37. COMMISSION DES AMAS STELLAIRES ET DES ASSOCIATIONS

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INTRODUCTION

As in previous years the report on Clusters and Associations is based mainly upon the information received by the writer in response to a circular letter distributed in September 1963 amongst 140 astronomers. It has been attempted again to condense at least part of the huge amount of information into the concentrated form of three tables. Preference has been given there to unpublished material and to clusters which are still being investigated rather than to published work. The latter may be easily found in the annual supplements to the 'Prague Catalogue'.

Clusters and associations belonging to the Magellanic Clouds or other external galaxies are not included in this report. They are reported on in Commission 28.

GENERAL CATALOGUES

G. Alter, H. Sawyer Hogg and J. Ruprecht published three Supplements (**1**, **2**, **3**) to the Catalogue of Star Clusters and Associations, containing a comprehensive compilation of available new data concerning star clusters and associations. (**1**) contains a complete list of new galactic co-ordinates for the 772 open clusters, 67 associations and 119 globular clusters listed in this most valuable catalogue. Similarly (**2**) gives the cosine values x^{II}, y^{II}, z^{II} for all objects. (**3**) announces again an increase of the number of open clusters bringing their total number up to 913. (**4**) contains a list giving the positions of the clusters on the maps of the Palomar Observatory Sky Survey, measured in millimeters from one corner.

To guarantee the smooth continuation of this catalogue, workers on the field of clusters are urgently requested to assist the authors of the Catalogue by sending them (any of the authors, G. Alter, H. Sawyer Hogg or J. Ruprecht) reprints of their published cluster papers.

Regular users of the Catalogue are reminded that new blank cards can be ordered from the Publishing House of the Czechoslovak Academy of Sciences, Vodičkova 40, Prague 2. New orders of the Catalogue may be placed also with Plenum Press, Inc, 227 West 17th Street, New York 11, U.S.A.

Alter and Ruprecht (**5**) published a paper on 'The system of Open Star Clusters and Our Galaxy—Atlas of Open Star Clusters'. It contains a general map of the galactic belt depicting the open star clusters and associations and 36 detailed maps of 10° longitude each, showing the galactic position and a symbolic representation of various properties of clusters. The textual part deals with the galactic distribution of open clusters, their relation to the spiral structure of the Galaxy and the statistical distribution of properties.

W. Buscombe (**6**) published a very useful compilation of 'Photometric Data for Galactic Clusters' as an Appendix to his paper on the Total Brightness of Galactic Clusters, which was

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presented at the IAU Symposium no. 20 (The Galaxy and the Magellanic Clouds). The main data listed in the booklet are distance moduli, colour excesses, linear diameters and integrated apparent and absolute magnitudes (blue) for 220 objects.

P. Mayer (7) has compiled a new list of the emission nebulae associated with open clusters.

ASSOCIATIONS

Ruprecht has prepared a new nomenclature of associations according to the proposal suggested by Commission 37 in Berkeley 1961. The system of the new nomenclature will be presented to the meeting of Commission 37 in Hamburg 1964.

Recent results and work in progress are summarized in Table 1 which is self-explanatory.

Table 1. Associations

Name	Observer and reference (see end of table)	Photometry, method and limiting magnitude			Other data obtained, remarks
II Cas IV	Kharadze, Bartaya		pg	13·0	sp. class
Cass VII	Kharadze, Bartaya		pg	13·0	sp. class
I Per I	Petrie, Odgers		pg	7	r.v., s.t., M (Hγ)
VIII Cas	Worrall (Cambridge)	*UBV*	pg		+Hγ(pg)
II Per II	Bappu *et al.* (1)	Hγ	pe	9	M_v
I Ori I	H. Johnson		pg	11·3	r.v. of 13 stars
	Abt + Hunter				r.v., rotation
	Bappu *et al.* (1)	Hγ	pe	9	M_v
	Hardie—Heiser	*UBV*	pe	9	in press
	Blanco (2)	O p	pg+pe	15	16 M stars
	Sinnerstad	Hβ,D	pe	10	narrow band photom.
I Gem I	Sinnerstad	Hβ,D	pe	10	narrow band photom.
I Mon II	Schmidt-Kaler, van Schewick	*UBV*	pe		13 O stars p.m., expansion age $2 \cdot 10^6$a
I Pup	Bok, Graham	*UBV*, Hβ	pe	11	
III Pup	Westerlund (3)	*UBV*	pe	11·6	23 OB stars + RS Pup
I Car	Bok, Graham	*UBV*, Hβ	pe	10	unpublished
I Cru (Cen)	Westerlund	*UBV*	pe	13	unpublished, OB + Be stars
II Sco II	Crawford, Hardie (4)	*UBV*, Hβ	pe	10	calibr. of M (Hβ)
II Sco II (Sco-Cen)	Morris (5)	m_{pv}	pg+pe	7	s.t.+M. 220 OBA stars
	Buscombe (6)		pg	7	r.v. 70 BA stars
	Buscombe (7)		pg	7	r.v. B stars
	Pik-Sin The (8)		pg		32 new Hα-stars near ρ Oph and σ Sco
	Bappu *et al.* (1)	Hγ	pe	9	M_v
	Thackeray		pg		r.v. of 40 stars
I Ara (Ara-Nor)	Whiteoak	*UBV*,Hγ	pe	10	s.t., 127 stars
I Sco I	Bok, Graham	*UBV*,Hβ	pe	11	unpublished
Sco IV	Pik-Sin The (9)	Hα	pg		new discovery RA 17^h08^m (1900) Decl. $-33°0$
	Roslund (*Lund Medd.* 1) in press	*UBV*	pe	12	250 OB stars
	Roslund	Hβ	pe+pg	12	
I Vul I	Kharadze, Bartaya		pg	13	spectra class
I Cyg III	Batten (Victoria)		pg		r.v., s.t., M(Hγ)
II Cyg I	Batten (Victoria)		pg		r.v., s.t., M(Hγ)

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Name	Observer and reference (see end of table)	Photometry, method and limiting magnitude			Other date obtained, remarks
VI Cyg II	Batten (Victoria)		pg		r.v., s.t., $M(H\gamma)$
	Reddish	*UBV*	pe	16	1700 stars (see text)
IV Cyg IV	Batten (Victoria)		pg		r.v., s.t., $M(H\gamma)$
I Lac I	Abt, Hunter				r.v., rotation
	Richardson (Victoria)		pg		r.v., s.t.
	Crawford (**10**)	$H\beta$	pe	10	69 stars, $m-M$
Ceph IV	Walker (Victoria)		pg		r.v., s.t., $M(H\gamma)$
	Blanco (**11**)		pir		faint $H\alpha$ stars
	Blanco (**2**)		pir	15	20 M-stars
Cas-Tau	Crawford (**12**) 1963	$UBV, H\gamma$	pe	6	comparison to Sco-Cen
Tau T 2	Sholomitsky (**13**)				H I discovered
Cas III, Cas IV, Cas V	Ampel (**14**)		pg + pe	12	s.t., C, M_V for 275 OB stars

Abbreviations and References

The following abbreviations are used:

o.p.	= objective prime	c-m	= colour-magnitude
p.m.	= proper motions	pir	=
r.v.	= radial velocities	pe	= photo-electric
s.t.	= spectral types	pg	= photographic

1. *Mon. Not. R. astr. Soc.*, **123**, 521, 1962.
2. *Astrophys. J.*, **137**, 513, 1963.
3. *Mon. Not. R. astr. Soc.* (in press).
4. *Astrophys. J.*, **133**, 843, 1961.
5. *Mon. Not. R. astr. Soc.*, **122**, 325, 1961.
6. *Mon. Not. R. astr. Soc.*, **124**, 189, 1962.
7. *Mon. Not. R. astr. Soc.* (in press).
8. *Contr. Bosscha Obs.* (in press).
9. *Contr. Bosscha Obs.*, no. 12, 1961.
10. *Astrophys. J.*, **133**, 860, 1961.
11. *Publ. astr. Soc. Pacif.*, **74**, 330, 1961.
12. *Astrophys. J.*, **137**, 523, 1963.
13. *Astr. Zu.*, **39**, 762, 1962.
14. *Acta astr.*, **14**, 52, 1964.

A particular search for OB- and M-associations in the Southern Milky Way is in progress at the Stockholm Observatory by means of objective prism plates obtained at the Boyden Observatory. The quality of the material does not permit luminosity classifications. One purpose of the investigation is to study the correlation between OB- and M-aggregations.

At the Royal Observatory Edinburgh, *UBV* magnitudes for 1700 stars to $V = 16$ in the area of Cyg II have been determined with the Schmidt telescope. The results show an excess of several hundred early type stars in the central half of the area. Preliminary analysis indicates that these extend over several kiloparsecs in the line of sight, and suggests that the 'association' may be a hole in the obscuration. Results will appear in the Publications of the Royal Observatory Edinburgh.

V. M. Blanco reports on his search (**8**) for M-type stars in the following young clusters or associations: Ori I, Cep IV, NGC2264, 6611, IC5146. No definite cluster or association members later than type M4 were found, the great majority being of type M2 or earlier. The results are interpreted in terms of Hayashi's recent work (**9**) on stellar evolution.

A. Blaauw, in collaboration with T. S. van Albada, is investigating statistical properties of the B-type binary stars in the nearest O-associations Per II, Lac I, Ori I, Cas-Tan-group. It is intended to find the distribution of the separation *a* between the components, and the mass distribution of the secondary components for values of *a* up to a few astron. units. These distributions are considered to be valuable information for the theory of the process of formation of the massive stars. For this purpose data in existing catalogues are supplemented with the results of an extensive programme of radial velocities of stars in the nearest O-association (**10**, **11**). The main conclusions are:

(1) The distribution function $A(\log a)$ decreases from $a = 0$ to $a = 1$ A.U. This is in contrast to the increase which has been suggested by Kuiper for stars of smaller masses in 1935.

(2) The distribution function of the secondary masses is not the same as the mass distribution of the so-called Initial Luminosity Function. The frequency of smaller masses increases much less with decreasing mass. It does agree with the frequency distribution suggested by Kuiper.

A new OB-association Pup III has been found by B. Westerlund. It consists of 23 OB stars and the long period cepheid RS Pup. Pik-Sin The has announced (**12**) the discovery of a clustering of OB stars in Sco. It is believed that these stars form a new association extending in R.A. from 17^h00^m to 17^h16^m (1900) and in Dec from— 31°30′ to 34°30′ (1900). It was designated by Alter *et al.* as Sco IV.

A search for unknown faint Hα-emission objects in Cep IV and for variable stars in the same region is at present being carried out at Warner and Swasey Observatory by D. MacConnell.

The survey of Hα-emission objects in selected regions of the Southern Milky Way, containing bright and/or dark nebulosities has been continued by Pik-Sin The. The co-ordinates of the centre of these regions and their approximate locations are given in Bosscha Observatory Report for the Year 1961, as follows:

Region of NGC 6334 and 6357	*Contr. Bosscha Obs.* no.	10
,, in Aql and Sct		14
,, in Lup and Sco		15
,, in Southern Coalsack		16
,, near m Cen		17
,, near ρ Oph and σ Sco		in press

Bappu and his collaborators have continued the photo-electric measures of Hγ absorption in early type stars as reported at Berkeley 1961 (cf. Tables 1 and 2). Γ-indices which are a measure of the Hγ absorption have been observed for stars in 7 open clusters and 3 associations. By using Γ indices and unreddened $(U–B)$ or $(B–V)$ values the spectral types and luminosity classes can be determined in the range O6 to A0. A $\Gamma-(U–B)_0$ diagram of clusters and associations of different ages shows the separation of age very effectively. Distance moduli determinations for Ori I and NGC 2362 using the Γ, M_v calibration for stars younger than $2 \cdot 10^7$ years indicate the convenience of abs. magnitude determinations with Hγ-photometry.

Work of the Asiago astronomers on Variables in associations will be referred to later in this report.

J. Sahade (**13**), with F. Berón Dávila, has investigated eclipsing variables in the associations of Schmidt's and other lists.

H. Abt and J. H. Hunter studied rotational velocities for the brighter stars in I Lac, I Ori, Pleiades and α Per cluster. Each group shows a distinction dependence of v_{rot} on spectral type. The stars in a certain spectral type range rotate unusually slowly, while those in another range rotate unusually rapidly, compared to field stars. The well-known dips at B2 and A2 in v_{rot} of field stars seem to be caused by large admixtures of several prominent groups (like UMa stream) having unusually low v_{rot} at these types.

D. Crawford (**14**), from a thorough comparison of *U–B* colours and Hβ intensities, observed in the Cas-Tau group and in the Sco-Cen association, reaches at the important conclusion that the Cas-Tau group as a whole is not real and that it should *not* be used in any fundamental calibration of absolute magnitudes.

Massevitch and Kotok (**15**) have determined the age of the hottest stars in the Ori I association under different assumptions on their evolution. It is concluded that the duration of the star formation process in the system is considerable.

OPEN CLUSTERS

A good deal of information on photometric, spectrographic and astrometric work published since 1961 or being carried out presently in open clusters has been tabulated in Table 2, as far as possible. Catalogues of cluster data, devoted to a general discussion of the system of open clusters, have been omitted from Table 2.

Hogg has extended his project of photographing southern open clusters with the 74-inch reflector to −45°. The photography is essentially complete. The collection will consist of about 150 sheets 8 × 10 inches, 50′ × 50′ (1′ = 4 mm).

Barkhatova and Syrovoi have compiled a new Atlas of Colour-Magnitude Diagrams for 120 open clusters in the *UBV*-system.

Table 2. Galactic Clusters

NGC and type	Observer and references (see end of table)	Photometry, method and limiting magnitude			Other data obtained, remarks
129	Hoag	Hγ	pe		s.t.
188	Sharov				structure
	Eggen	*UBV*		17^m	
189	Balázs (**1**)	*UGR*	pg	17	
Stock 24	Balázs (**1**)	*UGR*	pg	17	
225	Hoag	Hγ	pe		s.t.
330	Feast (**2**)				spectra, normal young cluster
436	Meurers				p.m.
457	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Hoag	Hγ	pe		s.t., search for variables
	Hoag	*UBV*	pg	15·5	300 stars
	Meurers				p.m.
	Abt				r.v. of 12 stars
581 =M103	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Oja	*BR*	pg	15·5	p.m.
	Oja		pg	14	spectral photometry
	Purgathofer (**3**)	*UGR*	pg+pe	13·5	
	Hoag	Hγ	pe		s.t.
Tr 1	Kharadze, Bartaya (**4**)			12·0	s.t. in the surroundings
	Oja	*BR*	pg	15·5	p.m.
654	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Hoag	Hγ	pe		s.t.
663	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Mayer (**5**)	*UBV*	pe		OB stars in the vicinity
	Worrall	*UBV*,Hγ	pg		
	Hoag	Hγ	pe		s.t.

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NGC and type	Observer and references (see end of table)	Photometry, method and limiting magnitude			Other data obtained, remarks
744	Hoag	Hγ	pe		s.t.
752	Artiukhina, Kholopov			15·8	density distribution, faint members
	Eggen (**6**)	*UBV*	pe	17	
	Woolley, Murray				p.m. plates taken
	Rohlfs, Vanýsek (**7**)	*BV*	pg	14·3	luminosity function
h+χ Per	Woolley, Murray				p.m. plates taken
	Wildey (**8**)		pg+pe	18	*c*−*m* diagram, 1000 stars
	Schmidt-Kaler, Rohlfs	*UBV*	pg	17·5	11 785 stars
	Bappu (**9**)	Hγ	pe	9	
	Sinnerstad	Hβ,D	pe	10	
	Meurers				p.m.
IC 1805	Schmidt-Kaler, Brosterhus Haffner, Schuster	*UBV*	pg	17	
957	Larsson-Leander	*BV*	pe+pg	16	s.t.
	Hoag	Hγ	pe		s.t.
Tr 2	Hoag	Hγ	pe		s.t.
1027	Hoag	Hγ	pe		s.t.
IC 1848	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Hoag	Hγ	pe		s.t.
1245	Chincarini (in press)	*UBV*			
	Hoag	Hγ	pe		s.t.
α Per cl. =Per mov.cl.	Bappu (**9**)	Hγ	pe	9	
	Heard, Petrie				r.v. + s.t.
	Petrie				convergent point
	Sinnerstad	Hβ,D	pe	10	
1342	Hoag	Hγ	pe		s.t.
Pleiades	Bappu (**9**)	Hγ	pe	9	
	Meadows	*UBV*			flare stars
	Sinnerstad	Hβ,D	pe	10	
	Reddish (**10**)	*UBV*	pg	16	3000 stars
	Crawford (**11**) (see also end of the table)	Hγ	pe		stars earlier than G0
1444	Hoag	Hγ	pe		s.t.
1502	Purgathofer (**12**)	*UBV*	pg+pe	14·5	
	Hoag	Hγ	pe		s.t.
1513	Bronnikova (**13**)				membership
1528	Larsson-Leander	*BV*	pe+pg	16	s.t.
	Hoag	Hγ	pe		s.t.
1545	Hoag	Hγ	pe		s.t.
Hyades	Wayman, Symms, Blackwell (**14**)				p.m., r.v.; convergent point; velocity dispersion
	Petrie, Gutmann (see also end of the table)				r.v.
1647	Hoag	Hγ	pe		s.t.
1662	Hoag	Hγ	pe		s.t.
1664	Hoag	Hγ	pe		s.t.
1778	Hoag	Hγ	pe		s.t.
1807	Purgathofer (**12**)	*UBV*	pg+pe	17·2	no cluster (?)
1817	Purgathofer (**12**)	*UBV*	pg+pe	16	
1893	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	

NGC and type	Observer and references (see end of table)	Photometry, method and limiting magnitude			Other data obtained, remarks
	Mayer (**5**)	*UBV*	pe		OB stars in the vicinity
	Hoag	Hγ	pe		s.t., search for variables
Stock 8	Mayer (**5**)	*UBV*	pe		OB stars in the vicinity
1907	Purgathofer (**15**)	*UBV*	pg+pe	15·5	
	Hoag	Hγ	pe		s.t.
1912	Hoag	Hγ	pe		s.t.
1960	Bronnikova (**13**)				membership
Orion Neb.	Walker	*UBV*	pe	14	
	Walker, Lallemand, Duchesne (**16**)				spectra of contracting stars
	Meurers (*Veröff. Bonn*)				p.m.
2099	Woolley, Murray				p.m., plates taken
= M37	Bronnikova (**13**)				membership 4123
	Brosterhus (**17**)	*UBV*	pg	17	2291 stars luminosity function
2129	Hoag	Hγ	pe		s.t.
2168	Woolley, Murray				p.m., plates taken
	Woolley, Jones, Lynden-Bell				s.t. + r.v.
	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Hoag	Hγ	pe		s.t., search for variables
2169	Eggen	*UBV*			
	Hoag	Hγ	pe		s.t.
2244	Walker	*UBV*	pg+pe	16	material collected
	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Hardie, Heiser	*UBV*	pg	13·5	
2264	Bappu (**9**)	Hγ	pe	9	
	Blanco (**18**)			*I* = 13·3	9 M stars found
2281	Woolley, Murray				p.m., plates taken
2286	Chincarini (**19**)	*UBV*	pe+pg	14·5	
2287	Hoag	Hγ	pe		s.t.
2301	Grubissich, Purgathofer *Z. Ap.*, **54**, 41, 1962	*UBV*	pe+pg	15·0	
	Hoag	Hγ	pe		s.t.
2323	Hoag	Hγ	pe		s.t.
2353	Hoag	Hγ	pe		s.t.
2354	Fenkart *Z. Ap.*, **54**, 49, 1962	*UGR*	pg+pe	16	
2360	Eggen	*UBV*			
2362	Bappu (**9**)	Hγ	pe	9	
	Fenkart *Z. Ap.*, **54**, 49, 1962	*UGR*	pe+pg	15	
2395	Chincarini (**19**)	*UBV*	pe+pg	14·5	
2420	Walker, Sarma (**20**)		pe+pg	16	similar to NGC 752
	Woolley, Murray				p.m., plates taken
2422	Smyth, Nandy (**21**)	*UBVR*	pg	13·5	
	Hoag	Hγ	pe		s.t.
2423	Smyth, Nandy (**21**)	*UBVR*	pg	13·5	
2437	Smyth, Nandy (**21**)	*UBVR*	pg	13·5	
= M46					
	Riddle	*UBV*	pg+pe	17	p.m.
	Meurers (**22**)				p.m.
2516	Stoy (**23**)				r.v. 15 stars
2539	Hogg	*UBV*	pe+pg	14	

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NGC and type	Observer and references (see end of table)	Photometry, method and limiting magnitude			Other data obtained, remarks
2546	Fernie (24)	U_cBV	pe	12	
2547	Stoy (23)				r.v. 10 stars
Praesepe	Artiukhina			13	search for new members
	Artiukhina (26)				density distribution
	Bappu (9)	Hγ	pe	9	
	Sinnerstad (see also end of the table)	Hβ,D	pe	10	
IC 2391	Lyngå (27)	UBV	pe	12	rel. p.m.
	Buscombe (28)	Hγ		9	s.t. and lum. (MK), r.v. for 35 stars
	Feinstein (29)			8	r.v., s.t.
	Feinstein (30)				instability
IC 2395	Lyngå (27)	UBV	pe+pg	12·5	
2669	Hogg, Bhatti	UBV		14	material collected
2670	Lyngå (27)	UBV	pe+pg	12·5	
Tr 10	Lyngå (27)	UBV	pe	11	rel. p.m.
2682 = M67	Artiukhina, Kholopov (31)				density distribution
	Eggen, Sandage	UBV		15	
	Murray			B = 16·5	p.m., 480 stars
	Woolley	BV		16	1 square degree
	Woolley (32)				stellar distribution
2682	Sher (33)	m_{pg}	pg	20	luminosity function
3114	Lyngå (27)	UBV	pe+pg	12	
	Jankowitz, McCosh (34)	U_cBV	pe+pg	13	
3228	Hogg (35)	UBV	pe	14	
Westerlund 1	Westerlund (36)	$UBVRI$	pe+pg	15·5	
IC 2581	Fernie (24)	U_cBV	pe	13	
	Smyth	UBR			plates taken
3293	Smyth	UBR			plates taken
Mel 101	Braes (37)	U_cBV	pe	12·6	
IC 2602	Whiteoak (38)	UBV	pe+pg	12	s.t. and luminosity
	Braes (25)	U_cBV	pe	9	
Tr 16 = η Car cl.	Feinstein (39)	UBV	pe	12	
Tr 17	Sher	UBV	pe+pg	15	material collected
3496	Sher	UBV	pe+pg	15	material collected
3572	Bok, Graham	UBV, Hβ	pe	10	material collected
Tr 18	Fernie (24)	U_cBV	pe	12	
	Bok, Graham	UBV, Hβ	pe	10	material collected
3603	Sher (40)	UBV	pe+pg	15	material collected
Mel 105	Sher	UBV	pe+pg	15	material collected
3766	Sher (41)	UBV	pe+pg	15	material collected
	Ahmed (42)	$UBVR$	pg+pe	13·5	
IC 2944	Thackeray, Wesselink				$c-m$ array and spectra
4052	Engver	UBV	pe+pg	15	
4103	Wesselink	BV			
4349	Fernie (24)	U_cBV	pe	12·5	
Coma	Bappu (9)	Hγ	pe	9	
Berenices	Meadows (43)				r.v. of met. line stars
	Meadows				rot. vel. of brighter stars
	Sinnerstad	Hβ,D	pe	10	
	Argue (44) (see also end of the table)	UBV	pe	15·5	180 stars

NGC and type	Observer and references (see end of table)	Photometry, method and limiting magnitude			Other data obtained, remarks
4755	Hogg	*UBV*	pe+pg	16	material collected
	Feast (**45**)				r.v. + s.t.
4852	Westerlund	*UBVRI*	pe+pg	15·5	material collected
H 8	Westerlund	*UBVRI*	pe+pg	16	material collected
5281	Hogg	*UBV*	pe+pg	14	material collected
	Smyth	*UBR*			plates taken
UMa mov.cl.	Stephenson (**46**)				search for white dwarfs
	Bappu (**9**)	Hγ	pe	9	
	Meadows (**47**)				rot. vel. of A stars
5822	Smyth	*UBR*			plates taken
5823	Smyth	*UBR*			plates taken
6025	Hogg	*UBV*	pe+pg	15	material collected
6067	Engver	*UBV*	pe+pg	15	
	Thackeray, Wesselink,	*UBV*	pe	16	
	Harding (**48**)	*BV*	pg	16	r.v., s.t. brightest stars
6124	The, Lyngå	*UBV*	pg+pe	16·3	material collected
6134	Smyth	*UBR*	pg	14	
6167	Smyth	*UBR*	pg	14	
	Whiteoak (**49**)	*BV*	pg	13·5	
6193	Westerlund	*UBVRI*	pe+pg	15	material collected
6204	Whiteoak (**49**)	*BV*	pg	13.5	
Westerlund 2	Westerlund (**50**)	(*U*,*B*) *VRI*	pe+pg	19	
6383	Thackeray				spectra of brightest stars
IC 4665	Abt				r.v., plates being taken
6451	W. Becker	*UGR*	pg		
6475	Buscombe	Hγ		9	s.t., r.v. of brightest stars (material collected)
	Hoag	Hγ	pe		s.t.
	Feinstein (**51**)			7	r.v. + s.t. of 7 stars
6494	Hoag	Hγ	pe		s.t.
Tr 31	W. Becker	*UGR*	pg		
6520	W. Becker	*UGR*	pg		
6530	Walker (**52**)				s.t. of faint stars
6531	Hoag	Hγ	pe		s.t.
Cr 469	Grubissich (**53**)	*UGR*	pg	16·7	
6603	Grubissich	*UGR*	pg		
6604	Kharadze, Bartaya (**4**)			12·0	s.t. in the surroundings
6611	Walker (**54**)	*UBV*	pe+pg	16·7	
= M16	Blanco (**18**)			*I* = 12·8	search for M stars
	v. Schewick (**55**)			13·2	p.m.
	Walker				faint T Tau, RW Aur stars
	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Hardie-Heiser	*UBV*	pg	14	plates taken
	Hoag	Hγ	pe		s.t.
Tr 33	Grubissich (**53**)	*UGR*	pg	16·1	
6633	Kraft, Mavridis				rot. vel.
IC 4725 = M25	Grubissich	*UGR*	pg+pe		
6649	The, Roslund (**56**)	*UBV*	pe+pg	16	
	Roslund, Pretorius (**57**)				1 possible Cepheid
Tr 35	Hardie, Heiser	*UBV*	pg	16	plates taken
	Apriamashvili (**58**)	$m_{pg} m_{pv}$	pg	16	s.t.

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NGC and type	Observer and references (see end of table)	Photometry, method and limiting magnitude			Other data obtained, remarks
6694	Hoag	Hγ	pe		s.t.
6704	W. Becker	*UGR*	pg	15·8	
An near 6704	W. Becker	*UGR*	pg	15·5	
6705 = M11	Savitsky (**59**)				p.m., 1617 stars
	Bronnikova (**13**)				membership
	Thackeray				spectra of brightest stars
	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
6709	Hoag	Hγ	pe		s.t.
Delta Lyrae cluster	Eggen	*UBV*			
6755	Steinlin	*UGR*	pg		
	Hoag	Hγ	pe		s.t.
6756	Steinlin	*UGR*	pg		
6779 = M56	Woolley, Murray				p.m. plates taken
6793	Upgren	*UBV*	pe	11	
Cr 399	Upgren	*UBV*	pe	11	
6802	Hoag	Hγ	pe		s.t.
Cr 401	v. Schewick (**55**)				p.m., no cluster
6819	Barkhatova, Shashkina (**61**)	*BV*	pg	15	
6823	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Mayer (**5**)	*UBV*	pe		OB stars in the vicinity
	Hoag	Hγ	pe		s.t.
Roslund 2	Upgren	*UBV*	pe	11	
6830	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Hoag	Hγ	pe		s.t.
6834	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Mayer (**5**)	*UBV*	pe		OB stars in the vicinity
	Hoag	Hγ	pe		s.t.
Mel 227	Hogg	*UBV*	pe+pg	14	material collected
6871	Hardie, Heiser	*UBV*	pg	16	plates taken
	Purgathofer (**3**)	*UGR*	pg+pe	15	
	Hoag	Hγ	pe		s.t.
	Lodén + Lodén (**62**)	*UBV*	pe	12·5	57 stars, photometric standards
Roslund 5	Upgren	*UBV*	pe	11	
6882/5	Hardie, Heiser	*UBV*	pg	14	plates taken
	Hoag	Hγ	pe		s.t.
6883	Purgathofer (**3**)	*UGR*	pg+pe	14·7	
IC 4996	Purgathofer (**3**)	*UGR*	pe+pg	14·5	
	Hoag	Hγ	pe		s.t.
6910	Hardie, Heiser	*UBV*	pg	16	plates taken
	Hoag	Hγ	pe		s.t.
6913	Kharadze, Bartaya (**4**)			12·0	s.t. in the surroundings
	Hardie, Heiser	*UBV*	pg	16	plates taken
	Hoag	Hγ	pe		s.t.
Roslund 6	Upgren	*UBV*	pe	11	
6939	Chincarini (**63**)	*UBV*	pe+pg	15·5	
	Woolley, Murray				p.m. plates taken
	Barkhatova, Shteinberg				*c-m* diagram, old cluster

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NGC and type	Observer and references (see end of table)	Photometry, method and limiting magnitude			Other data obtained, remarks
6940	Larsson-Leander				systematic errors of magnitudes
	Hoag	Hγ	pe		s.t.
Roslund 7	Upgren	*UBV*	pe	11	
7031	Hoag	Hγ	pe		s.t.
7039	Schoneich (**64**)				real cluster
7062	Hoag	Hγ	pe		s.t.
7063	Hardie, Heiser	*UBV*	pg	16	plates taken
	Hoag	Hγ	pe		s.t.
7067	Hoag	Hγ	pe		s.t.
7086	Hoag	Hγ	pe		s.t.
7092	Woolley, Murray				p.m. plates taken
= M39	Woolley, Jones, Lynden-Bell				s.t. + r.v.
	Meadows (**47**)				rot. vel. of A stars
	Meadows				r.v. of A stars
7128	Hoag	Hγ	pe		s.t.
7142	Eggen	*UBV*			
IC 5146	Walker				faint T Tau, RW Aur stars
	Blanco (**18**)			I = 12·9	4 M stars found
7160	Hoag	Hγ	pe		s.t.
7209	Hoag	Hγ	pe		s.t.
IC 1434	Larsson-Leander	*BV*	pe+pg	16	s.t.
7235	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Hoag	Hγ	pe		s.t.
7243	Woolley, Murray				p.m. plates taken
7261	Hoag	Hγ	pe		s.t.
7380	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Hardie, Heiser	*UBV*	pg+(pe)	16	plates taken
	Hoag	Hγ	pe		s.t.
7510	Schmidt-Kaler, Brosterhus, Haffner, Schuster	*UBV*	pg	17	
	Hoag	Hγ	pe		s.t.
An x, An y near NGC 7510	Grubissich	*UBV*	pg		
7654	Woolley, Murray			16	p.m.
= M52	Hoag	Hγ	pe		s.t.
H 21	Barkhatova, Zhelvanova				*c-m* diagram, luminosity function
7788	Barkhatova, Zhelvanova				*c-m* diagram, luminosity function
	Grubissich	*UBV*	pg		
7789	Woolley, Murray				p.m. plates taken
Blanco 1 = ζ Scul. cl.	Westerlund (**65**)	*UBV*	pe	10	
Pleiades	Golay (**66**)	*UBV*	pe		44 stars
Hyades	Rufener, Hauck,				31 stars
Praesepe	Goy, Peytiemann,	B_1, B_2			34 stars
Coma Berenices	Golay (**67**)	V_1, G			26 stars

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Abbreviations and References to Table 2

Abbreviations are the same as for Table 1, page 612

The following references are indicated in the table by numbers.

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Photometric Work

Larsson-Leander (**16**) has made a critical study of the various series of magnitudes and colours that have been obtained for stars in NGC6940. It appears that the photographic magnitudes and colours given by Hoag *et al.* (**17**) are affected by systematic errors amounting to about 0·10 mag for certain magnitude intervals. This, together with the small sample of stars measured and the inclusion of several non-members, explains the peculiar downward slope that has been found for the giant sequence by Johnson *et al.* (**18**).

A photo-electric photometry of Tr 16, including η Car, in the *UBV* system has been done by Feinstein (**19**) for the brightest stars until magnitude 12. The position of η Car in the *c-m* diagram and in the two-colour diagram is very unusual. If η Car is a member of the cluster, it is in the 'gap'. If it is not physically connected, there are many suggestions about this very peculiar star.

At the Flagstaff Station (U.S. Naval Observatory) an extensive programme on 64 clusters is under way by Hoag. Photo-electric Hγ-measures and spectral classifications have been completed for 380 early type stars, selected from these clusters. Polarization measures are now being made for the same stars. The investigation aims at determining values of reddening and absolute magnitudes of individual stars for interpretation of the polarization data.

The Perseus double cluster is still being investigated at several observatories under various aspects. Wildey (**27**) completed an extensive photographic-photoelectric investigation of the association and parts of the clusters proper. Approximately 1000 stars have been measured down to $V = 17$ with reliability, and $V = 18$ with unreliable photographic extension. In the two-colour diagram the O stars turn away from the early star sequence and follow a short sequence parallel to and nearly coincident with the blue end of Arp's (**28**) blackbody sequence. The intrinsic-colour versus spectral type relation is also found to be monotonic, unlike the previously published curve of Johnson (**29**). The *c-m* diagram is split into three sequences which can be interpreted as signifying three fairly distinct maxima in the rate of star formation at three epochs in the past.

At Bonn, Schmidt-Kaler and Rohlfs are completing a photometric study (pe scales from Johnson and Wildey, pg plates from the Hamburg 80/120 cm Schmidt) of all stars (6935) in a $36' \times 60'$ field and of eight comparison fields of equal total size (4750 stars) down to $V = 17·5$. Reducing the iris readings is being done automatically by an IBM 650 programme set up by Brosterhus (**30**). It is intended to tie the faint end of the main sequence of the Perseus double cluster directly to the Hyades main sequence. A similar investigation, based on observations of 18 early type open clusters, has been started by Schmidt-Kaler with Brosterhus, Haffner, Schuster.

Westerlund reports on his photo-electric photometry of emission objects and of OB stars in or near clusters in the Coalsack region. The material for the infra-red spectral survey of the Southern Milky Way is complete and the identification work of C, S and M stars has begun. High priority will be given to the search for red stars as possible members of cluster. The analogous work by Mavridis, centred on NGC129, 188, 752, 7789, 7790, M25, is being continued (see Table 2).

To investigate the membership and apparent broadening of the faint end of the Pleiades main sequence discussed by Herbig and the distribution of obscuring matter, an extensive *UBV* photometry of 3000 stars to $V = 16$ has been carried out by Reddish at the Royal Observatory Edinburgh, using the 40/60 cm Schmidt telescope. The results show that the apparent broadening of the faint end of the main sequence is spurious and has two causes: (i) errors of several tenths of a magnitude in the photometry of Johnson and Mitchell due to effects of nebulous fog on the photographically determined magnitudes, (ii) the inclusions of field stars within the proper motion criterion. Any intrinsic dispersion of the main sequence does not exceed $\pm 0{\cdot}08$ mag down to $V = 16$. The absence of a contracting sequence is confirmed and raises the possibility that the brighter Pleiades stars may be the result of accretion.

Pesch has worked on the same problem at Kitt Peak National Observatory. The *V* magnitudes of the faint stars of the Pleiades observed with the 36-inch reflector agree well with those of Johnson and Mitchell (1958), but the colours show a large scatter. The errors in $(B-V)$ are such as to reduce the width of the main sequence as presented by Johnson and Mitchell.

The need of suitable *UBV* standards for cluster photometry, both at the Northern and the Southern Sky, is still urgently felt by many observers. Measurements with highest possible accuracy of magnitudes and colours have been measured for 57 stars around NGC6871 in Cygnus by L. O. and K. Lodén (**31**). The data range approximately over the magnitude interval 8 to 12·5 and the $(B-V)$ interval $-0{\cdot}1$ to $+2{\cdot}2$. The average internal probable errors in the result are for V 0·0025, for $B-V$ 0·0033 and for $U-B$ 0·0047. *UBV* photometric standard regions are being prepared, too, by Argue (**32**) in Praesepe (20 stars) and Coma (150 stars).

Walker, using the Lallemand tube at the Lick 120-inch spectrograph, has continued his spectroscopic work on *UV* excess stars in Orion Nebula and NGC2264. Thus energy curves from 3500Å to 4300Å have been obtained for YY Ori and HS Ori, the former under specially favourable conditions. The curve of YY Ori definitely rises shortward of the Balmer limit, and indeed is still rising at 3500Å. Hence, while some Balmer emission is present, it appears that Balmer emission cannot account for the entire *UV* excess, and we must assume with Ambartsumian that some unknown physical process is occurring. The Balmer lines are visible to H 17, quite in contrast to HS Ori, when again large *UV* excess is present, but the last visible hydrogen line is H delta. The rise in the energy curve at 3500Å might be explained by Balmer emission, if a suitable external energy source—infalling material—can be found. The existence of infalling material appears indicated by the fact that half of the observed *UV* excess stars show redward displaced H-absorption lines. They tend to occur among the brighter members of the group. More observations of all members of the group are needed. Walker plans to make some all-night runs with simultaneous spectroscopic and photometric observations to tackle the problem in further detail.

Narrow-band photometry at 3500, 4100, 4700 and 5500Å for 31 members of the Coma cluster was carried out by Strömgren. He attempted to strengthen the calibration of the intrinsic colour vs. Balmer index diagram in terms of absolute magnitude, and to compare the metallic-line index obtained in Coma and Hyades.

The seven colour photometry developed at Geneva Observatory (**113**) permits to introduce a parameter of metallicity *m*. The correlation of *m* with the classification of metallic stars (Weaver) is excellent. We have found several stars unknown as metallic stars by the spectroscopists but with photometric characters of the metallic line stars. We have found such stars in Pleiades, Hyades, Praesepe (**114**).

Spectrographic Work

Kraft and Mavridis have started a study of the rotational velocities of the members of the open cluster NGC6633. The observational material consists of spectrograms with dispersion 20-40 Å/mm taken with the 200-inch and 60-inch reflectors of the Mt. Wilson and Palomar Observatories. Spectrograms for 50 stars in the area of NGC6633 and 28 comparison stars with known rotational velocities have been already taken and are currently studied.

Petrie has begun a programme of spectrographic observations of members of 12 open clusters. The observations will, at present, be made with a single-prism spectrograph giving a linear dispersion of 51 Å/mm at Hγ and stars to 9·0 mag will be included. Later it is hoped to observe still fainter members with a fast grating spectrograph. The programme is undertaken to supply spectral types for independent estimates of reddening, absolute magnitudes from spectrophotometric measures, and radial velocities to check on membership and to give an estimate of the frequency of binaries. Further, Petrie has determined a convergent for the Hyades using the Hamburg proper motions and finds that it is approximately 30° from the cluster. The negative-radial velocities are not in agreement with this conclusion and further study of the discrepancy is necessary. Petrie and Gutmann are measuring radial velocities of selected members of the Taurus cluster employing a Coudé spectrograph for the brighter member (5·5 and 10 Å/mm). The purposes are to investigate the radial velocity difference between the yellow giants and main sequence stars, and to investigate the possibility of a small K-term in the radial velocities.

Feast has used spectrographic data for B type super-giants in NGC4755, 3293 and h and χ Per to recalibrate the intrinsic colours and absolute magnitudes of these stars. The three clusters have very similar HR diagrams. Considering the clusters together there is a conspicuous gap between the top of the main sequence and the super-giant branch. Such a gap was found first in the SMC cluster NGC330 by Arp and it is now clear that it not a sign of abnormal chemical composition of these stars, as it was at one time suggested. The radial velocities in NGC4755 and h and χ Per tend to show the dependence on absolute magnitude previously found by Feast in NGC3293 (1958).

Determinations of radial velocities for stars in clusters and associations have also been commenced by Abt (**33**) at the Kitt Peak 36-inch reflector Cassegrain spectrograph. Work has been completed on a dozen bright stars in NGC457, plates for IC4665 are being taken.

Variable Stars

A paper on 'Eclipsing Variables in Galactic Clusters' has been published by Sahade and Dávila (**13**). The same authors have studied the clusters with ages of the order of those that contain W UMa systems, but no conclusion was possible to obtain.

Cepheids in open clusters IC2581, NGC2546, 4349, Tr. 18 have been searched for by Fernie (**34**) with negative results. A variable star, probably a Cepheid, was found in NGC6649 by Roslund and Pretorius (**35**). Hoag reports on searches for variables in NGC457, 1893, 2168.

Rosino reports on his search for Variable Stars in Clusters as follows: Nebular variables in young clusters or in T-associations have been studied in Asiago since 1961 on blue and infrared plates obtained with the 122-cm telescope and with the 40/50-cm Schmidt. The examined regions are:

(1) Orion trapezium. Continuing the researches on this important association 105 new Variables have been discovered and 16 flares observed. 103 previously known Variables have been studied by Rosino and Cian (**20**).

(2) ξ Ori (IC434 + NGC2024). 102 new variable stars of the nebular type have been discovered by Rosino and Tomissich in a field of 30 square degrees (**21**).

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(3) NGC7023. This is a T-association with a clustering of nebular variables around BD + 67° × 1283. 12 variable stars have been studied by Rosino and Romano (**22**).

(4) NGC6530 = M8. 47 nebular variables have been studied and 27 discovered by Rosino and Carraro (**23**).

(5) NGC1999. 9 variables discovered, 48 observed by Maffei (**24**).

(6) 49 Ori + NGC2244. 23 new variables found by Maffei (**25, 26**).

(7) Other associations and nebulae under advanced study by Maffei (number of new dis covered variables in brackets). NGC6618(8); 6514 (12); 1579 + IC405 (8); IC447 + NGC2264 (50). λ Ori, NGC7000 and IC5070 are investigated by Rosino.

A detailed report of variables is given in Appendix 2 to the Report of Commission 27.

Proper Motions

Lavdovsky (**36**) has published a catalogue of proper motions and m_{pg} of 14 196 stars in 13 open clusters (NGC129, 457, 581, 752, 869, 884, 1907, 1912, 2168, 6882, 6885, 7092, 7209) and in their vicinities. The results of the discussion of the proper motions of the clusters NGC129, 457, 581, 7209 and Tr.1 have been published by Lavdovsky (**37**).

Motions of 58 open clusters have been investigated statistically also by Bronnikova (**38**). A similar work, referring to the motions of open clusters mentioned in the 1961-report of Commission 37 (p. 446) was undertaken by Barkhatova and published in (**39**).

An extensive programme on proper motions has been commenced by Woolley and Murray, working as Guest Investigators at Mt. Wilson during the autumn of 1961. They secured second-epoch astrometric plates with the 60-inch reflector on many clusters for which early plates had been obtained by van Maanen. At least two pairs of plates of 14 clusters (cf. Table 2) are now at Herstmonceux for proper motion measurement. The proper motions in the N30 system of the Hyades have been analysed by Wayman, Symms, Blackwell at Herstmonceux. Radial velocity data will supplement the proper motions for a new discussion of the convergent point and velocity dispersion.

Luminosity Function

Starikova (**40**) has intercompared the luminosity function of 13 open clusters using the Kolmogorov and Pearson criteria. For 10 of the clusters there is an essential difference between the luminosity functions at their centres and outer regions.

Peruansky (**41**) has classified 45 open star clusters according to peculiarities of the bright and faint ends of their luminosity functions. The difference between the mean apparent magnitudes of the stars in the periphery and the centre of the cluster seem to be an indicator of its age.

Artiukhina (**42**) has studied the distribution of the stellar density in the Praesepe cluster. She shows that the systems of bright and faint stars of the clusters have different centres of concentration, the distance between them being about 18′ (0·8 psc). Both of the systems have an elongated form (nucleus 70′ × 100′ for bright stars, 117′ × 147′ for fainter stars).

Mention should also be made here of a similar paper by Artiukhina and Kholopov (**43**) referring to M67. Both clusters, M67 as well as Praesepe, consist of a nucleus and a tenuous corona. M67 is shown to have more than 850 members. Tenuous coronas have been established also by the same authors for M37 and NGC752.

At the Uppsala Observatory, Kvistaberg Station, Wallenquist is investigating the distribution of stars in galactic clusters on the basis of star counts on Palomar Sky Atlas maps as well as on plates taken with the 100/135/300-cm Schmidt at the Kvistaberg Station.

The luminosity function of open clusters has been briefly discussed by van den Bergh (**44**). He emphasizes the deficiency of faint stars in clusters as compared with the general stellar population in the vicinity of the Sun. It is true, the data on which his result has been based are not very large. Systematic differences, however, seem to be indicated in many cases and have to be accounted for by special assumptions on the luminosity function of star formation, at any case.

Many other authors (cf. Table 2) have studied the luminosity functions of several open clusters, with the aim of comparing the clusters functions with the Field function. These attempts are suffering to a great extent from the small range of luminosity observed in most of the clusters. It is essential, however, to reach at least $V=18$ or even 20 in order to arrive at significant results. The statistical influence of the field stars in the cluster area has to be accounted for and needs carefully measuring an equal number of stars in representative comparison areas. Considering these difficulties it is not surprising that the results as to both the present and original luminosity function are widely dispersing.

In this connection a paper of K. H. Schmidt (**45**) is to be mentioned in which total masses and ages of 129 open clusters are derived from the observed luminosity functions, diameters and spectral types. This is certainly the most comprehensive tabulation of such data we have at present. From these Schmidt calculates the original total mass ($1{\cdot}1 \times 10^3 M_{\odot}$) and the average total age of clusters ($1{\cdot}2 \times 10^9$ years), which indicate that only 3 or 4 per cent of the present stars have originated in clusters.

STELLAR GROUPS

Eggen reports on three colour observations of all stars brighter than mag. 5·5 (vis) obtained for the purpose of surveying for stellar groups.

The stellar content of previously found stellar groups, like the Pleiades group, Hyades group, Sirius group, Groombridge 1830 group, and of a number of new groups of high velocity stars has been further analysed by Eggen (**46**) in detail. A number of RR Lyrae variables as well as sub-dwarfs have been identified as members of these groups.

SPACE DISTRIBUTION OF OPEN CLUSTERS AND ASSOCIATIONS

Open clusters are considered long since as most valuable indicators of galactic structure up to distances of a few kiloparsec. It has become very clear now that only early type clusters which contain stars of spectral type B2 or earlier may serve as reliable spiral tracers, whereas clusters of later type, will have smoothed out, due to their space motion, any original concentration of the places where clusters had been formed. Many papers are dealing with this problem, but only a few of them are to be mentioned here.

A good deal of papers and discussions presented at the IAU/URSI Symposium no. 20 on 'The Galaxy and the Magellanic Clouds' held at Mt. Stromlo in March 1963, was devoted to these problems. An excellent preliminary report on the Symposium has been given by Bok (**47**). The most impressive contribution came from W. Becker who made two compilations of all existing three-colour observations, the first (**48**) for 82, the second (**49**) for 156 clusters. The method of three-colour photometry as is used in Basel has been applied to most of the observations. The clusters with earliest spectral- or colour-type O to B2 show a distribution along three spiral arms, the clusters of the later type in the opposite show a random space distribution in the galactic plane. The spiral structure is of the same kind as in Sc-spirals. A comparison with H II-regions and long period Cepheids shows that these objects define exactly the same spiral arms as the early type clusters (**50**).

The present ideas on the pattern of the inner spiral arms ($220° < l^{\mathrm{II}} < 355°$) have been summarized by Bok in a paper to be published in the minutes of Symposium no. 20.

J. Ruprecht (paper in press) has estimated the distances of new open clusters listed in Supplement 3 to the Catalogue of Star Clusters and Associations (**1**). The new clusters containing bright blue stars (declination north of $-33°$) confirm very well the spiral arms defined by W. Becker (**48**).

Schoneich and Nikolow (**51**) have shown that open clusters with large dispersion of points on the two-colour diagram belong to the spiral arm populations.

A statistical study on 100 open star clusters is being prepared by Imagawa (Kyoto University). He classified the clusters into three groups according to the absolute visual magnitude of the turn-off point M_{to} in the *c-m* diagrams: I) $M_{to} < -2{\cdot}0$, II) $M_{to} = +1{\cdot}0$, III) $M_{to} > +2{\cdot}5$. Preliminary results are following: (i) Group I shows the galactic arm structure, while II and III do not. (ii) Slight outward motions seem to exist for I. (iii) Luminosity functions are obtained for these clusters theoretically by considering both evolution and escape of stars. For group I they are well coincident with the observed ones, and for II and III definite conclusions are not yet obtained.

EVOLUTION

It has become now more and more clear that the assumption of equal age for all members of a cluster leads to serious conflicts. The upper turn of age and the age inferred from the position of faint members with respect to a normal main sequence do not agree in young clusters, not even in the Pleiades, where stars down to $V = 16$ can be observed. Furthermore, no T Tauri stars have been found in the Pleiades and other young clusters of advanced age. Several proposals have been made to solve this problem. Hayashi (**9**) has computed theoretical evolutionary tracks taking into account the hydrogen convective zones in contracting stars. The lack of very late-type contracting stars in young clusters can be understood if one assumes that the less massive proto-stars did not have time to appear in the *c-m* diagram. The selective preference of OB clusters within the cluster research of the last ten years tends to set a limit to the mass of a proto-star that may have reached the quasi-stable contracting stage (Blanco (**8**)). On the other hand, several suggestions have been made to reduce drastically the contracting time scale (Cameron, 1961).

From a somewhat different point of view Herbig (**52**) has dropped the assumption of coevalness and replaced it by a 'spread-in-ages' picture. In this picture the formation of a cluster or association is a very gradual process producing less massive stars over a long period in a massive dark cloud. Eventually the formation of a high luminosity OB star will stop the ordinary star formation.

The study in seven colours of the bright stars in the Pleiades leads us to suppose that two sequences with different ages are existing in the Pleiades. One is in the part which is rich in interstellar material, the other one is in the poor part (**114**).

The total range of work on evolution of stars and clusters will be reported on within Commission 35.

GLOBULAR CLUSTERS

(Prepared by A. R. Hogg)

New bibliographical surveys appear as Supplements 4 and 5 to the 'Catalogue of Star Clusters and Associations', Prague (**2, 3**). Dr Sawyer Hogg reports the completion of the first Supplement to her 'Bibliography of Individual Globular Clusters'. This supplement, which was delayed in publication, is now due to appear in December 1963. It follows the same form as the first bibliography and includes literature from 1947 through 1962.

A tabular summary of work on individual clusters appearing since the last Assembly is given in Table 3. This does not include Magellanic or other extragalactic globular clusters, these subjects being dealt with in other Commissions.

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Table 3
Globular Clusters
(Bracketed numbers refer to references at end of report)

Cluster NGC	Dimensions Distance	Surface Brightness Colour	Spectro-photometry	*c-m* Array Ref.	System	m_{lim}
104	(88)		(70) (72)	(64)	*BV*	15
				(107)	*BV*	16
				(65)	*BV*	18
362			(70) (72)			
2419	(53)			(75)	*BV*	20
2477				(109)	*BV*	16
2808			(70)			
4147	(53)					
4590 M68	(53)					
4833			(72)			
5024	(53)		(56) (69)			
5053 M53	(53)	(55)	(70) (72)			
5139	(88)			(108)	*BV*	16
5272 M3	(53)	(55)	(56) (69)			
5466	(53) (63)			(63)	*PV*	19
5634	(53)					
5694	(53)					
5824	(53)					
Abel 5				(75)	*BV*	20
5897	(53)					
5904 M5	(53)	(55)	(56) (69)	(59)	*BV*	22
5986	(53)					
6093 M80	(53) (88)		(56) (69)			
6121 M4	(53)					
6144	(53)					
6171 M107	(53)	(55)				
6205 M13	(53)	(55)	(56) (69)			
6218 M12	(53)	(55)				
6229	(53)		(56) (69)			
6254 M10	(53)	(55)	(56) (69) (72)			
6266 M62	(53)					
6273 M19	(53)	(55)	(56) (69) (72)			
6284	(53)					
6287	(53)					
6293	(53)					
6304	(53)					
6316	(53)					
6325	(53)					
6333 M9	(53)	(55)				
6341 M92	(53)	(55)	(69) (110)			
6342	(53)					
6355	(53)					
6356	(53)		(56) (69) (72)			
6388			(72)			
6397			(72)	(111)	*UBV*	17
6402 M14	(53)	(55)	(56) (69)			
6426	(53)					
6440	(53)					

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Table 3 continued

Cluster NGC	Dimensions Distance	Surface Brightness Colour	Spectro-photometry	*c-m* Array Ref.	System	m_{lim}
6441			(72)			
6453	(53)					
6517	(53)					
6522	(53)		(72)	(107)	*UBV*	17
6528	(53)		(72)			
6539	(53)					
6553	(53)					
6569	(53)					
6624	(53)					
6626 M28	(53)		(56) (69)			
6637 M69	(53)		(72)			
6638	(53)					
6642			(72)			
6652	(53)					
6656 M22	(53)	(55)	(56) (69) (72)			
6681 M70	(53)					
6712	(53)	(55)	(72)	(57)	*BV*	18
6715 M54	(53)		(72)			
6723	(53)	(55)	(72)	(110)	*BV*	16
6752			(70) (72)	(110)	*BV*	16
6760	(53)					
6779 M56	(53)		(56) (69)	(84)		
6791				(75)	*BV*	20
6809 M55	(53)		(72)			
6838 M71	(53)	(55)	(56) (69) (72)			
6864 M75	(53)		(56) (69)			
6934	(53)		(56) (69)			
6981 M72	(53)		(72)			
7006	(53)		(56) (69)			
7078 M15	(53)		(56) (69) (72)			
7089 M2	(53)	(55)	(56) (69) (72)			
7099 M30	(53)		(56) (69)			
Abel 13				(75)		
7492				(63)	*PV*	19

Statistical studies

Lohmann (53), using the photo-electric photometry of Kron and Mayall (54), has computed intrinsic colours, the interstellar absorption, the distances and absolute integral magnitudes for 67 clusters. He notes the major effect of interstellar absorption in reducing the apparent diameter and concludes that the cluster diameters depend neither on the absolute integral magnitude, nor on the galacto-centric distance. The mean velocity of cluster stars computed from the Schuster equation varies from 5·2 to 11·8 km/sec in a sample of 15 clusters. Lohmann also discusses surface brightness and space densities in some 16 clusters (55, 56).

Colour Magnitude Arrays

A summary of colour-magnitude investigations on individual clusters is included in Table 3. Because of the faintness of individual stars and the crowded fields, photometric work in this area is largely confined to astronomers having access to the large telescopes. L. Smith and

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Sandage (**57**), investigating NGC6712, confirm an earlier conclusion that the absolute magnitudes of the brightest stars in a globular cluster depend on its chemical composition. Cuffey (**58**), measuring 400 stars to 19^{m} in NGC 5466, derived a *c-m* relation similar to that of M3. NGC5139 (ω Centauri) has been intensively studied by Woolley and collaborators who have measured 6000 stars complete to $V = 16^{m}$ in the outer regions and are also engaged in proper motion and spectral studies of this cluster. The basic data are to appear as *Royal Observatory Annal* no. 2. NGC 6522 is also being studied by this group and the photometry of 400 stars is in course of publication.

Arp (**59**) finds from *UBV* photometry of NGC5904 (M5) a metal abundance of 1/17th of the solar figure, which is relatively metal rich for a globular cluster. The field reddening is negligible, and the age is estimated at 22×10^{9} years. Sandage (**60**) has applied Hoyle's 1959 evolutionary models to estimate ages for M3, M5 and M13, using modern photometric results with blanketing corrections. Because the theory does not predict the observed shape of the *c-m* diagram, the results are uncertain. The ages depend on the assumed H:He ratio. For a ratio of 100:1, the ages are 26, 24 and 22×10^{9} years for M3, M5 and M13. For a ratio of 3:1, these results should be decreased by a factor of 1·6. The metal content in the two cases is constant at 0·1%. N. J. Woolf (**61**), from considerations of fuel supply, gives a limiting age of 6 to 8×10^{9} years for NGC5272 (M3). Böhm-Vitense, Hohlweger and Kohl (**62**) write of evidence that metal abundance in globular clusters decreases with increased distance from the galactic plane (**63**).

Wildey (**64**), in discussing his results on 47 Tuc to $V = 14{\cdot}6$, concludes that the absolute magnitudes of the stars of globular cluster red giant branches are dependent on chemical composition and that there is a strong increase in the relative concentration of stars redward of the RR Lyrae gap, compared with the blue side, as metal abundance increases. This concentration is also noted by Tifft (**65**). Possibly the junction of the horizontal branch and the red giant branch is redder for stars of higher metal abundance. Walker (private communication) has re-examined photometric results for NGC5272 (**66**), NGC6205 (**67**) and NGC6341 (**68**). He concludes that there is some evidence for a fine structure of the red giant branch which may have a 'red' edge composed of (possibly younger) stars having a greater *UV* excess than (possibly older) stars forming a 'blue' edge to the band. The decision whether these differences are due to a difference in metal abundance resulting from evolutionary history, or from differences in temperature and surface gravity, requires the computation of theoretical colours from extensive detailed model atmospheres.

Spectrophotometry

The technique of photo-electric spectrum scanning has been applied by van den Bergh and Henry (**69**) to the integrated light from 23 globular clusters. Discontinuities in the spectral energy distribution near $\lambda = 4000$ Å correlate well with Morgan's metallic line strength indices, whilst other combinations of colour indices allow estimates of reddening to be made. These results have been re-discussed by Lohmann (**56**) and corrections applied for interstellar absorption effects. Aller and Faulkner (**70**) have published results from spectral scans of 10 southern clusters and assigned 'energy distribution equivalents', i.e. the spectral type of the star whose spectral energy distribution most closely matches that of the cluster. These equivalents are generally later than the integrated spectral types of the globulars, indicating a metal deficiency in the latter. Kron (**71**) has measured 21 southern clusters on his six-colour photometric system. Gascoigne and Koehler (**72**) report on G-band intensity in 25 southern globular clusters. The G-band index, which reflects the strength of the horizontal branch relative to the giant branch, correlates well with the Morgan metal types, but displays some anomalies in relation to spectral types.

Spectra

Spectra of field and cluster stars in NGC5139 have been obtained by Harding (**73**); Stephenson (**74**) has reported an objective prism search for M giants in NGC6838, whilst Kinman (**75**) is working on NGC6791, 6205 and 7078. He has also secured spectra of 9 globular clusters in M31 for radial velocities and spectral types.

Stellar Density, Light Distribution, Luminosity Functions

Space distribution for 16 clusters have been reported by Lohmann (**55**). Ivan King (**76**) has counts on plates for 50 clusters north of $\delta = -40°$ with results showing that each cluster is characterized by a star number factor, a core radius and a limiting radius set by the galactic tidal field. Kholopov, working on NGC5466 (**77**), 7078 (**78**) and 7089 (**79**), finds that with increasingly concentrated clusters, the ratio of the outer to inner density increases and large scale density fluctuations in the outer regions become more noticeable. This conclusion is supported by Blagikh's investigation of NGC6341 (**80**). King (**76**) has found that in NGC6205 (=M13) red and blue stars have no significantly different distribution in radial or angular directions. Stellar distribution measures in NGC6397 are reported from the Royal Observatory. Kinman and Michie are deriving luminosity functions for NGC6205 and 6791 (**75**), whilst Wesselink is photo-electrically scanning various clusters.

Proper Motions

Proper motion measures are being continued by the Royal Observatory group in the NGC104, 5139 and 6522 fields.

Galactic Data

Galactic data have been computed from the Kron and Mayall observations (**54**) by Fernie (**81**) who finds the distance from the Sun to the galactic centre to be 9·3 kpc. Comparison with other recent data leads to an adopted value of 9·7 kpc. Sharov and Pavlovskaya (**82**) discussed Kinman's radial velocities for 70 globular clusters. They conclude that clusters participate in the general galactic rotation with an angular rotational velocity which falls off with distance to a value of 10 to 11 km sec^{-1} kpc^{-1} in the solar neighbourhood. The dispersion in cluster velocities increases with the distance, indicating either (*a*) a different origin for different clusters or (*b*) an infiltration of extra-galactic globular clusters.

Stellar content—Variables—Dust.

Kinman has in progress a search for bright blue stars in globular clusters. Two new stars of this kind were found in NGC6025 (M13) and another two in NGC7078(M15). Radial velocities confirm that these stars are actually cluster members.

Rosino (**83, 84**) has examined the following clusters for variable stars, viz. NGC5824, 5986, 6304, 6558, 6569, 6637, 6681 on Radcliffe material, and with Kinman (**85**) has studied Abel no. 1, 5, 7, 11, 12 and NGC7492 on Lick and Asiago material. Rosino has also studied variables NGC6864 (M75) and NGC6712 for secular variations of period (in press). Margoni (**86**) is investigating NGC5024 (M53) for secular variations of periods and NGC6981 (M72) and NGC6402 (M14) for elements of known variables. P. Mayer (**87**) has studied two type *c* and eight type *a* variables in NGC6229. Eggen (**88**) has made *UBV* studies of variables in ω Cen, 47 Tuc and NGC6093 (=M80) and discussed intrinsic colours. Wilkens (**89**) is observing variable stars in NGC104, 3201, 5139, 5904, 6121, 6397, 6541 and 6656. Arp (*et al.*) (**67**) have reported on long period and red variables in 47 Tucanae. Lohman (**53**) has summarized absolute magnitudes of RR Lyrae stars as determined by seven investigators over the last decade. Results range from +0·5 to +0·8 for both pg and *V*. To this summary can now be added Tifft's (**65**) estimate of $M_v = +0{\cdot}55$ for the 47 Tuc variables. Tifft also finds that the luminosity of the cluster type variables does not depend on the metal abundances. Stothers (**90**) has studied 80 variables with periods in excess of 20^d from a selection of 31 clusters. Sixteen long period variables showed a period-maximum luminosity relation similar to field variables, but brighter by about $1^m.5$. There is but little correlation amongst semi-regular and irregular variables. Clusters which contain variables of $P \sim 100^d$ are usually devoid of, or poor in, RR Lyrae stars. Idlis (**91**) has adduced additional confirmatory evidence for his earlier discovery of the existence of interstellar matter in some globular clusters.

A detailed report of variables is given in Appendix 2 to the Report of Commission 27.

Dynamics and Structure

Agekian (**92**) has investigated stellar systems having a force field with local fluctuations. Stellar velocities in such a field correspond to discrete chance processes. The effect of multiple encounters on such processes has been worked out and a corrected probability function is tabulated.

In another contribution Agekian (**93**) discusses the density and average velocities of stars in the central regions of globular clusters, assuming that the movements of the stars are close to linear oscillations through the centre of the system. Agekian (**94**) has also found expressions for the quasi-stationary state of spherical clusters taking dissipation into account. For clusters of low central condensation such characteristics as density, velocity dispersion, velocity of centroid, potential, rate of dissipation, are obtained as functions of the distance from the centre. Agekian and Petrovskaya (**95**) discuss density distribution in spherical clusters during different phases of their evolution.

Hénon (**96**) considers a dynamical cluster model which is in a quasi-steady state slowly evolving under the effect of internal encounters. The cluster is assumed to pass through a homologous series of states, to be made up of stars of equal mass and to have a velocity distribution that is isotropic throughout. The external galactic field is taken into account and leads to a unique solution having a finite mass and radius. The projected density agrees with observation except at the centre of the model where the density becomes infinite. There is a uniform rate of loss of mass (2300 solar masses per 10^9 years) independent of total mass or age. The density distribution was also computed for stars with different masses. More recently, an unsuccessful attempt has been made to develop a model with a non-isotropic velocity distribution.

Ivan King (**76**) has calculated self-gravitating models based on the velocity distribution that is a steady-state solution of the Fokker-Planck equation in a square-well potential. If the cut-off velocity is determined by a finite tidal limit rather than by an escape to infinity, a family of models, which closely fit the star count observations, is obtained. The higher concentration curves strongly resemble the brightness profiles of giant elliptical galaxies in contradiction of an earlier misconceived extrapolation. The rate of escape of stars is fairly constant throughout a model, so that these models are close to the desired long-term stability. The rate depends strongly on the central concentration, being least for the most concentrated models.

Michie (**97**) has published theoretical investigations into the structure of spherical systems. A three-parameter distribution function in terms of energy and angular momentum and a cut-off at the energy of escape is used. With appropriate values for the parameters the results agree with the observations of 47 Tuc by Gascoigne and Burr (**98**). A continuation (**99**) of this work allows accurate computation of the loss of stars of different mass at varying distances from the centre of the system. As evolution proceeds the low mass stars evaporate at a continually increasing rate relative to stars of average mass. A wide range of models is now available from a distribution function derived for the inner regions from the Boltzman equation with encounters (**100**). Encounters and mixing are assumed to be important in the early stages, but later the structure does not change significantly. All models are self-supporting, have finite mass and satisfy the viral theorem. Michie and Kinman (**101**) have described the application of these models to 35 globular clusters using Kron and Mayall data (**54**). For seven of these clusters surface density figures were used as well and there was good agreement in this overlap.

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The results suggest elongated stellar orbits. Further progress in this joint investigation is reported by Kinman, who writes that parameters have been calculated from existing observations to describe the luminosity profile of the central portions of over 50 systems. These profiles should be largely independent of external forces, though sensitive to the stellar orbital eccentricities. Systems more than 20 kpc from the galactic centre have profiles which may be attributed to quite eccentric stellar orbits. Nearer the galactic centre there is no relation between type of profile and galactocentric distance which, possibly, is due to the eccentric galactic orbits of the system. The profile is correlated with the scale and mean density of the systems and hence the scale and density of outer systems are correlated with the galactocentric distance, those at 20 kpc being noticeably larger and less dense. Systems with central relaxation times shorter than 10^{10} years are noticeably more centrally condensed than those of longer relaxation time. The profile is independent of the metal abundance in the cluster. Owaki (**102**) has studied a model to account for the change of globular clusters with time. This is based on a change in the velocity distribution function of the constituent stars. The large clusters, e.g. NGC5139, are still not in equilibrium, medium sized clusters like NGC5272 and 5904 are close to equilibrium. Ages from computed and observed space distributions agree fairly well with ages from *c-m* arrays. Owaki also has in press papers dealing with the formation of the outer envelope of globular clusters (the space density distribution is found to be proportional to r^{-4}); the disintegration due to tidal effects of the Galaxy (the upper limit of the mass of existing clusters is estimated at 10^7 solar masses); the change in radius due to stellar evolution (based on the assumption that the gas from the exploded stars at the final stage of evolution escapes to outer space). Owaki and Matsunami have together studied the effect of the galactic tide on the radius mass and central condensation of the cluster, whilst Matsunami has in press a method of computing mean values of orbital elements of globular clusters using only their positions and radial velocities.

A summary account of the work on the dynamics and structure of clusters which is in progress at the Royal Observatory has been given by Woolley (**103**) in the Halley lecture for 1961. This seeks to explain the major features of a cluster in terms of total mass, total energy and age. The photo-electric observations made by Kron and Mayall have been shown by Woolley and Dickens (**104**) to conform with a theoretical model based on a truncated isothermal gas sphere. The models have been extended by the same authors to provide a first order theory of the rotation of a globular cluster (**105**) and also to calculate the rate of escape of stars from a globular cluster as a result of stellar encounters (**106**). An extensive observational programme of stellar magnitudes, colours, proper motions, radial velocities and surface photometry is in hand to provide material to check the theoretical results (**107**).

RECOMMENDATIONS

(1) Alter, in a comprehensive discussion with Haffner, has pointed out that the time is getting ripe to abandon the term 'galactic cluster' definitely in favour of 'open cluster'. Obviously, 'galactic' has become more and more a topographical rather than a typological characteristic. It has no bearing on apparent features and/or apparent distribution. If one keeps to the present system, one will be forced to distinguish between extragalactic galactic clusters and galactic galactic clusters. In the proposed terminology there would be no internal friction, if one spoke about 'galactic globular clusters'.

(2) In their publication (**5**), The System of Open Star Clusters and Our Galaxy—Atlas of Open Star Clusters, Alter and Ruprecht suggest the advisability of discussing renumbering the open star clusters. The arrangement of the cluster system in nearly all catalogues is based on the sequence of equatorial co-ordinates, although the system of open clusters itself is a galactic one. It is particularly this incoherence between the actual distribution and the disposition in catalogues which calls for a review.

It is quite natural that the first numeration of open star clusters was based on the equatorial system, since it was part and parcel of Dreyer's New General Catalogue which included all earlier observations of conspicuous objects on the celestial sphere, galactic and extragalactic nebulae, including also open star clusters, so that the order records was, as a matter of course, that of the celestial sphere, i.e. the usual equatorial system. However, even this order was later interrupted by the two Index Catalogues, registering the new objects with a new numeration again in equatorial order, and by almost all the following catalogues by a number of authors, e.g. Melotte, Raab, Shapley, Trumpler, Collinder, Haffner, Ruprecht, Berkeley. A glance at the map of open star clusters makes it clear that too many kinds of designations clutter up the region.

Although no catalogue will ever be complete since every new discovery will interrupt the series, it appears advisable to deliberate the question of renumbering the open star clusters to have the system brought into a homogeneous form. (The situation is quite different from that of the globular clusters, which are not distributed throughout the entire galaxy and whose numeration is based predominantly, with only a few exceptions, on the New General Catalogue).

This is, of course, not a scientific problem proper, but a question of scientific technique and orderliness, the solution of which will give the astronomer a homogeneous series of numbers based on the natural distribution of open star clusters and permit an easier survey of clusters in every region of the galactic circle.

After having examined several possibilities, the following arrangement appears to be advisable. The clusters are characterized by two concurrent series of designations, the first being the current numbers, the second giving the galactic co-ordinates in abbreviated form (the last figure in longitude and latitude being the first decimal of degree). The first is intended to serve as brief working designation, the second as precise localization of the object. Any new entry in the first designation would be dealt with decimally, corresponding to its place in the second designation. The following few lines represent an example of the designations.

Examples of proposed designations for clusters

No.	Gal. Co-ord.	RA 1950	Dec	Earlier Design
101	2400 S 093	07^{m} $05^{s}.2$	$-28°08'$	Ru 12
102	2401 N 002	07 42·5	−23 45	2447
103	2401 S 008	07 39·0	−24 13	Ru 29
104	2415 S 006	07 42·9	−25 24	Ru 32
105	2416 N 020	07 52·8	−24 10	2482
106	2416 S 026	07 35·4	−26 29	Ru 27
107	2421 N 005	07 48·2	−25 19	Ha 16
108	2422 N 006	07 49·0	−25 20	Pi
109	2424 S 035	07 33·4	−27 37	Ha 11
110	2425 N 118	08 30·3	−19 29	Ru 62

Perhaps this new system would not be proposed for discussion, if not a new second edition of the Catalogue of Star Clusters and Associations by Alter, Ruprecht and Vanysek (Prague) were presumed to be prepared and published up to the next congress in 1967. This will provide the opportunity to change the pagination of the cards into a new, homogeneous system attributing just one number to each individual object. It would be rather simple to re-arrange on this occasion the clusters in a new galactic order.

Members of the Commission are requested to consider this question because this will facilitate the discussion at one of the meetings of Commission 37.

(3) Walker stresses the need of completely publishing the photometric observations of individual

stars in clusters. At the Berkeley meeting of Commission 37 it was merely recommended that detailed data on the photo-electric standard sequence stars be given. There are, however, critical objects such as M 67, M 13, etc. where a complete knowledge of the existing photometric data is essential which can not be superseded by a diagram. It arises the question whether there should be some special provision made for the publication of extensive lists of observations of individual stars.

(4) Ruprecht, at the Hamburg meeting, will present a recommendation as to the nomenclature of associations.

In conclusion, the writer wants to thank all astronomers who have kindly contributed to this report by sending various kinds of information. Particular thanks are due to Dr A. R. Hogg, Member of the Organizing Committee, who has compiled the whole report on Globular Clusters, and to Dr J. Hardorp, who has arranged the tabulation of the data on Open Clusters.

H. HAFFNER
President of the Commission

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