11, 72
4DC	11588	Sep. 29/30, 72
4DD	12083	Dec. 10/11, 72
4DI	12077	Dec. 10/11, 72
4DN	13363	May 21/22, 73
4DR	13515	May 31/ June 1, 73
4DV	13301	May 8/9, 73
4DX	15961	Mar. 4/5, 74
4EB	13303	May 8/9, 73
4EH	13134	April 24/25, 73
4EJ	11742	Oct. 13/14, 72
4EO	13139	April 24/25, 73
4EP	11579	Sep. 29/30, 72
4EQ	16491	Aug. 8/9, 74
4ER	11533	Sep. 11/12, 72
4ES	11534	Sep. 11/12, 72
4ET	11580	Sep. 29/30, 72
4EU	16514	Aug. 9/10, 74
4EV	13931	Oct. 1/2, 73
4EW	11582	Sep. 29/30, 72
4EX	16513	Aug. 9/10, 74
4EY	11586	Sep. 29/30, 72
4FA	11538	Sep. 11/12, 72
4FB	11576	Sep. 29/30, 72
4FC	11500	Sep. 10/11, 72
4FE	13257	May 4/5, 73
4FF	16494	Aug. 8/9, 74
4FG	13241	May 2/3, 73
4FJ	11729	Oct. 10/11, 72
4FN	11739	Oct. 13/14, 72
4FO	11509	Sep. 10/11, 72
4FW	16484	Aug. 8/9, 74
4FX	11494	Sep. 10/11, 72
4GF	11584	Sep. 29/30, 72
4GG	11585	Sep. 29/30, 72
4GL	13188	April 27/28, 73
4GO	11589	Sep. 29/30, 72
4GQ	16502	Aug. 9/10, 74
4GR	16503	Aug. 9/10, 74
4GS	16493	Aug. 8/9, 74
4GT	13332	May 10/11, 73
4GU	11528	Sep. 11/12, 72
4GX	11462	Sep. 9/10, 72
4HA	11501	Sep. 10/11, 72
4HB	13497	May 30/31, 73
4HC	11504	Sep. 10/11, 72
4HD	13329	May 10/11, 73
4HE	11535	Sep. 11/12, 72
4HF	11506	Sep. 10/11, 72
4HG	13932	Oct. 1/2, 73
4HH	13191	April 27/28, 73
4HI	13330	May 10/11, 73
4HJ	11702	Oct. 10/11, 72
4HK	13331	May 10/11, 73
4HL	11697	Oct. 10/11, 72
4HM	11698	Oct. 10/11, 72
4HN	11699	Oct. 10/11, 72
4HO	11700	Oct. 10/11, 72
4HP	11701	Oct. 10/11, 72
4HQ	11502	Sep. 10/11, 72
4HR	11530	Sep. 11/12, 72
4HT	11530	Sep. 11/12, 72
4HU	11705	Oct. 10/11, 72
4HV	11590	Sep. 29/30, 72
5EU	13549	June 1/2, 1973
5EX	13911	Sep. 30/31, 73
5FP	3621	Jan. 22/23, 69
5FW	13519	May 31/ June 1, 73
5GT	16489	Aug. 8/9, 74
6FO	11740	Oct. 13/14, 72
8GI	2272	May 27/28, 68
9AJ	3516	Jan. 13/14, 69
9AU	2303	May 28/29, 68
9BN	11543	Sep. 11/12, 72
9CW	999	Oct. 23/24, 67
9EJ	11731	Oct. 10/11, 72
9EM	82	May 15/16, 67
9ET	2280	May 27/28, 68
9EU	2281	May 27/28, 68
9FL	3515	Jan. 13/14, 69
9GI	2224	May 23/24, 68
9GN	8261	Mar. 7/8, 71
9HI	2299	May 28/29, 68
9HN	2335	May 29/30, 68
9HR	9711	Oct. 14/15, 71
9HS	2226	May 22/23, 68

V. *Description of Remarks*

Further information about 4636 stars is given in the back of the catalogue, starting on p. 407. To aid the user in deciding whether to consult the remarks for a particular star, the following notation is used in Column 3c of the catalogue:

B indicates that the remark contains the HR (Bright Star Catalogue) number and the Bayer or Flamsteed designations where applicable. In a very few (<10) cases other numerical Flamsteed-like designations were inadvertently included.

L indicates that information from the astronomical literature is given. In most cases individual literature references are not given: references systematically searched for HD stars south of $\delta = -53°$ (by APC) are listed at the end of this section. Remarks were generally restricted to those relevant to the spectral appearance, such as rotation, variability, and duplicity, and generally have included only information about the star which might affect the spectral classification. Visual double stars noted in the HD catalogue whose duplicity was not detected during the spectral classification are included under the 'L' remarks, but visual doubles from other sources are not listed.

O includes remarks that do not fit into any other category. Almost all of these are NGC or IC designations for nebulae and CoD nos. or a note that there is no CPD or CoD number. Most such remarks plus some in other categories are taken from the Henry Draper Catalogue. Corrections of previously undiscovered errors in positions and other information in the HD catalogue which we found have also been listed as O remarks.

R Nearly half of the stars in the remarks table have remarks of this type. With the exception of one group described below, all 'R' remarks were written by NH in the course of the spectral classification and all are related in some way to the spectrum. Most of the symbols and notation are self-explanatory, but note that "yld." was used for yields and yield (followed by a temperature or luminosity type) since an arrow or an implies sign was not available. Note also that in quotations the close quote sign is the same as the open quote sign, and hence faces the wrong direction. We discuss some of the more frequent types of 'R' remarks, in order of frequency of occurrence.

In nearly 400 cases the fact that the star was visually double was deduced from the appearance of the spectrum (fuzzy, double-lined, or closely overlapped) and the following data were listed (taken from Lick Publ. **21**, 1963, unless otherwise noted): 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.

Over 300 stars in the catalogue have composite spectra or possibly composite spectra and each of these has a remark so that they can be easily differentiated from known double stars which also sometimes have two types listed in the catalogue.

Remarks are made for all stars (≅250) 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 ≅175 do. Similarly some 80 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 130 of the 'R' remarks pertain to fuzzy or closely overlapped spectra some of which are probably new visual or spectroscopic doubles.

Almost all of the ≅125 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.

About 80 stars of widely different spectral types have 'R' remarks because the various spectral line ratios indicate discrepant temperature or luminosity types and it was not possible to arrive at a consistent type. Some of these are certainly due to the composite or closely double nature of the stars, while others reflect abundance anomalies. Still others may be caused by overlapping spectra or emulsion defects.

Other smaller categories of 'R' remarks include: ≅50 substantial disagreements with the HD catalogue, mainly with respect to spectral types; ≅35 possible Fm δ Del types; ≅30 stars with strong CH—these are not indicated in the catalogue spectral types.

The only 'R' remarks not written during the classification were those giving unpublished spectral types by Garrison and Hagen in cases where a spectral type (listed in the catalogue) was also obtained from Michigan plates. The additional type is given in the remarks because in many cases the Michigan spectrum was quite overexposed. It also provides an opportunity for those interested to compare the results.

V All variables and suspected variables are indicated by a 'V' after the magnitude. Each has a remark in the back of the catalogue giving variable star designation, type of variability, 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. All but 100 were taken from the HD Catalogue. In the case of types taken from the catalogues by Jaschek *et al.* (1964) and by Kennedy and Buscombe (1974) the above are quoted rather than the original reference in these catalogues. MK types for stars brighter than $4^{m}.75$ not included in the paper by Hiltner, Garrison, and Schild referenced below have been kindly provided by R. F. Garrison and Gretchen L. Hagen Harris in advance of publication. Although the types are preliminary, they are on a more homogeneous system than any others available. References marked with a dagger below were used as sources for spectral types. Stars which were too faint to classify on Michigan plates were not searched for in the dagger references, since chances of them being found were small. Instead the HD type was given. Note that in the remarks the reference to Hiltner, Garrison, and Schild (1969) is incorrectly given as Hiltner, Schild, and Garrison.

References

L = reference for 'L' remarks
V = reference for 'V' remarks
† = reference for '†' remarks

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IEF285I    SYS2.FORTLIB                                        KEPT
IEF285I    VOL SER NOS= K3SYS2.
IEF285I    SYS1.PL1LIB                                         KEPT
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IEF285I    SYS1.FORTSSP                                        KEPT
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IEF285I    SYS2.COBLIB                                         KEPT
IEF285I    VOL SER NOS= K3SYS6.
IEF285I    SYS1.ALGLIB                                         KEPT
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      XXFT06F001 DD  SYSOUT=&OUT,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=&BLKSIZE)        00000250
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      //
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IEF237I 232    ALLOCATED TO PGM=*.DD
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IEF237I 232    ALLOCATED TO FT06F001
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IEF237I 331    ALLOCATED TO SYSPRINT
IEF237I 231    ALLOCATED TO SYSPRINT
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364 RECORDS IN FILE 1 OF TAPE

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RECORD 1 OF FILE 2
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RECORD 232 OF FILE 2
LENGTH = 6400 BYTES

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                         232 RECORDS IN FILE   2 OF TAPE

IEF142I - STEP WAS EXECUTED - COND CODE 0000
IEF285I   SYS75272.T080533.RV000.YZJRJDA2.LODMOD         PASSED
IEF285I   VOL SER NOS= K3SCR3.
IEF285I   SYS75272.T080533.RV000.YZJRJDA2.S0001195       SYSIN
IEF285I   VOL SER NOS= K3SCR4.
IEF285I   SYS75272.T080533.RV000.YZJRJDA2.S0001195       DELETED
IEF285I   VOL SER NOS= K3SCR4.
IEF285I   SYS75272.T080533.SV000.YZJRJDA2.R0001191       SYSOUT
IEF285I   VOL SER NOS= K3SCR3.
IEF285I   SYS75272.T080533.SV000.YZJRJDA2.R0001192       DELETED
IEF285I   VOL SER NOS= K3SCR3.
IEF285I   SYS75272.T080533.SV000.YZJRJDA2.R0001193       DELETED
IEF285I   VOL SER NOS= K3SCR4.
IEF285I   SYS75272.T080533.RV000.YZJRJDA2.R0001194       KEPT
IEF285I   VOL SER NOS= JJC085.
IEF280E K 0D5,JJC085,YZJRJDA2,GO
IEF373I STEP /GO      / START 75272.1939
IEF374I STEP /GO      / STOP  75272.1944 CPU    0MIN 13.40SEC MAIN 186K LCS    0K
 - STEP 03 -      RETURN CODE = 0000                               STEP TIME =      .51 MINS=(CPU=      .22,IO=      .29)
                                  IO IN SECS: DISK=    4.80,DRUM=      .48,TAPE=   12.13,CELL=      .00,OTHR=      .13
IEF285I   SYS75272.T080533.RV000.YZJRJDA2.LODMOD         DELETED
IEF285I   VOL SER NOS= K3SCR3.
IEF375I  JOB /YZJRJDA2/ START 75272.1933
```