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New and Suspected Variable Stars in VSF 193

Abstract. - Identification charts and tables are given for 275 variable or suspected variable stars in Sagittarius, together with a summary of the work thus far accomplished in VSF 193.

Nearly forty years ago at Harvard College Observatory I discovered or re-discovered over 500 variable stars in VSF 193, centered at 18^h23^m -23°.3 in Sagittarius. The positive-negative superposition method for discovery was used. Each of eleven plates of the MF series (ten-inch Metcalf refractor, f.l. 45 in.) was compared with one of four positives, and five plates of the A series (24-inch Bruce refractor, f.l. 135 in.) with one positive. Before the examination of the variable stars had progressed far, Dr. Shapley discontinued the project, and my brief resumé of what had been accomplished was incorporated into the Shapley and Swope (1934) report on variable stars in low galactic latitudes. Many years then elapsed before the work was resumed, mainly during the summers since 1957 at the Maria Mitchell Observatory with the help of young women college undergraduates whose trainee program was supported largely by successive grants from the National Science Foundation. Results to date on periods or types of variability have been published in the following sources:

Year	Reference				Number of Variables
1932	Bull. No. 890, Harvard Col. Obs., p. 13				1 nova
1934	Annals, Harvard Col. Obs.,Vol. 90, p. 187				18
1955	Astron. J. Vol. 60, p. 259 (Dishong & Hoffleit)				1 nova
1957		62	120		65
1958		63	78		20
1958		63	511	(Andersen)	1 nova
1959		64	241		6
1959		64	417		41
1960		65	100		20
1961		66	188		45
1962		67	228		12
1963		68	207		27
1963		68	253	(Houk)	1
1964		69	301		15
1965		70	307		24
1966		71	130		11
1967		72	711		12
1968	I.A.U. Info. Bull. on Variable Stars No. 254				1
1968				277	10
1968				312	8
1969				387	12

Year	Reference		Number of Variables
1969	I.A.U. Info. Bull. on Variable Stars No.	395(Akyuz)	1
1970		474	1
1971		592	3
1972		617	6

In addition, in 1967 in Information Bulletins 228 and 231 Dr. Nancy Houk has given spectral classes of 137 of the previously published red variable stars.

The total number of variable stars already published in this survey is 360. All of the remaining variables or suspected variables found in VSF 193 are listed in Table I.* Finder charts are given for all of these. Included are stars from the above references published since 1964, and a few other variable stars that happen to occur on the same charts as the new variables. The charts were traced by Ruthe Seifart from the enlarged projections of MF plates. The original scale of the plates is 167"/mm while the charts represent areas approximately 10' x 10'. In all cases South is at the top and East to the right.

In Table I the first column gives the number of the chart. If more than one variable is marked on a chart, the letters a, b, etc., are assigned in order of increasing right ascension. The magnitudes given depend in most cases upon 200 to 500 plates, although in a few instances only some 20 plates of the A series were usable for stars

* See p. 18 ff.

with bothersome optical companions, very faint stars, or stars close to the edges of the field.

The late-type spectral classes were estimated on infra-red objective prism plates of the Warner and Swasey Observatory (Case-Western Reserve). Those underlined were estimated by myself; the others by Nancy Houk who classified all of the red stars with maxima 14.5 mag. pg. or brighter in a selected 20 square degree area. In a few instances these late spectral types may refer to a companion star instead of the variable. For five of the variables subsequently determined to be RR Lyrae type, spectral class M had orginally been assigned. In two of these instances the Bruce plates revealed the faint red companion.

Three suspected variables of small amplitude were at the time of discovery supposed to be red stars by virtue of their somewhat more fuzzy appearance than the images of the comparison stars on blue-sensitive plates. Eventually a check on the objective prism plates for the Henry Draper Extension revealed that all three are planetary nebulae. On re-examination of the direct plates, I would still suspect these stars of slight variability, but this may be a spurious photographic effect. The only similar instance found in the General Catalogue of Variable Stars is for V567 Sgr, found by Swope (1938) on similar Harvard plates. While she found a variation of about one magnitude, the General Catalogue indicates that the object is non-variable (cst). Herbig (1950) found no evidence for either spectral, radial velocity or light variation and therefore inferred that the Harvard observations may represent only instrumental effects. Liller and Shao at Harvard are obtaining UBV magnitudes of nuclear stars of planetary nebulae, a few of which are being especially watched because they have been suspected of variability.

Among the stars in Table I unclassified as to types of variability, 83 appear to have M-type spectra. The majority of these have small amplitudes which may, however, be affected by companions. Since a high percentage of stars with late type spectra is expected to be variable (Houk 1967), these merit further investigation with higher resolution.

The next to last column in Table I gives one of three types of entries: the final designation of already named variables; the reference to a previous publication for published variables not yet listed in either the General Catalogue, or the Catalogue of Suspected Variable Stars; or, for the heretofore unpublished variable stars, code letters indicating the observers who estimated the magnitudes. Footnotes to the Table identify the observers and give the years in which they participated in the project, and the colleges from which the summer student assistants came.

In the final column, an asterisk refers to a separate footnote, while the letter c indicates that the star appears to have an optical companion which might affect the magnitude estimates. Close companions are prevalent in this crowded field. Among the more than 500 variable stars examined, 168, or nearly a third, have companions noted either on the limited number of available Bruce plates, which have the more open scale of 60"/mm, or they were inferred from the small amplitudes and flat apparent minima of the light curves found for Mira-type stars. Undoubtedly 33% is only a lower limit to the percentage of variables somewhat affected by unresolved companions.

The distribution of the variable stars according to the type of variability and apparent magnitude at maximum is shown in Table II. The stars of undetermined type are separated into two categories: those known to have late spectral classes, and all others. Both groups are then sorted according to amplitude of apparent variation. Table II includes five variables discovered in this survey but not included in Table I because they have meanwhile been independently discovered and published elsewhere (V 1176, 1182, 1187, and 1601 Sgr).

In the groups with apparent amplitudes less than 0.5 mag. the variability has, of course, in every case been questioned. In all such cases more than one observer has conceded the probality of variation on the plates examined.

Table II indicates that the maximum frequency of the variables of all types is close to magnitude 14.0 at maximum light. This is more indicative of the optimum magnitudes for discovery on the MF plates, than of cosmical significance.

For other than the long period variables and high-amplitude semi-regular stars, the numbers discovered in each category have been too few to warrant analyses for the completeness of discovery.

Table II. Distribution by Type and Magnitude at Maximum

Magnitude:	10	11	12	13	14	15		Total
Type Var.								
M			3	19	99	70	12	203
SR			2	6	28	32	5	73
RV				3	3	3		9
L			1	3	9	1		14
C	4	1	1	5	3	4		18
RR			1	4	14	21	5	45
UV				1				1
UG			1	0	1	4		6
RCB		1	1	1	1			4
I				7	10	13		30
N	6	3						9
E	5	1	4	7	14	13		44
Total Classified	15	6	14	56	182	161	22	456
Unclassified:								
M-Type Spectrum								
AMPLITUDE								
< 0.5					5			5
0.5 - 1.0			3	6	17	24	3	53
1.0 - 1.5			1	1	6	5		13
1.5 - 2.0				1	1			2
> 2.0					2			2
Total			4	8	31	29	3	75
Not M-Type Sp.								
0.5 - 1.0			1	2	11	9	4	27
1.0 - 1.5				1	2	9		12
1.5 - 2.0					1	2	2	5
> 2.0					3	1		4
Total			1	3	17	21	6	48
GRAND TOTAL	15	6	19	66	230	210	31	579

Even for these the estimates are not very meaningful except for indicating the feasibility of continuing the search on the available plate material. For the discovery of the long period variables, only three pairs of the MF plates used can be considered both as "independent" and with time intervals sufficiently long for the detection of variables of these types (Table III).

Table III. Independent Pairs for the Detection of Long Period Variables.

Pair	Date of positive	Date of Negative	Interval
1	5 September 1925	21 August 1928	3 years
2	25 August 1924	28 April 1930	6
3	30 August 1929	10 June 1931	2

The numbers of long period variables found once, twice and three times among these three pairs are given as a_i in Table IV, where A represents the total number of such variables found on the three pairs of plates, w is the probability of discovering a variable once, and N is the total number of variables inferred from these data. These values are based upon the method published by van Gent (1933). Under "MF" are the numbers actually found on all of the MF plates intercompared (11 interdependent pairs) and under "All" the total numbers found on both MF and A plates. The A-plates, however, cover only about half of the area of the MF. The values N are ostensibly the number one would expect to find from an exhaustive search of the particular type of MF plate material used. The MF plates actually searched would thus appear to have revealed about three-fourths the expected numbers. But with the better Bruce A-plates considerably more are discernable. The discovery probabilities appear to decrease with fainter magnitudes. This is to be expected from the greater uncertainty in identifying faint blended images in crowded regions as those of long period variables.

Table IV. Discovery of Long Period Variables.

Mag. at Maximum	A	a_1	a_2	a_3	w	N	MF	All	%MF
12-13	14	8	4	2	0.24	25	17	24	68
13-14	38	33	4	1	.14	105	87	121	83
14-15	19	18	1	0	.07	95	67	88	70
Total	71	59	9	3	-	225	167	233	74

That there is no obvious correlation between period and magnitude at maximum for the long period variable stars found in this region is shown in Figure 1. The maximum concentration appears to be near a period of 240 days and magnitude 13.8. If there were no obscuration and the Wilson-Merrill (1942) period-luminosity relation were to hold, this would indicate a maximum concentration of these stars at about 7 kpc - an upper limit to their mean distance since many of the magnitudes must be appreciably affected by obscuration.

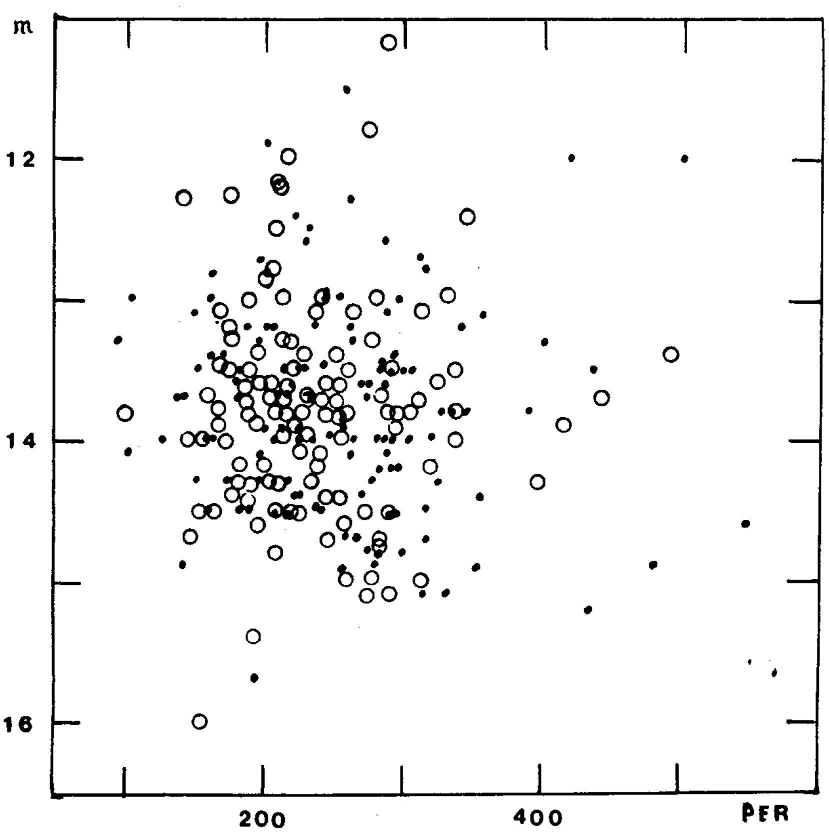


FIGURE 1

(Open circles for stars in the less obscured regions).

The distributions by period and uncorrected distance are shown in Table V. Here the zigzag line indicates the approximate limiting distances for detecting variables 14.5 mag. at maximum. On the Nantucket plates this is effectively the limiting magnitude for the recognition of variables as belonging to the Mira type. At the mean galactic latitude of the region, $-7\overset{\circ}{.}5$, the stars in the more transparent regions and having periods less than 200 days can be seen to distances beyond the galactic center. On the other hand, very few long period variables have been found out to be 3 kpc, the practical limit for the discovery of the less luminous stars with periods of 400 days or more.

The long period variables have been sorted into two categories according to the relative overall appearance of obscuring matter in their immediate surroundings. If the variables were uniformly distributed in space we would expect for each period an approximately three-fold increase in their numbers with increasing magnitude. The small numbers of stars for magnitudes brighter than 13, compared with those 13-14 mag. (Table VI) confirm that the density is not constant but increases appreciably as we approach the galactic center. Already at 14-15 mag., however, the numbers level off, mainly because of observational selection effects. The faint limiting magnitude of this survey is still too bright for extinction effects to be clearly indicated (as in Wolf-diagrams) by differences in magnitude-frequency distributions between the obscured and relatively clear regions.

Table V. Frequencies of Periods and Distances.

kpc		200	250	300	350	400	450	500^{d}	Total
1	0	0	2	1	0	1	1	1	6
2	1	0	3	4	2	3	0	0	13
3	0	6	8	8	2	1	1	1	27
4	0	7	16	7	1	1			32
5	2	9	16	3					30
6	3	15	10	4					32
7	7	14	5	1					27
8	6	9	4						19
9	8	6	3						17
10	5	5							10
11	5	3							8
12	6	0							6
13	4	1							5
14	2								2
15	1								1
16									
Total	50	75	67	28	5	6	2	2	235

Table VI. Period-Magnitude Distributions.

Period	*	Mag: 12	13	14	15	16	Total
150-200	C	0	1	16	10	1	28
	O	0	2	11	9	1	23
200-250	C	0	6	20	15	0	41
	O	1	4	16	13	0	34
250-300	C	2	0	17	7	4	30
	O	1	2	17	17	1	38
300-350	C	0	1	7	2	1	11
	O	0	2	6	6	2	16
> 350	C	0	0	3	1	0	4
	O	0	2	3	6	1	12
Totals	C	2	8	63	35	6	114
	O	2	12	53	51	5	123
	O+C	4	20	116	86	11	237

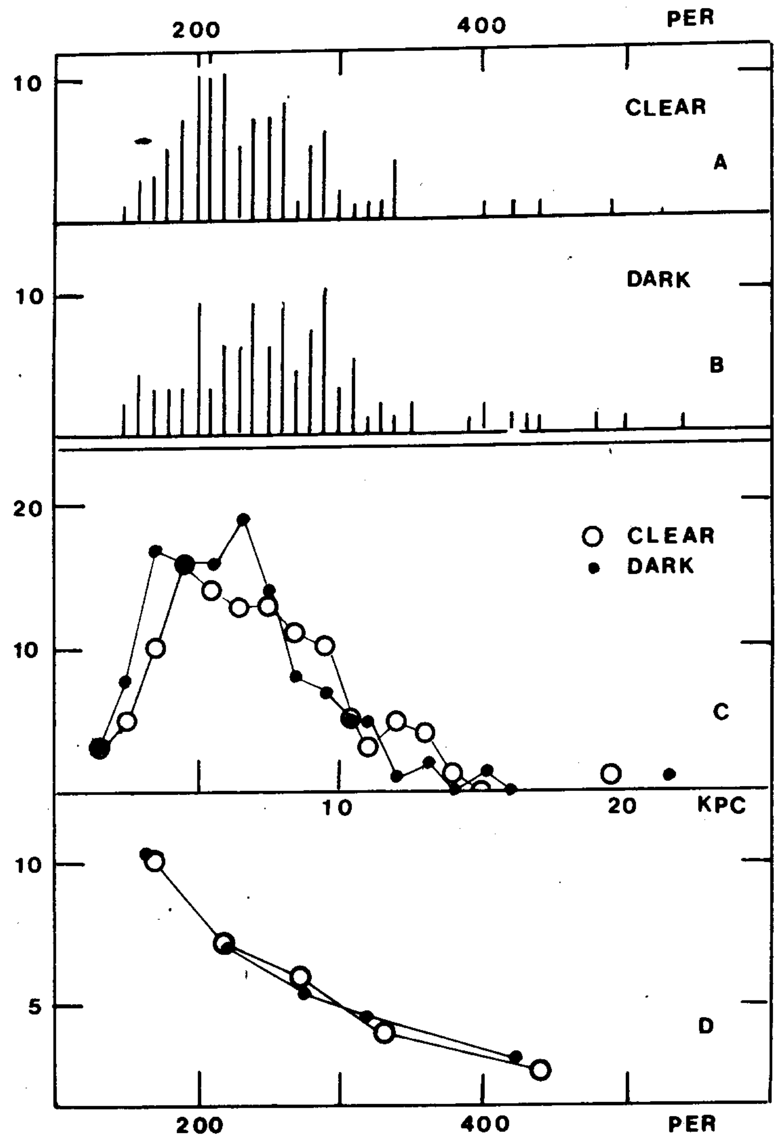
*O, obscured; C, clear

Table VII compares the average apparent magnitudes, periods and distances in three magnitude groups. Here $\overline{kpc}$ refers to the average of the distances whereas kpc($\bar{P}$) is the distance corresponding to the average period. The discordance between these values is an indicator for the dispersion in the distances, which range from 2 to 15 kpc. The difference between the mean distances of the obscured and relatively clear regions reflect mainly the differences in average period-length.

Table VII. Average Parameters in Three Magnitude-Intervals.

Mag. Interval:	12-13		13-14		14-15	
	Clear	Obscured	Clear	Obscured	Clear	Obscured
n	8	12	64	58	37	54
$\bar{m}$	12.4	12.5	13.5	13.5	14.3	14.3
$\bar{P}$	222	278	246	241	227	259
$\overline{kpc}$	4.2	3.8	6.0	5.6	9.4	7.6
kpc($\bar{P}$)	3.8	2.7	5.3	5.4	8.9	7.1

The frequency distributions by period are shown in Figures 2a (clear regions) and 2b (more obscured), while Figure 2c shows the frequencies of the uncorrected distances. The stars in the same line of sight as the dark nebulosities have an apparent average distance of 6.2 $\pm$ 2.0 kpc, not significantly different from the average of 7.1 $\pm$ 2.1 for the stars in the more transparent looking regions. Two compensating effects may account for this coincidence. In the more obscured regions one would expect the distances uncorrected for absorption to appear greater than in transparent regions. On the other hand, many of the actually more distant stars in the dark regions are too much obscured to be seen at all; whence the average distances in the obscured regions refer to a group of stars more nearby than those in the clear regions. Moreover, the separation of the two groups may not be sufficiently definitive. Although approximately equal numbers of stars are represented, it is



200
400
PER
10
CLEAR
A
10
DARK
B
20
CLEAR
DARK
10
C
10
20
KPC
10
5
D
200
400
PER

FIGURE 2

significant that the relatively transparent areas occupy less than one-third of the total area of the field. The variables ascribed to obscured regions frequent mainly the dimmed boundaries between the clear regions and the lanes of densest obscuration, generally avoiding the darkest parts of the lanes altogether. The entire field is very complex in appearance.

When the stars are sorted by period (Table VIII and Figure 2d) the average distances in the two groups again show no significant differences. The relatively nearby stars of longer period dubiously suggest that the obscured average more distant by 0.5 kpc, corresponding to an extinction of 0.3 mag. The stars at these distances are on the order of half a kiloparsec below the galactic plane. The more distant stars are farther below the plane (Z in Table VIII) and would therefore be affected by little additional absorption; but they would be expected to confirm at least the absorption found at shorter distances, if real.

Table VIII. Average Parameters for Equal Intervals in Period.

	Relatively Clear					More Obscured				
Interval days	n	$\bar{P}$	$\bar{m}$	$\overline{kpc}$	Z	n	$\bar{P}$	$\bar{m}$	$\overline{kpc}$	Z
150-200	28	181	13.8	10.2±.5	1.3	23	176	13.8	10.4±.5	1.4
200-250	41	223	13.7	7.2±.2	0.9	34	224	13.6	7.1±.2	0.9
250-300	30	272	13.9	5.8±.3	0.8	38	276	13.8	5.2±.2	0.7
300-350	11	330	13.8	3.9±.3	0.5	16	319	14.0	4.5±.3	0.6
>350	4	438	13.8	2.6±.2	0.3	12	422	13.9	3.1±.3	0.4

Future work in this region should stress the importance of obtaining accurate magnitudes of the variable stars in different colors, for the purpose of evaluating extinction.

My associates and I have been deeply indebted to the U.S. National Science Foundation under whose support the major part of this investigation has been accomplished. I wish also to express thanks to Ruthe Seifart for her meticulous preparation of the identification charts.

Dorrit Hoffleit
Maria Mitchell Observatory
Nantucket, Mass., U.S.A.

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Table I. Variables and Suspected Variables in VSF 193.

Var.	R.A. (1900)			Dec.		Max.	Min.	Type	Sp.	Obs.# Ident.	R*
1	18^h	7^m	4^s	-26°	33'.8	11.9	12.4		M5	A,Ro	
2		7	50	-27	2.0	12.5	13.7	I?	M5:	Ku,T	
3		8	30	-23	59.8	13.3	14.2		M5:	A,Le	
4		8	46	-18	56.7	13.4	14.4	SR?	M7	A,H,W,	*
5		9	30	-19	41.4	13.7	15.8	RV?		A,BC	
6		10	14	-27	39.0	14.6	15.5		M2:	Ho	*
7		10	23	-27	3.5	13.8	15.0		M3:	Ho	
8		10	24	-18	54.2	14.8	15.4			BC	
9		10	45	-21	24.8	15.2	15.9			Sa	c
10		11	0	-24	0.0	14.5	16.2	SRa		V2331	
11		11	9	-21	30.2	14.3	14.8			A,H	
12		11	21	-26	29.6	14.0	14.8		M5	Ro	
13		11	22	-25	57.0	13.5	15.5	SR	M:	T	*
14		11	29	-27	51.7	11.1	12.1	SRa	M2	V2513	
15		11	48	-26	34.9	15.0	15.8		M:	A,W	
16		12	36	-23	58.8	14.8	16.2			A,Ki	*
17		12	52	-27	34.8	14.5	16.2	M	M5	V2520	c
18		12	59	-24	39.7	14.2	15.5		M7	T,P	*
19		13	7	-25	44.4	13.5:	14.0:		M8:	T,P	*
20		13	24	-26	19.0	14.7	15.8		M4:	P	
21		13	25	-24	56.2	12.7	13.5		M4	P,Do	
22		13	34	-23	49.9	14.0	14.5		M6	A,T	
23		13	37	-23	19.0	12.6	13.3	I	M5	V2333	
24		13	46	-23	56.9	14.5	16.0	SR	M8:	V2524	
25		13	48	-26	43.5	14.0	15.4	RR		P,W	*
26		13	49	-23	31.5	14.5	15.2	E?	M:	H	
27		13	50	-18	57.2	13.6	14.3	RR		BC	
28a		13	55	-22	15.4	13.8	16.0	EA		V2525	
28b		13	56	-22	10.0	12.4	13.0	E?	M6:	Jo,Se	
29		13	56	-23	53.6	14.3	15.4	I?	M5:	A,L	
30		14	2	-22	58.2	13.6	[15.0	EA		V2527	
31		14	8	-23	23.1	12.8	13.8	I?	M7	Z	
32		14	8	-27	19.4	14.3	15.0			A,Se	
33		14	16	-28	5.6	14.3	14.9			A,Se	c
34		14	18	-23	59.4	14.9	[15.6		M	A,Ki	
35		15	9	-23	8.4	14.3	16.3	SRa	M:	V2534	*
36		15	23	-23	56.2	14.7	15.7		M7	A,Ki	
37		15	27	-22	22.8	13.3	13.9		M5	A,We	
38		15	50	-22	31.2	15.6	16.4		M6	A,We	
39		15	56	-23	36.2	13.5	14.7		M7	R	
40		15	55	-23	57.1	13.7	14.3		M:	Ki	
41		16	1	-24	25.1	14.2	15.4	SR?	M5	T	
42		16	16	-23	18.8	14.3	[16.2	E		vS,H	*
43a		16	19	-27	34.3	13.7	14.6		M1:	A,Se	c

Var.	R.A. (1900)			Dec.	Max.	Min.	Type	Sp.	Obs.# Ident.	R*
44	18h	16m	22s	-25°10'.3	14.2	15.4	RV?	M5	H,De	
45		16	23	-22 40.0	13.5	14.3	EW?		R,We	*
46		16	46	-23 40.0	12.2	12.9		M2:	Z	
43b		16	49	-27 28.4	12.2	[16.5	M	M:	WW Sgr	
47		16	59	-23 52.0	14.2	14.8		M4	R	
48		17	2	-24 24.6	13.8	14.7		M2	P,H	
49a		17	4	-24 41.1	14.7	15.2		M	H,De	
50		17	5	-25 29.6	14.9	15.7		M	vS	
49b		17	6	-24 40.2	13.3	15.1	M	M6	V1868	
51		17	18	-22 25.6	13.5	14.2	EW?		We	
52		17	28	-21 56.0	14.6	16.0	I?		A,We	
53		17	35	-23 32.1	15.0	16.2	M?	M5:	G	
54a		17	37	-23 23.3	14.5	[16.3	M	M6	V2332	*
55		17	38	-25 29.0	13.8	15.5	EA		V2338	
56		17	40	-21 33.6	14.3	15.2			A,As	
57		17	54	-27 22.8	13.8	15.1	I?	M6	Ro	
58a		17	57	-25 57.1	14.1	15.2	I?	M	H	
54b		18	3	-23 21.7	14.0	16.3	M	M2	V2339	
58b		18	8	-25 56.4	15.4	16.4	SR?	M4	V514	
59		18	17	-21 43.2	13.0	14.0		M2	Jo	
60		18	18	-22 54.0	14.0	16.3	M	M7	V2340	
61		18	23	-22 21.3	14.0	15.5	SRa	M	V2542	
62		18	25	-23 50.0	13.5	14.6	SRa	M4	V2341	
63a		18	26	-24 56.2	12.8	14.8	RV	M:	V2342	
63b		18	34	-24 55.8	15.4	16.6	RRa		IBV387	*
64		18	37	-23 22.9	14.0	[16.0	M	M7	V2343	
63c		18	42	-24 58.9	15.6	16.6	RR		IBV 312	*
65a		18	47	-26 32.4	13.7	[14.5	M	M7:	V2543	
66		18	50	-26 39.0	15.0	[16.0	M	M:	V2544	*
67		18	54	-24 26.6	14.9	15.8:		M6:	P	
65b		18	56	-26 29.6	14.0	15.4	SRa	M4	IBV 387	
68a		18	57	-23 11.3	13.0	16 :	M?	M:	vS,Z	*
65c		18	58	-26 29.4	13.6	16.0:	M	M7:	V1656	
68b		18	59	-23 9.2	13.7	[16.3	M	M2	V1657	
69		19	13	-21 47.9	13.6:	14.5			L	*
70		19	13	-22 17.6	14.3	15.0		M7	A,Gu	
71		19	24	-22 14.4	13.1	13.7			A,Gu	
72		19	38	-23 15.4	11.8	12.4		Pd	vS,L	*
73		19	46	-24 25.0	15.0	16.0	RR?		P,Wh	*
74		19	58	-23 3.7	14.4	16.3	C		V2546	
75a		20	8	-22 10.1	12.8	13.9		M2	Co	
75b		20	10	-22 9.1	14.0	14.5		M:	A,Gu	
76		20	12	-23 13.5	13.1	14.0	I?	M3	Z	*
77		20	13	-21 16.8	12.5	14.3	RR		B	*
78		20	15	-24 17.5	13.5	14.8	C?		L	*

Var.	R.A. (1900)	Dec.	Max.	Min.	Type	Sp.	Obs# Ident.	R*
79	$18^h\ 20^m 17^s$	−22°16′.4	14.4	15.1		M7	A,Gu	
80	20 20	−23 18.0	14.7:	15.7:			R	*
81	20 21	−24 52.7	13.1	13.6			P,H	
75c	20 23	−22 7.8	13.7	14.6	EA		A,H	
82	20 27	−22 5.7	14.5	16.4	M	M3	V2548	
83a	20 27	−22 49.6	13.8	14.6	I?	M5	vS,H	*
84	20 28	−27 58.3	13.0:	14.0:		M2:	St	
85a	20 40	−24 14.6	14.8	16.0	E?		P	
85b	20 41	−24 17.8	13.6	14.1			P,H	*
83b	20 45	−22 49.5	14.5	[16.3	M	M8	V2345	
86	20 45	−23 28.9	13.4	14.8:	RR		V2344	*
87	20 47	−21 29.4	14.8	15.9			A,As	
88	20 48	−21 10.9	12.1	13.0	SRb	M6	V2346	
89	20 49	−24 21.7	13.6	14.3	RR?		Co,P	
90	20 54	−26 12.3	13.6	15.0	I?	M6	H	*
91a	20 54	−24 46.1	15.2	16.0		M2	P,Wh	
92	20 56	−21 46.4	13.8	14.4		M3	A,Le	
93	20 56	−24 59.7	14.2	14.7		M6	Sa	*
94a	20 59	−22 21.1	15.0	[16.0	M		V2549	
95	21 3	−23 39.7	14.7	16.1	SR?	M:	G	
96	21 3	−26 3.1	14.0	14.8		M:	H	
91b	21 8	−24 38.8	14.9	15.7	Ib?	M8	P,Wh	
97	21 14	−23 26.7	14.5	15.5	E?	M2	G	
98a	21 19	−22 6.5	13.6	14.1		M3:	A,We	
94b	21 19	−22 18.3	14.6	15.9			A,H	*
99	21 21	−24 46.6	14.3	15.2	RR		V2552	*
98b	21 27	−22 3.8	14.3	15.0		M6	A,We	
100	21 31	−23 19.6	14.4	[16.	M	M:	V2553	*
98c	21 33	−22 4.6	13.8	[16.5	M		V1662	
101	21 39	−23 53.4	13.5	14.5		M6	R	
102a	21 41	−27 41.0	12.7	14.0	Ne?		V1998	
102b	21 43	−27 42.6	13.9	15.0	I?		A,H	
102c	21 44	−27 43.9	13.8	[16.0	M		LP Sgr	
103	21 53	−26 28.0	13.0	14.1		M6	H,St	*
104a	22 2	−24 52.7	15.0	16.5			P	
105a	22 3	−25 15.4	13.8	16.0		M4	P	*
105b	22 7	−25 17.6	13.9	14.2		M3	P	
106	22 14	−21 11.8	13.9	14.3		M5	A,Le	
107a	22 16	−23 21.0	14.5	15.8	RV?	M3	A,H	c
104b	22 20	−24 55.8	13.6	16.5	M	M3:	V1664	
108	22 21	−22 10.2	14.2	[16.1	M	M8	V2557	
109	22 22	−24 28.0	13.3	13.8		M5	P,H	
110	22 23	−22 17.0	14.0	15.5	SR	M3−6	V2558	*
107b	22 27	−23 16.6	14.1	[15.5	M	M4	V2348	
111	22 29	−22 23.4	14.4	15.2		M7	A,We	
112	22 34	−23 4.4	15.9	16.5			A,We	*

Var.	R.A. (1900)	Dec.	Max.	Min	Type	Sp	Obs.# Ident.	R*
113	$18^h22^m40^s$	-23°35'.4	14.4	15.0	I?	M7	A,Se	
114	22 45	-22 30.0	14.3	15.0		M5	A,Do	
115	22 45	-25 51.6	13.8	15.5	I	M6	V2350	
116a	22 47	-22 5.4	14.8	15.3			A,Gu	
116b	22 50	-22 3.6	15.6	16.2			A,Gu	
116c	22 51	-22 3.4	15.4	16.2	RR		A,Gu	*
117a	22 53	-24 40.5	13.4	14.6	I?	C	St,Le	c
118	22 53	-26 41.7	14.2	15.6	I?	M0:	Gu	
119	22 57	-22 51.4	14.0	[16.0	M	M8	V2562	*
116d	22 58	-22 10.2	13.8:	14.2:		M:	A,Gu	*
120	23 4	-25 25.7	13.7	14.7	SR?	M3-7	P,Le	*
121	23 6	-23 53.4	13.3	13.9		M:	A,H	
122	23 7	-23 1.2	14.3	15.0		M4	A,H	
117b	23 10	-24 37.6	14.2	[16.0	M	M8	IBV 617	
117c	23 11	-24 36.4	13.5	[15.5	M	M:	V2565	*
116e	23 12	-22 6.3	13.5	15.4	M	M7	V2352	
123	23 13	-20 52.6	12.0	12.6		M5	B	
124	23 15	-22 36.8	14.3	15.2	RR?		Bo	
125	23 16	-24 49.7	13.7	14.1		M3	P,H	
126	23 20	-24 27.9	13.6	14.1	Ib	M5	V2353	
127	23 24	-20 44.4	13.6	14.3		M:	A,Le	*
128	23 38	-24 41.9	14.9	15.9			P	
129	23 39	-22 26.8	14.3	15.1		M7	A,H	
130	23 49	-22 10.7	14.6	15.7		M:	A,Wo	
131a	23 54	-23 14.8	14.6	15.5	I?	M8	Wo	*
132	23 58	-25 38.0	14.1	15.3	RR		V2569	
131b	24 2	-23 19.3	14.7	15.8	M	M6	IBV 617	*
133	24 2	-24 56.3	12.4	13.2	UV?	M5	V2354	
131c	24 9	-23 14.4	14.6	16.2	RR		V2570	
134a	24 10	-24 3.3	14.9	16.1	I	M7	A,Wo	
135	24 26	-22 27.6	13.9	16.6	M	M3	V2357	
134b	24 35	-24 2.0	14.5	16.0	RR?	M2?	A,Wo	*
136	24 35	-25 13.5	13.2	13.7			St	
137a	24 38	-23 42.5	13.9	14.5	I	M5	V2358	*
137b	24 43	-23 42.8	14.3	15.5	RR		Di,A	*
138a	24 43	-24 54.5	14.3	15.0		M5	P,La	
139	24 45	-23 9.7	14.5	15.9	M	M7	V2571	
140	24 46	-26 33.4	13.8	14.9	EA		A,Se	
138b	24 50	-25 0.2	14.0	14.8	E?		P,La	
141	25 15	-21 51.5	14.3	16.2	M	M5:	V2573	*
142a	25 24	-24 51.9	13.3	16.5	M	M7	IK Sgr	
142b	25 28	-24 51.9	13.8	14.1		M5	P,H	
143	25 36	-26 22.8	14.1	[15.5	SRa	M2:	V2576	
144a	25 40	-25 17.0	14.1	15.5	RR		P,J	
145a	25 47	-23 31.9	14.5	16.0	M	M:	V2578	*

Var.	R.A. (1900) Dec.		Max.	Min.	Type	Sp.	Obs.# Ident.	R*
146a	$18^h25^m50^s$	-24°25!0	13.5	14.1		M5:	P,H	
145b	25 51	-23 33.6	14.9	16.0			A,H	*
144b	25 53	-25 17.6	11.8	15.9:	M	M9	IM Sgr	
147	25 54	-25 6.5	14.1	15.2			P,La	*
146b	25 59	-24 27.0	13.4	14.1		M:	P,H	
148	26 0	-23 58.8	13.9	15.3	RR		V2580	
149	26 1	-23 27.0	13.9	14.4			A,Di	
150a	26 11	-22 7.2	14.0	16.4	M?	M9	Hi	*
152a	26 22	-23 20.5	14.1	[16.5	M	M4	V1680	
151	26 26	-22 37.0	15.0	15.5			A,H	
152b	26 31	-23 18.6	13.9	14.9	Ib?	M7	V2363	
150b	26 37	-22 10.9	14.1	14.7		M6	Do,H	
153	26 51	-26 26.7	12.9	13.5		M6	A,St	
154a	26 54	-25 15.8	14.2	15.9	RR		V2584	
154b	27 5	-25 10.4	13.3	15.9	M	M7	V1684	
155	27 6	-23 9.0	11.2	11.8		M5	Z	
156	27 16	-23 42.0	12.4	12.9			A,Z	*
157	27 22	-22 20.2	14.7	16.3	RR?		A,Sw	
158	27 22	-21 52.6	15.1	[16.0	M	M:	V2585	
159a	27 25	-22 56.1	14.4	15.5			A,Ap	*
159b	27 32	-22 52.7	14.7	15.5		M	A	
160	27 32	-23 21.9	14.3	[16.0	M	M5	V2586	
161a	27 36	-25 8.5	13.8	14.3		M6	H	
162	27 42	-23 49.0	13.9	14.6	I?	M6	A,Bo	*
163	27 43	-24 32.8	14.2	14.8	E?		P,Gr	*
164	27 46	-26 59.8	13.3	13.8			A,Se	
165	27 51	-22 43.4	12.5	13.2		Pd	A,Z	*
161b	27 51	-25 10.2	14.1	[16.5	M		V1686	
166	27 59	-21 2.4	14.3	16.4	M	M9:	V2588	
167	28 1	-23 37.0	14.1	14.9	I?	M7	A,Bo	*
168	28 2	-24 29.9	12.7	13.7	Ib	M7	V2364	
169	28 4	-23 24.2	14.7	16.0	I?		A,H	*
170b	28 10	-24 34.0	14.6	15.5		M7	P	*
171	28 25	-23 6.1	14.5	15.7	RV		V2589	
172a	28 36	-22 0.6	14.7	16:	M	M6:	V2365	
172b	28 41	-22 1.6	14.7	15.6	RR		V2366	
173a	28 45	-23 57.6	12.9	14.2	SRb	M7	V2367	
174	28 49	-25 23.0	14.2	15.0	RR?		Di	
175	28 53	-23 43.8	14.2	14.8		M5	H	
176	28 57	-25 7.4	14.5	16.2	RR?		P	
173b	28 58	-23 55.6	13.7	14.8	RR		AJ 69	*
177	28 59	-21 38.7	14.9	[15.9	M		V2591	
178	29 8	-21 24.7	15.7	[16.4	M	M7	V2368	
179	29 15	-23 29.4	13.7	14.7	I?	M2	A,Se	

Var.	R.A. (1900)	Dec.	Max.	Min.	Type	Sp.	Obs.# Ident.	R*
181a	$18^h29^m21^s$	-23°52'.2	14.8	[16.5	SRa	M6:	V2007	*
180	29 24	-22 27.5	15.0	16.4	M	M9	V2369	
181b	29 24	-23 50.0	13.6	14.3	RRc		V2592	
182	29 25	-20 58.8	12.0	12.6		M6	B	
183	29 38	-24 35.0	14.2	14.9	short?		H	
184a	29 58	-22 42.4	14.6	15.2			A,H	
184b	30 2	-22 44.3	14.5	16.3	M		V1698	
185	30 2	-24 10.7	12.3	13.1	I?	M:	Z,Au,H	
186	30 2	-25 12.0	14.2	14.8:		M2	P,Gr	
187a	30 9	-23 52.0	13.3	14.2	RR		H,Au	*
188	30 14	-20 48.6	12.8	14.8	SRb?	M5	V2370	
189	30 21	-21 36.4	13.8	15.6		M0	De	
187b	30 24	-23 45.8	14.0	14.6			H,Au	
190	30 33	-22 52.0	14.8	16.1	M	M6:	V2598	*
191	30 33	-24 3.3	12.0	13.0:			H,Z,Av	*
192	30 48	-22 13.9	13.2	14.1		M6	A,H	
193	30 50	-22 20.6	14.8	15.6	RR?		Sa	*
194a	30 46	-26 56.9	13.4	14.3			H	
194b	30 52	-26 57.4	13.4	14.2		M3	A,H	
195	31 11	-24 47.2	13.9	14.9	Ib?	M8	P,Gr	
196	31 11	-25 24.2	13.4	14.3			A,H	
197	31 19	-21 34.2	14.3	15.6	SR	M3	V2600	
198	31 34	-22 39.0	14.8	16.2	I?		A,He	
199	31 35	-22 17.6	14.4	16.2	M	M7	V2372	
200	31 54	-27 46.2	13.8	15.1	RR		V2374	
201	31 55	-22 5.7	14.5:	15.5			A.He	*
202	31 59	-22 46.7	14.3	15.3		M6e	V2601	*
203	32 14	-25 38.2	13.0	13.9	SR	M6	V2376	
204	32 16	-27 47.0	11.8	12.6	RR?		Ro	
205	32 18	-21 29.7	14.7	16.0	I?	M2	A,We	
206	32 41	-23 10.7	12.0	12.6	I?	M5	AJ 70	
207	32 41	-26 53.6	13.3	14.6	EA		Cr	
208	32 44	-22 46.2	13.8	15.4	RR?		A,Ja	
209	33 1	-19 56.4	12.8	14.5		M5	B	
210	33 3	-20 33.4	14.6	15.5			A,De	*
211	33 7	-21 14.2	12.5	15.2	RRab		IBV 474	
212	33 45	-24 3.1	13.2	13.8			A,Co	
213	34 6	-24 36.6	11.7	12.5	EW		A,Tw	*
214	34 7	-21 28.1	13.5	14.5	EA		V2606	
215	34 7	-18 44.2	13.7	[15.5	M	M9	V2378	
216	34 38	-26 52.8	12.7	13.4	I?	M5:	Se	
217	34 39	-25 19.6	13.2	13.8		M3	Al	
218	34 45	-26 10.8	11.9	13.1	SRa	M3	V2608	

Var.	R.A. (1900)	Dec.	Max.	Min.	Type	Sp.	Obs.# Ident.	R*
219	18h34m48s	-24°49!3	13.6	14.2			A1	
220	35 7	-23 22.2	15.0	16.3:	RR?		Ja,A	
221	35 16	-25 49.2	13.8	14.9	I	M5	V2380	
222	35 36	-21 28.1	12.5	13.0		M3:	B	
223	36 9	-19 52.1	11.8	12.4	E?		A,B	*
224	36 43	-26 8.3	11.9	13.2		M2:	Cr	
225	36 56	-19 7.0	14.6	[16.1	UG		V2383	
226a	37 26	-21 18.8	13.9	16.2	M		V1710	
226b	37 30	-21 17.7	14.2	15.8	M		AJ 72	
227	37 33	-23 2.2	14.0	15.0	RR?		Ja,A	
228	38 2	-21 48.2	11.5	12.1		M:	B	
229	38 6	-23 0.3	14.2	15.4	E		A,H	
230	38 24	-20 22.2	14.2	15.5	RRab		IBV 592	
231	38 38	-24 7.6	14.0	14.8	short		Sa	
232a	38 42	-19 29.4	9.8	10.5	EA	A0	YY Sgr	*
232b	38 48	-19 29.0	14.8	16.0	I?		A,Le	

Observers

A Jean Hales Andersen, Harvard 1955, 1958

Al Laura Alford, Randolph-Macon 1963

Ap Karen Alper, Case Western Reserve 1968

As Mary Ashman, Mt. Holyoke 1967

Au Doris Austin, Wellesley 1963

B Meredith Baldwin, Wellesley 1960

BC Jennifer Bagster-Collins, Mt. Holyoke 1959

Bo Linda Bothwell, Goucher 1966

Co Sharon Cox, Arizona 1961

Cr Sandra Crino, Wellesley 1961

De Linda Deery, Whitman 1968

Di Elizabeth Dippel, Mt. Holyoke 1963

Do Catherine Doremus, Indiana 1965

G Nahide Gokkaya, Wesleyan 1965

Gr Nancy Gregg, Colorado 1969

Gu Judith Guthrow, Randolph-Macon 1967

H D. Hoffleit

He Susan Hess, St. Johns 1966

Hi Alice Hine, Vassar 1966

Ho Nancy Houk, Michigan 1962

J Jean Jackman, Vassar 1968

Ja Judith Jacobs, Smith 1964

Jo Lorella Jones, Radcliffe 1962

Ki Bonnie Kime, Wellesley 1964

Ku Andrea Kundsin, Wellesley 1957

L Gretchen Luft, Mt. Holyoke 1961

La Joann Lawless, Wellesley 1969

Le Wendy Levins, Vassar 1967

P Zora Prochazka, Harvard 1955

R Diana Reeve, Wellesley 1963

Ro Judith Robinson, Vassar 1961

Sa Martha Safford, Wellesley 1962

Se Sandra Servaas, Wellesley 1967

St Ilona Strockis, Wellesley 1960

Sw Marilyn Swim, Pomona 1965

T Jane Turner, Wellesley 1965

Tw Marilyn Twomey, Wellesley 1968

vS Gunilla von Schwerin, Harvard 1955

W Jean Warren, Swarthmore 1965

We Diana Welch, Park College 1967

Wh Janice White, Whitman 1969

Wo Katharine Wood, Vassar 1966

Z Catherine Zastrow, Mt. Holyoke 1960

* Remarks

c	Indicates images affected by companion
Var. No.	
4	Indications of cycles of about one month
6	Three companions
13	Cycles about 60 days; resembles UU Her
16	Period about 10 days?
18	Usually blended with 15 mag. companion
19	Fuzzy blended images resolved on only a few plates
25	Blended with three companions one of which has M-type spectrum
35	Overlapping spectra
42	Only one deep minimum observed, J.D. 2426591.361
45	Period about 0.78 day?
54a	An error in position in Astron. J., Vol. 71, p. 130, Var. No. 1, is carried over into I.B.V.S. No. 311, 1968, and the General Catalogue of Variable Stars: for 11 minutes of R.A. read 17 minutes
63b	Near globular cluster M28
63c	S.I. Bailey Var No. 8 in cluster M28; c.f. Ann. Harvard Coll. Obs. 38, Plate XI
66	Suspect companions
68a	Blended images. One companion, seen only on J.D. 2424431, may be a 13 mag. asteroid
69	Only one maximum, J.D. 2425854
72	HD 169460, NGC6629, planetary neb.

73 16 mag. companion

76 Usually near maximum

77 Two companions

78 Period 13-15 days?

80 Blended images

83a Only 5 observed, widely separated maxima

85b Spectrum overlapped by M-type star

86 Has companion with M-type spectrum

90 Light curve resembles R Cor Bor but with small amplitude

93 Blended images

94b Probably short period. Double images resolved on only 33 Bruce plates; preceding of two stars; companion 15.6 mag.

99 15.7 mag. companion, spectral class M7

100 Blended with two companions

103 Companion rarely resolved

105a Images blended except on Harvard Bruce plates

110 Conspicuous change in spectrum

112 Flanked by red stars

116c Probable RR Lyrae type. Blended images resolved only on Harvard Bruce plates

116d Magnitudes refer to blended images. The variable may be the fainter component, about 14.7 mag.

117c The variable is a faint star closely following the 12.5 mag. star marked on the chart. Seldom resolved.

119 At minimum a 16 mag. companion revealed. Variable is N of close pair.

120 Normally at maximum. Part of the observations indicate period of 53 days.

127 Overlapping spectra

131a 15.8 mag. companion rarely resolved

131b Variable is faint star N of brighter star with early M-type spectrum.

134b Appears to be RR Lyr type; if so, M2 may refer to overlapping spectrum.

137a Near cluster NGC 6642

137b Near cluster NGC 6642

141 Overlapping spectra

145a 1' N of NGC 6642. Companion

145b S of cluster NGC 6642. Estimates useful only on Harvard Bruce plates, on which companion is resolved.

147 Short period? Affected by companion on all but Bruce plates

150a Only three maxima observed: J.D. 2423948-9, 24765, 26557-594. Except on Bruce plates generally blended with nearby brighter star to S.

156 Suspect companion

159a 15.4 mag. companion, resolved on 66 Harvard Bruce plates. Only one well defined maximum, J.D. 2426557-569.

162 Probable companion. Amplitude small, but good correlation between the observers

163 Same as 170a

165 HD 171131, IC 4732, planetary nebula.

167 Small amplitude but good correlation between observers

169 Appears to be slowly varying

170a Same as 163.

170b Preceding variable on chart, 170a, is same as No. 163.

173b Member of globular cluster M22

181a Probable member of M22

187a H.S. Hogg Var. No. 15, Pub. David Dunlap Obs., Vol. 1, 297, 1944. Companion appears to have M type spectrum

190 15.8 mag. companion rarely resolved except on Bruce plates

191 Companion. Very bright object in lower left corner of chart represents globular cluster M22

193 Blended with 15 mag. companion

201 15 mag. companion rarely resolved

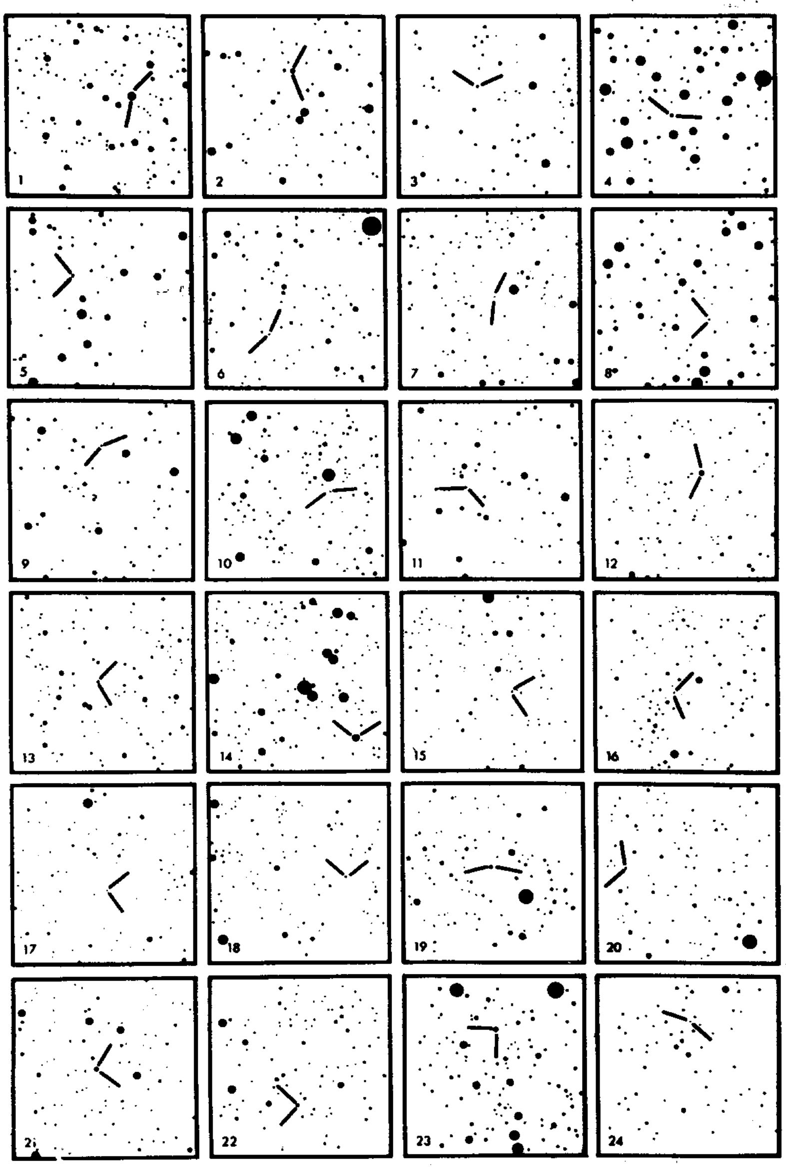
202 MHα 208-51. Preceding of pair separated by 0'.3.

210 Usually blended image of two stars; var. is the Sf

213 Provisional period by Marilyn Twomey, 0.364913 day. A spectral class, M2, found by Miss Houk presumably refers to a close preceding unresolved companion seen on the red Palomar charts of this region but not on the blue.

223 Variable Suspect No. 4299.

232a Not examined in this survey: too bright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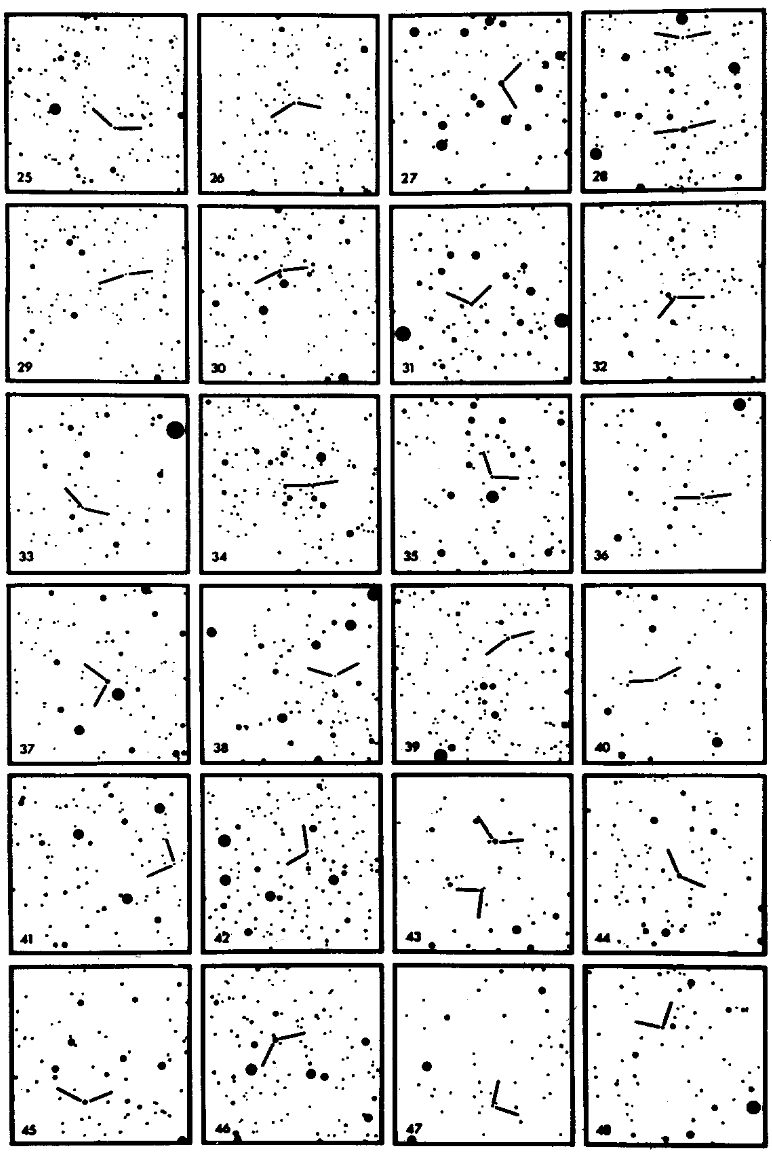
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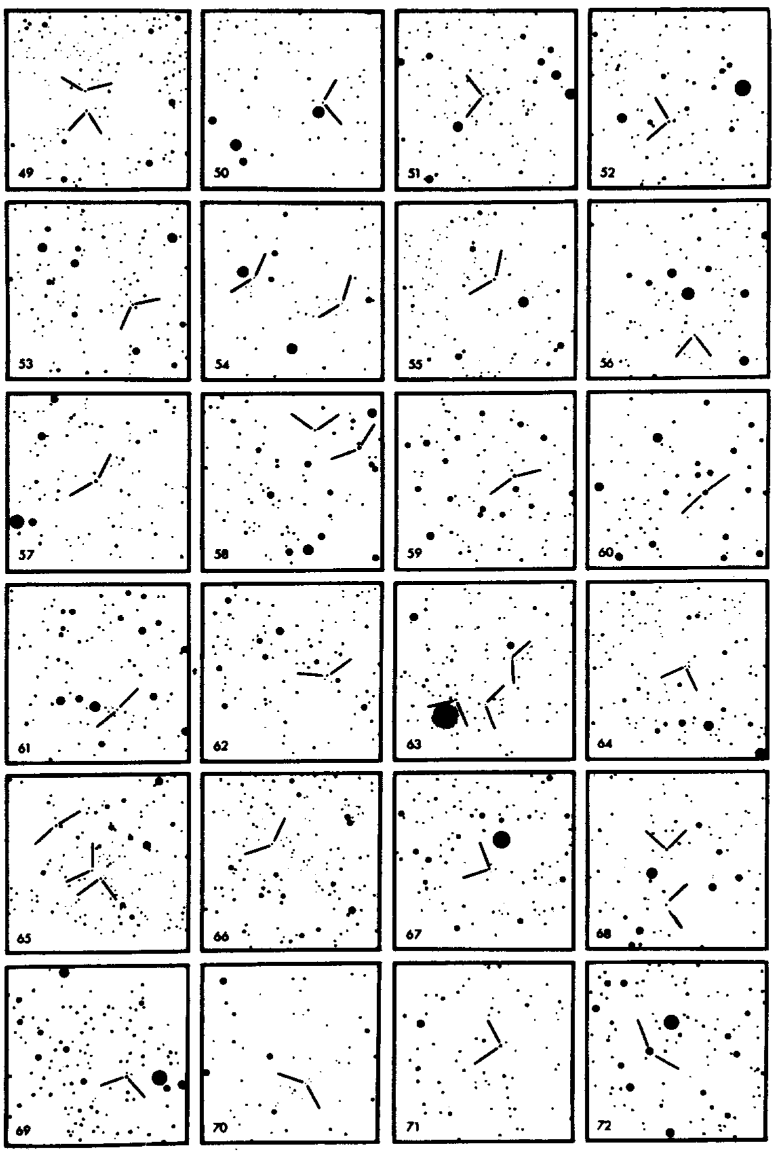
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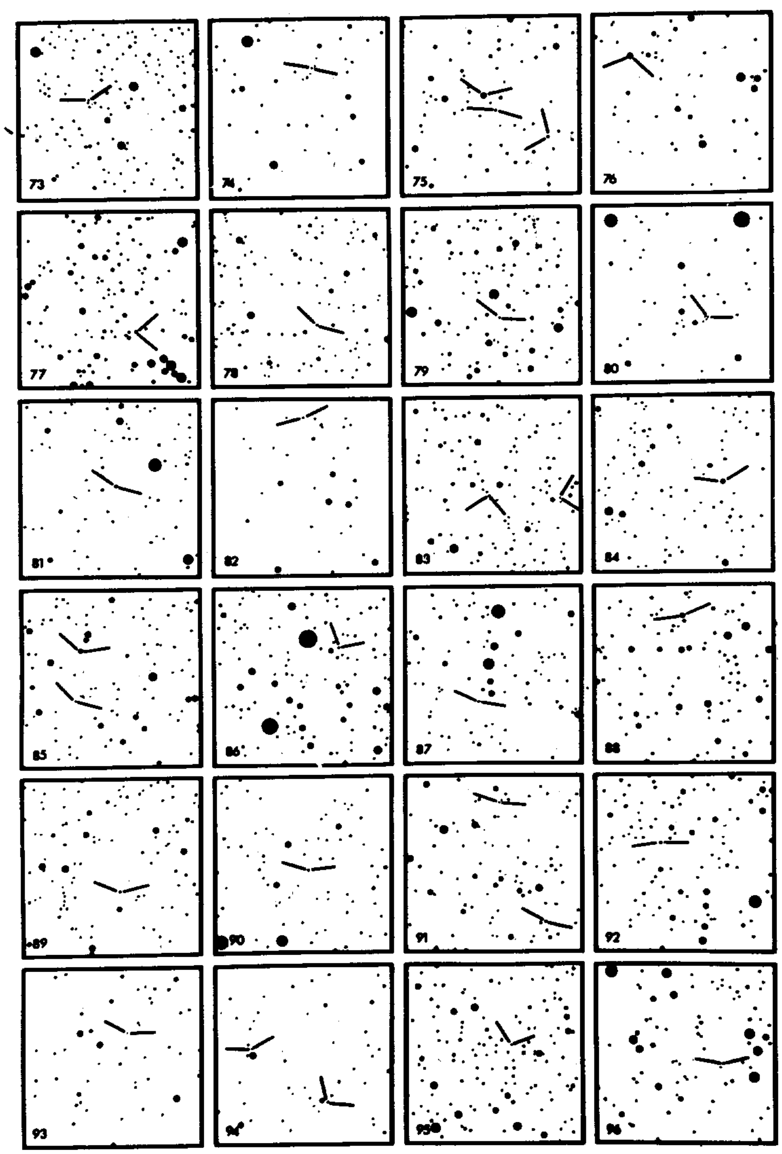
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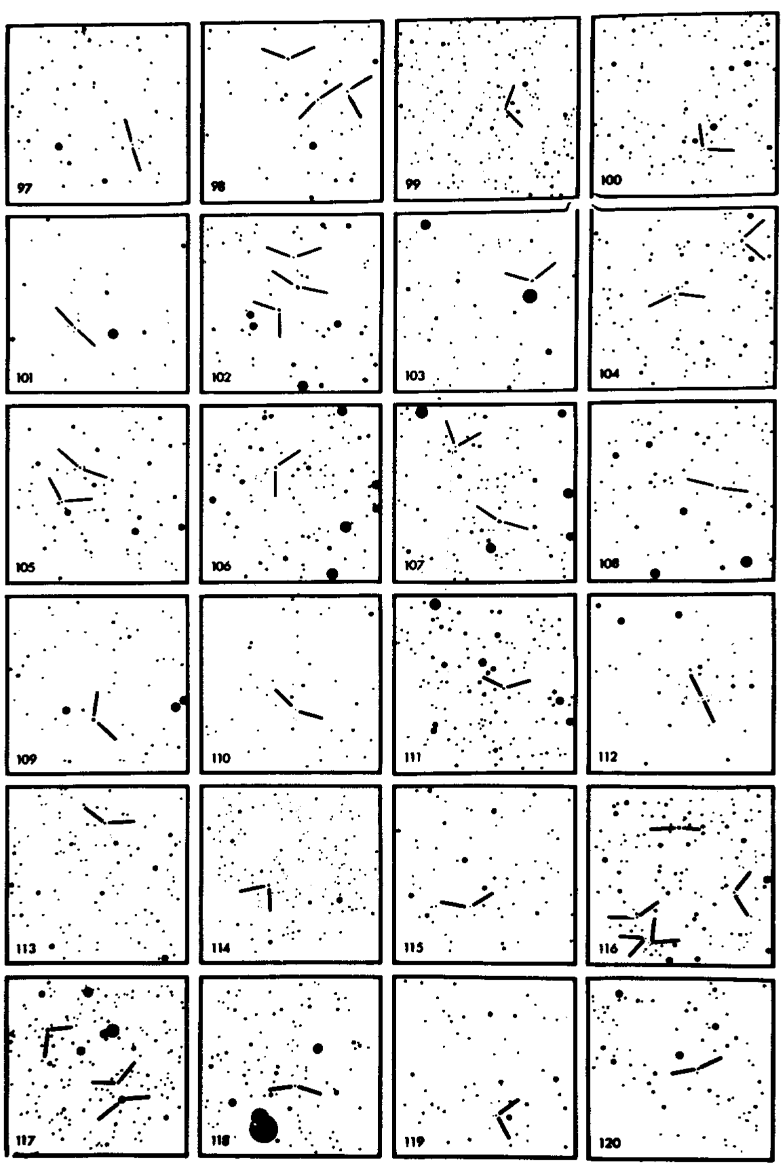
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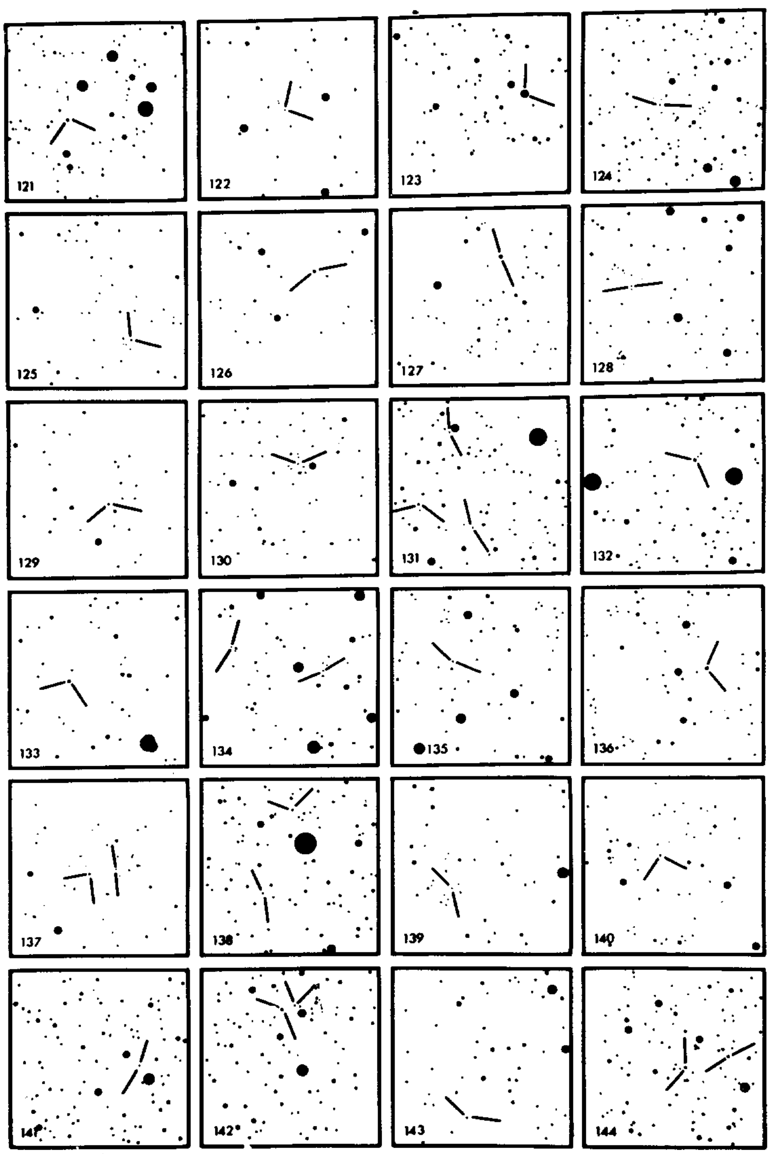
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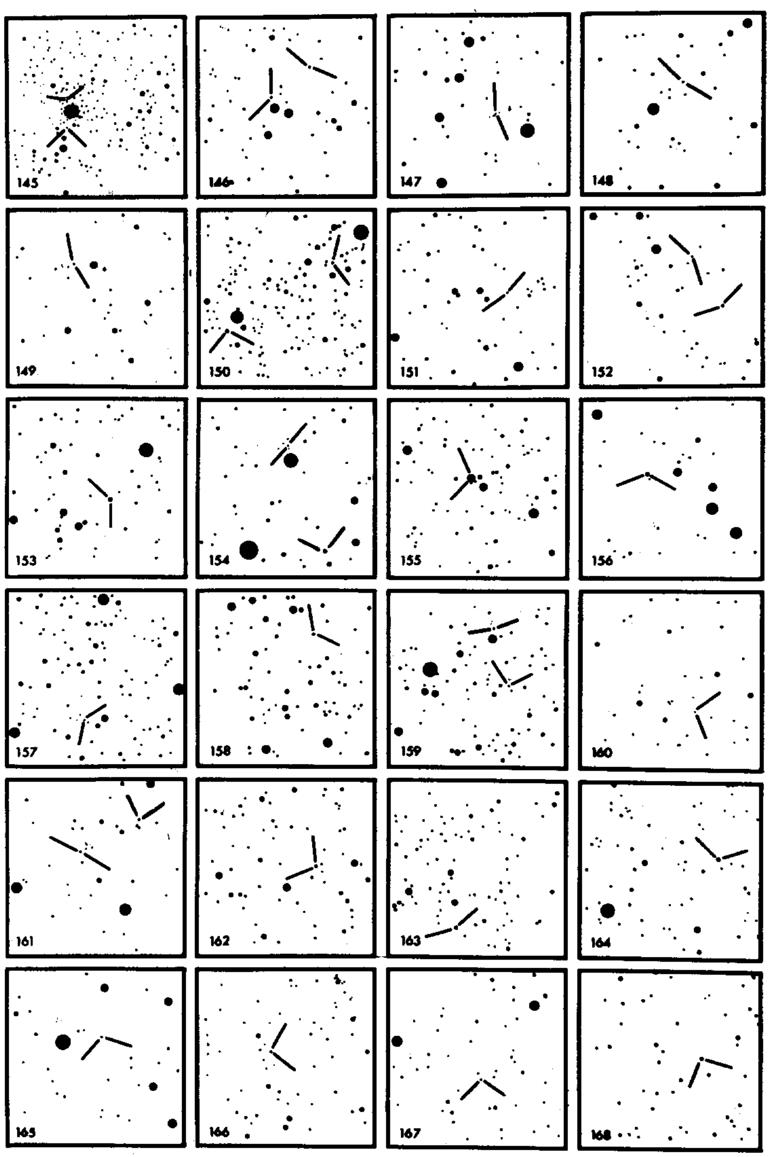

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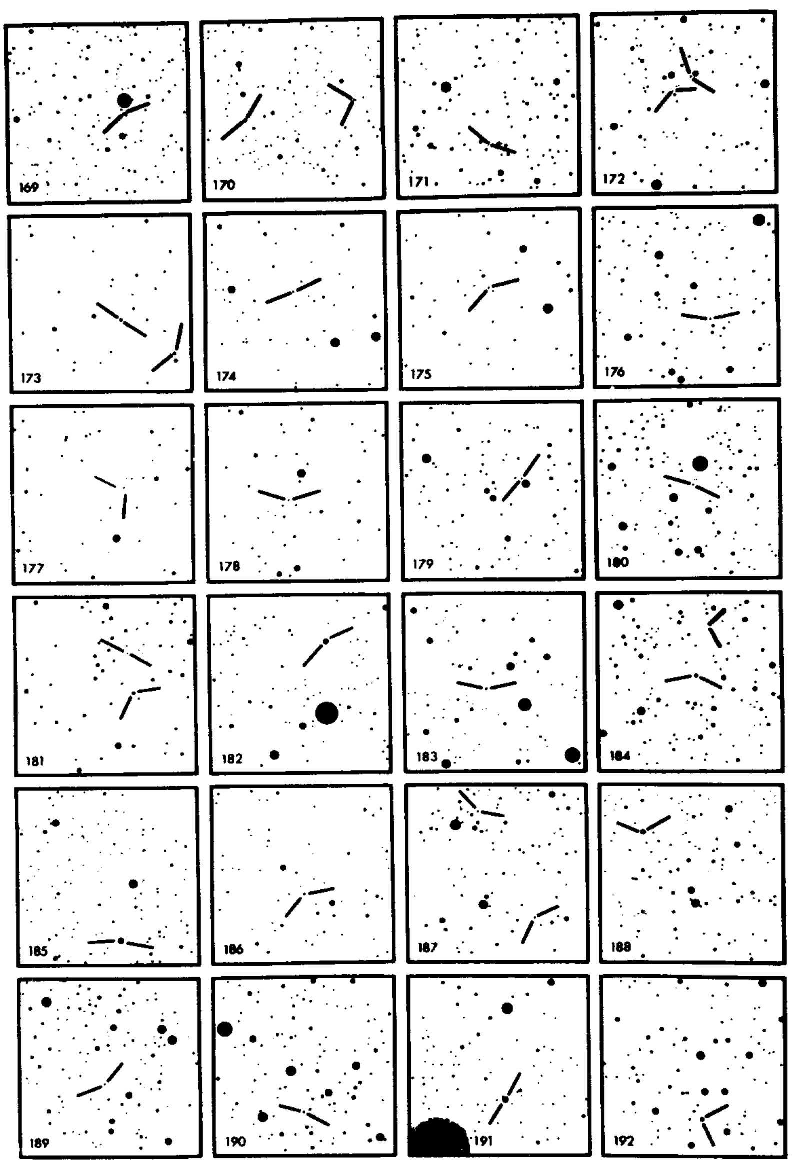
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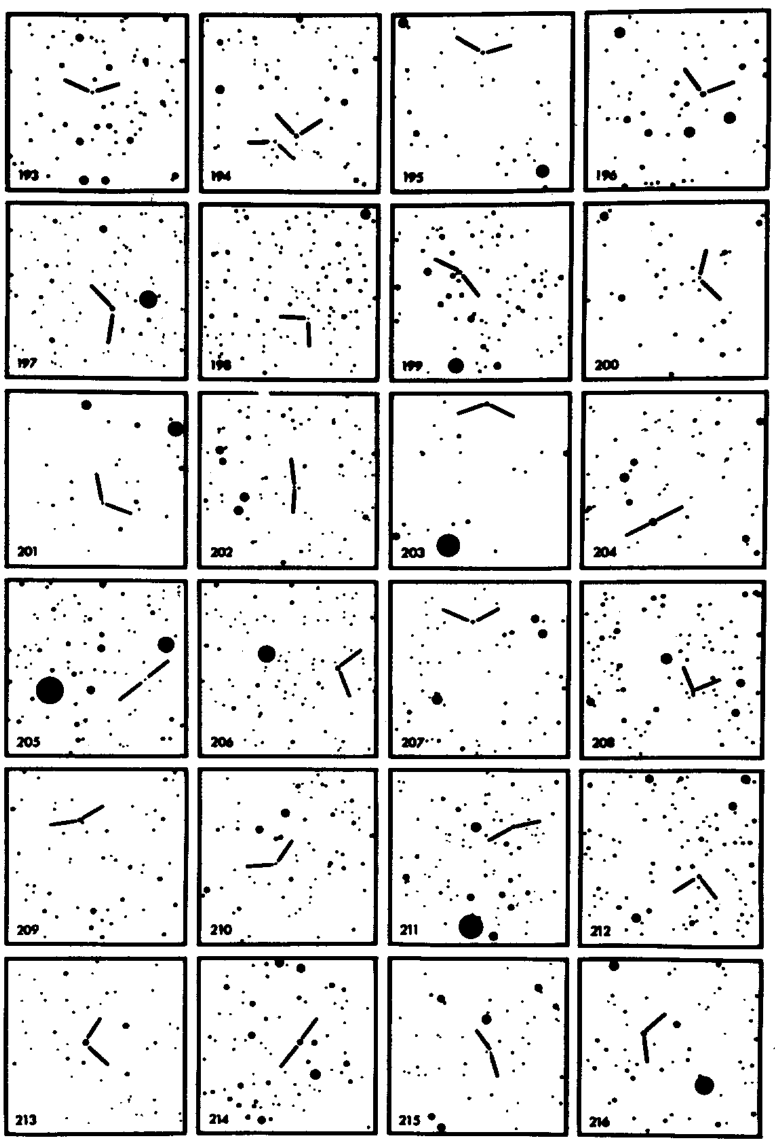
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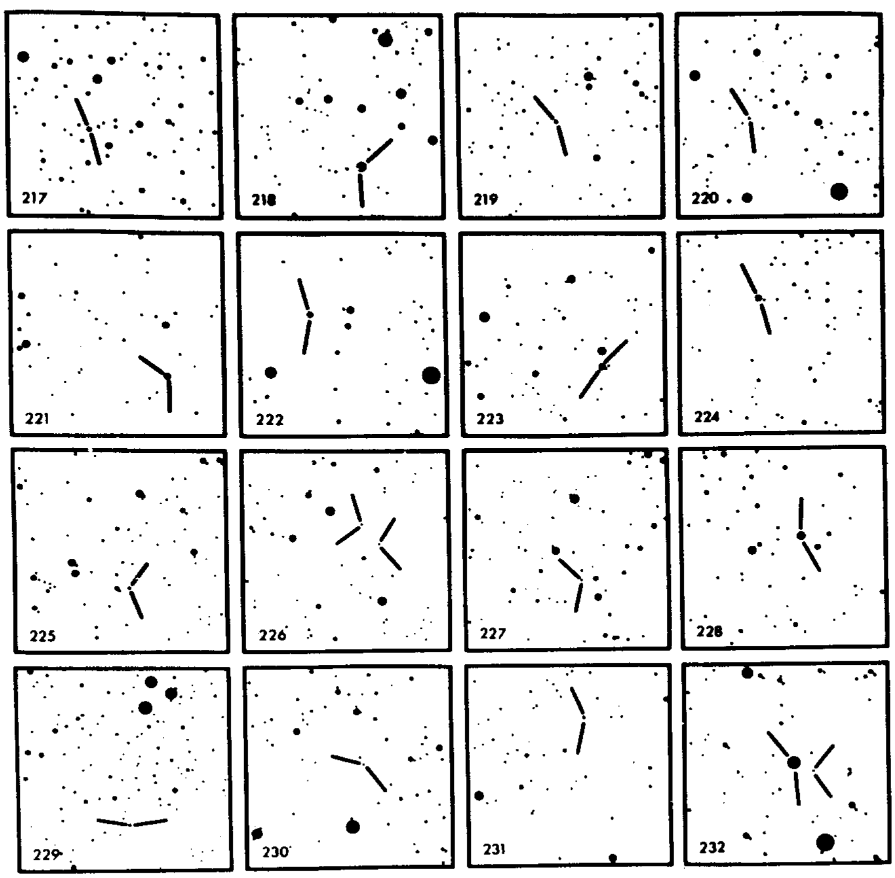
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