A NEW CATALOGUE OF BRIGHT GALAXIES AND CLUSTERS OF GALAXIES*

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THE SCOPE OF THE CATALOGUE

In order to extend the data given in the Shapley-Ames Catalogue of 1250 of the brightest galaxies and in the NGC and IC catalogues, we have been engaged for some time in the compilation of a new catalogue listing the positions and apparent photographic magnitudes of all galaxies north of $\delta = -30°$ and brighter than about $m_p = +15.5$. In addition, the catalogue will record basic data on all rich clusters of galaxies north of declination $-30°$ that can be recognized readily on exposures taken in yellow light with the 48-inch Schmidt telescope.

The sky north of declination $-30°$ contains 30,940 square degrees, of which about 10,000 square degrees can be considered obscured by the interstellar dust clouds. The remaining 20,940 square degrees are estimated to contain on the average 0.5 clusters of galaxies per square degree and 1.5 galaxies brighter than 15.5 mag. per square degree. Our catalogue may therefore contain the order of 10,000 rich clusters of galaxies and 35,000 galaxies brighter than $m_p \cong +15.5$.

THE CATALOGUE

To obtain the necessary data for the catalogue the following photographs are being used:

1. Direct photographs of 10 minutes exposure with the 18-inch Schmidt telescope on films of emulsion type 103a-O.

2. Schraffier-pictures on Agfa commercial or on IIa-O films with the 18-inch Schmidt. With the stars smeared out over an area of $1' \times 1'$ and an exposure time of 23 to 30 minutes, squares of stars of apparent magnitude $m_p \cong +15.3$ can be distinguished

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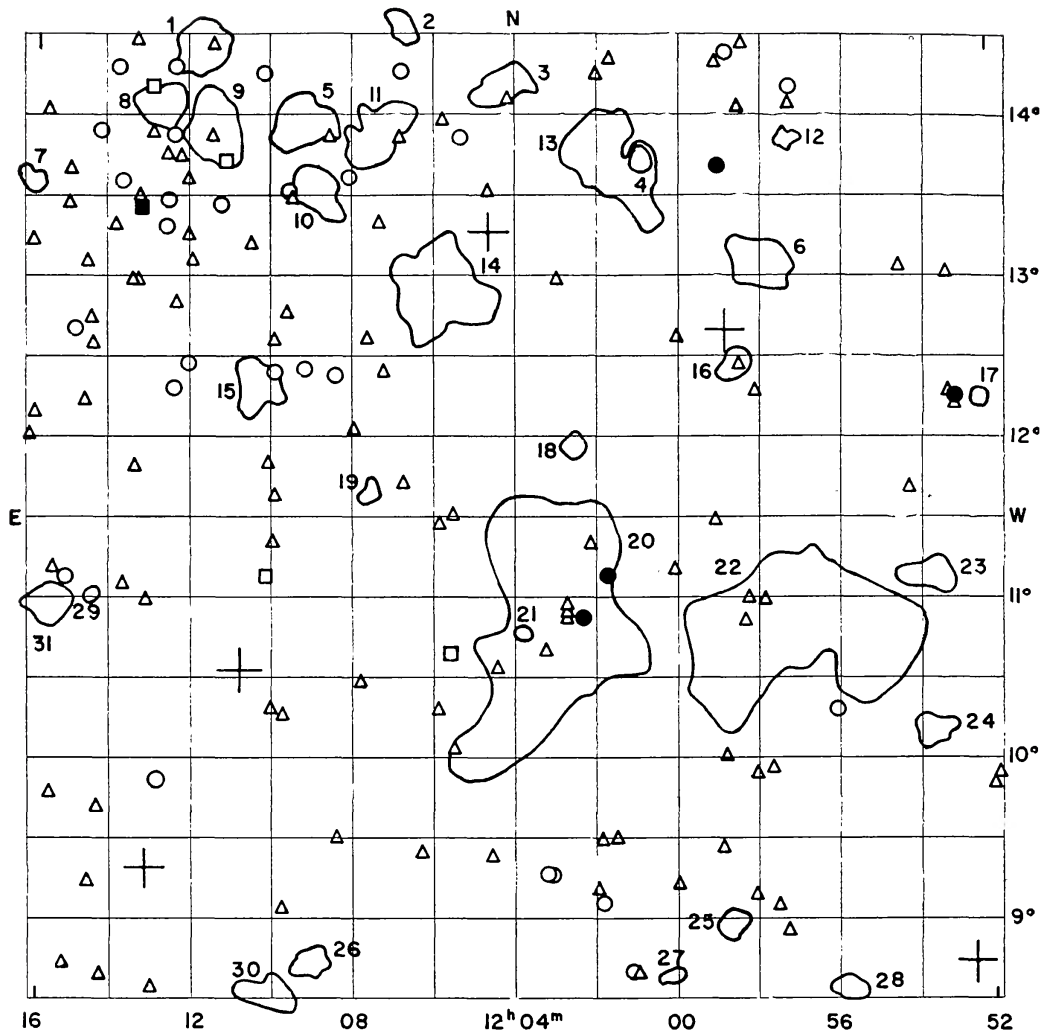
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FIGURE 1

from the general background of the night sky, the brightness of which is of the order of $m_p = +12.8$ per square minute of arc.

3. Plates taken with the 48-inch Schmidt telescope on 103a-D emulsion behind a yellow plexiglass filter and 103a-O emulsions with, respectively, exposure times of fifteen and eight minutes.

The catalogue consists of charts covering square areas of 36 square degrees centered approximately on the plates of the National Geographic Society–Palomar Observatory Sky Survey made with the 48-inch Schmidt, copies of which have been made available to many observatories. The locations of all galaxies and their brightness within 0.5 mag., as well as the locations and con-

TABLE I

CLUSTERS OF GALAXIES IN 48-INCH SCHMIDT FIELD
CENTERED AT α = 12^{h}04^m, δ = +11°30'(1950)

Cluster	Character	Population	Diameter in cm (1 cm = 672")	Distance	Number on Chart
1152.3 + 1215	Compact	39	0.6	ED	17
1153.5 + 1108	Med. compact	116	1.4	VD	23
1153.5 + 1010	Med. compact	62	1.2	D	24
1155.6 + 0834	Med. compact	68	1.0	VD	28
1156.8 + 1054	Med. compact	296	6.0	Near	22
1157.1 + 1352	Compact	36	0.6	ED	12
1157.8 + 1306	Open	94	1.7	MD	6
1158.4 + 1227	Med. compact	93	1.0	ED	16
1158.6 + 0857	Med. compact	78	1.0	ED	25
1200.1 + 0837	Compact	46	0.6	ED	27
1200.8 + 1345	Med. compact	59	1.1	VD	4
1201.4 + 1341	Open	205	3.5	MD	13
1202.5 + 1157	Med. compact	49	0.8	ED	18
1202.9 + 1051	Open	272	7.0	Near	20
1203.8 + 1046	Compact	49	0.5	ED	21
1204.2 + 1411	Open	106	1.7	VD	3
1205.8 + 1255	Open	185	3.7	D	14
1206.8 + 1434	Open	59	1.0	VD	2
1207.5 + 1353	Med. compact	105	2.1	D	11
1207.6 + 1138	Med. compact	42	0.7	ED	19
1208.9 + 1332	Open	87	1.8	VD	10
1209.1 + 0842	Med. compact	56	1.1	VD	26
1209.3 + 1357	Open	101	2.0	D	5
1210.2 + 0832	Open	75	1.5	D	30
1210.5 + 1220	Open	59	1.8	D	15
1211.6 + 1355	Open	124	2.3	D	9
1211.9 + 1426	Med. compact	102	1.9	D	1
1212.8 + 1404	Med. compact	96	1.5	D	8
1214.7 + 1102	Compact	39	0.6	VD	29
1215.6 + 1058	Open	62	1.7	D	31
1216.2 + 1337	Compact	47	0.8	VD	7

Total number of cluster galaxies = 2907.
Average number of galaxies per cluster = 93.8.
Clusters No. 7 and 31 are respectively identical with the clusters No. 24 and 11 on the next chart east.

tours of all rich clusters of galaxies recognizable on the 103a-D photographs, are plotted on the charts. Two tables are intended to go with each chart. The first table will give the positions for
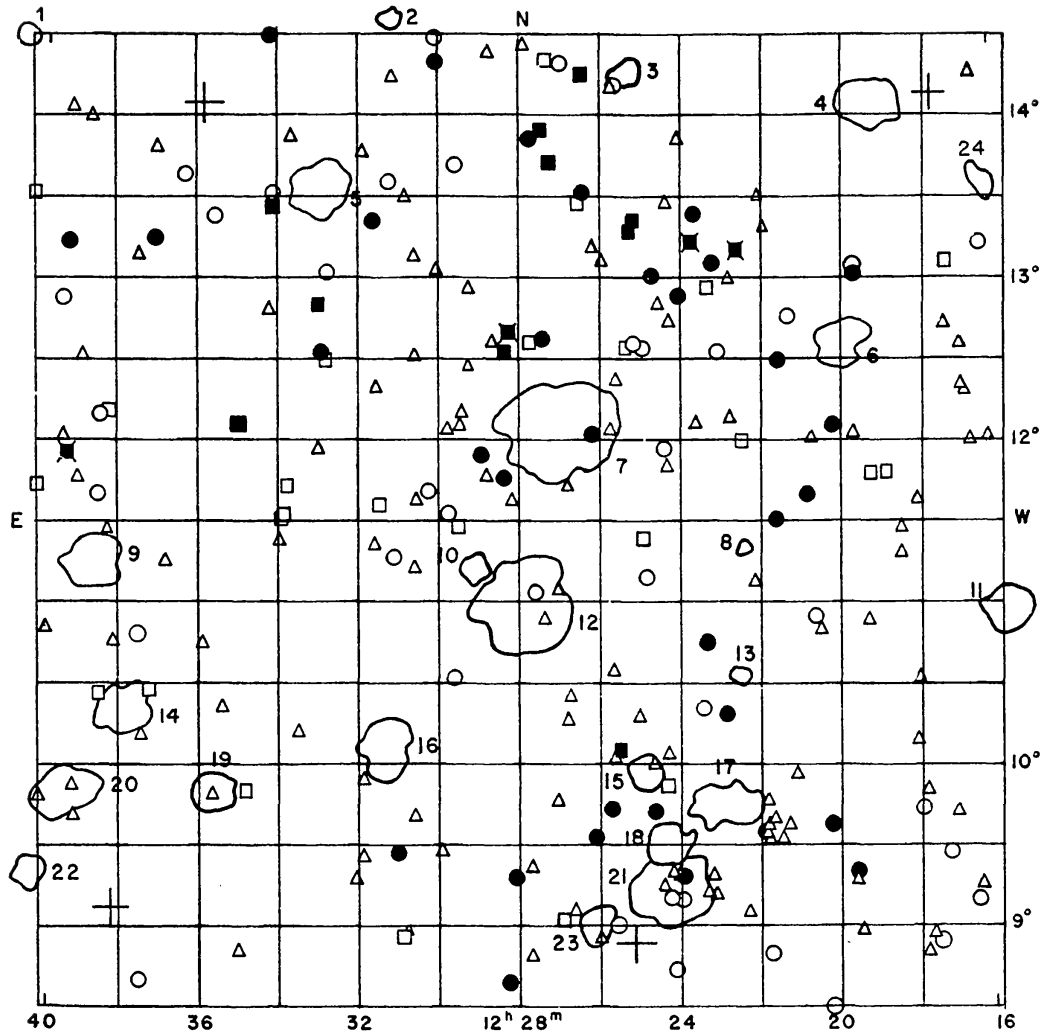
FIGURE 2

1950 of all galaxies brighter than $m_p \cong +15.5$ on a given chart, their photographic magnitudes, and identifications with NGC or IC objects, if any. The second table will list the positions for 1950 of the approximate centers of the rich clusters with their populations, apparent diameters, structural types, and estimated distances on Hubble's old distance scale.

Four examples of the charts are reproduced in the present paper as Figures 1–4. The data concerning the clusters of galaxies on these charts are given in Tables I–IV, respectively. The following universal designation for clusters, adopted by the Mount Wilson and Palomar observers, is being used. Cl 1215.6 + 3025

TABLE II

CLUSTERS OF GALAXIES IN 48-INCH SCHMIDT FIELD
CENTERED AT $\alpha = 12^h28^m$, $\delta = +11°30'$(1950)

Cluster	Character	Popu-lation	Diameter in cm (1 cm = 672″)	Distance	Number on Chart
1215.6 + 1058	Open	62	1.7	D	11
1216.2 + 1337	Compact	47	0.8	VD	24
1219.0 + 1405	Open	207	2.1	MD	4
1219.7 + 1237	Open	128	1.9	D	6
1222.3 + 1121	Compact	46	0.5	ED	8
1222.4 + 1033	Compact	42	0.6	VD	13
1222.7 + 0946	Med. compact	105	1.7	MD	17
1224.1 + 0914	Med. compact	244	2.4	Near	21
1224.2 + 0931	Med. compact	105	1.5	VD	18
1224.8 + 0957	Med. compact	92	1.3	VD	15
1225.2 + 1417	Open	78	1.0	VD	3
1226.0 + 0859	Med. compact	61	1.3	Near	23
1226.9 + 1205	Med. compact	477	3.7	D	7
1227.9 + 1059	Compact	484	3.5	MD	12
1229.1 + 1112	Compact	89	1.0	VD	10
1231.3 + 1437	Compact	36	0.7	ED	2
1231.4 + 1007	Med. compact	157	2.0	VD	16
1233.0 + 1334	Open	148	2.1	D	5
1235.7 + 0950	Med. compact	102	1.3	VD	19
1238.0 + 1020	Compact	121	2.0	VD	14
1238.8 + 1116	Open	138	2.0	D	9
1239.5 + 0949	Open	99	2.0	Near	20
1240.7 + 0918	Compact	114	1.4	D	22
1240.9 + 1429	Med. compact	68	0.9	VD	1

Total number of cluster galaxies = 3250.

Average number of galaxies per cluster = 135.4.

Clusters No. 11 and 24 are respectively identical with No. 31 and 7 on next chart west.

Clusters No. 1 and 22 are respectively identical with No. 2 and 33 on next chart east.

means that the 1950 coordinates of the center of the cluster are $\alpha = 12^h 15^m6$, $\delta = +30° 25'$.

THE GALAXIES BRIGHTER THAN $m_p \cong +15.5$

The positions of all galaxies listed in the catalogue are determined to an accuracy of $\pm0^m07$ in right ascension and $\pm1'$ in declination.
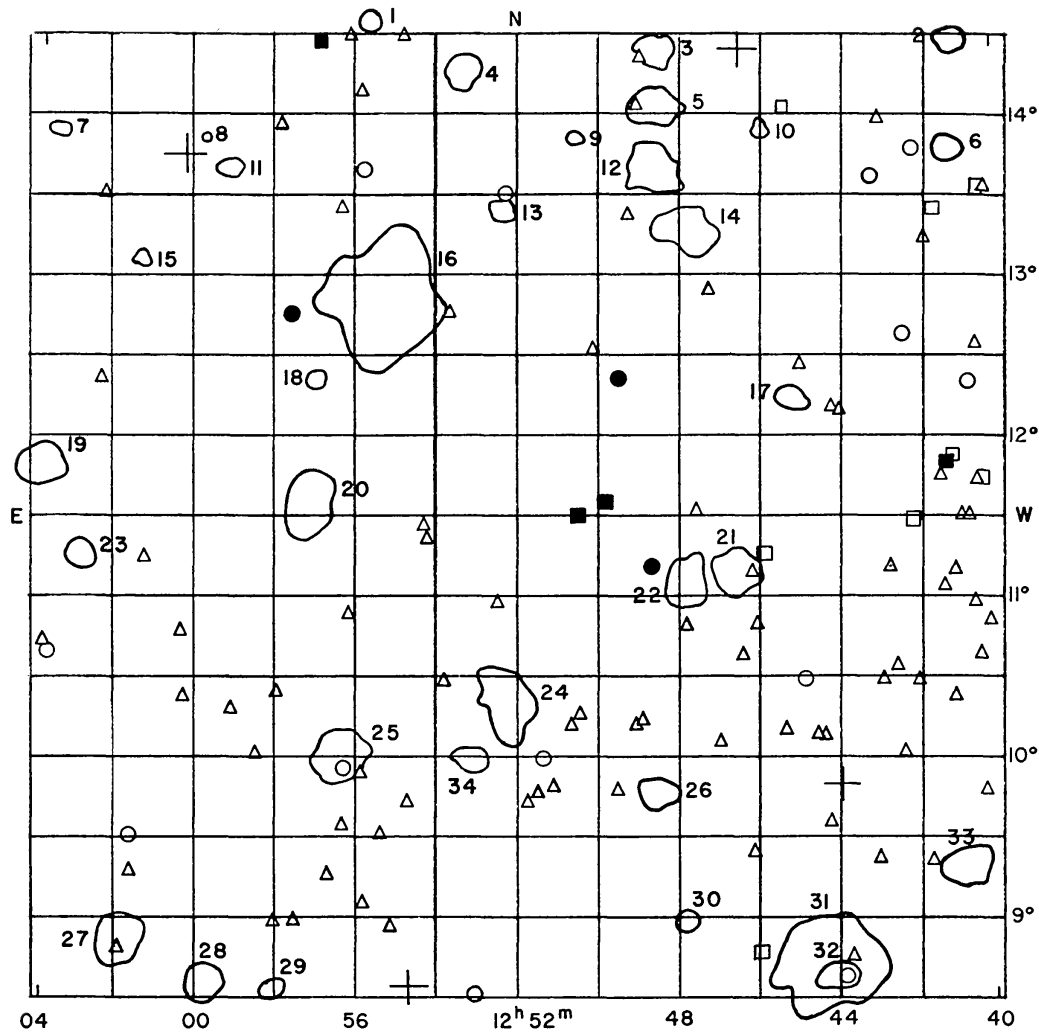
FIGURE 3

The photographic magnitudes of the galaxies brighter than $m_p \cong 15.3$ were measured by comparing their Schraffier image squares, using step scales, with the squares of stars in Selected Areas of the Mount Wilson Catalogue. The step scales cover the range $+10 < m_p < +15$ in 30 steps and were calibrated against the stars in several selected areas. It has been possible to estimate the tenths of the resulting intervals with remarkable precision, and an intrinsic accuracy of ± 0.05 mag. may therefore be expected for the measurements. The accuracy of the final measurements of the photographic magnitudes of galaxies is, however, affected by considerable systematic errors arising from different sources,

TABLE III

Clusters of Galaxies in 48-inch Schmidt Field
Centered at $\alpha = 12^h52^m$, $\delta = +11°30'(1950)$

Cluster	Character	Population	Diameter in cm (1 cm = 672")	Distance	Number on Chart
1240.7 + 0918	Compact	114	1.4	D	33
1240.9 + 1429	Med. compact	68	0.9	VD	2
1241.1 + 1348	Med. compact	68	0.9	VD	6
1243.9 + 0837	Open	82	1.3	VD	32
1244.2 + 0842	Open	120	3.6	MD	31
1245.0 + 1230	Open	66	0.8	VD	17
1245.8 + 1355	Med. compact	53	0.7	VD	10
1246.4 + 1109	Open	148	1.8	MD	21
1247.7 + 1333	Open	70	2.0	MD	14
1247.7 + 1104	Open	118	1.7	D	22
1247.8 + 0857	Compact	85	0.7	VD	30
1248.4 + 0945	Med. compact	103	1.2	D	26
1248.5 + 1424	Open	97	1.2	VD	3
1248.5 + 1404	Open	106	1.6	D	5
1248.5 + 1340	Open	157	1.8	VD	12
1250.5 + 1351	Med. compact	44	0.5	VD	9
1252.2 + 1020	Open	151	2.2	D	24
1252.4 + 1325	Med. compact	64	0.8	ED	13
1253.2 + 0959	Med. compact	81	1.1	ED	34
1253.3 + 1417	Open	85	1.4	D	4
1255.3 + 1251	Med. compact	381	5.0	MD	16
1255.7 + 1436	Med. compact	52	0.6	VD	1
1256.4 + 1001	Open	196	1.9	VD	25
1257.1 + 1221	Med. compact	57	0.6	ED	18
1257.3 + 1133	Open	169	2.0	VD	20
1258.2 + 0833	Med. compact	59	0.8	VD	29
1259.2 + 1340	Open	56	0.7	ED	11
1259.8 + 1351	Compact	35	0.4	ED	8
1259.9 + 0835	Compact	91	1.3	VD	28
1301.5 + 1306	Med. compact	52	0.6	ED	15
1302.0 + 0852	Med. compact	129	1.7	D	27
1303.1 + 1116	Med. compact	98	0.9	VD	23
1303.6 + 1354	Compact	50	0.5	ED	7
1304.0 + 1150	Open	108	1.4	D	19

Total number of cluster galaxies = 3413.
Average number of galaxies per cluster = 100.4.
Clusters No. 2 and 33 are respectively identical with No. 1 and 22 on the next chart west.
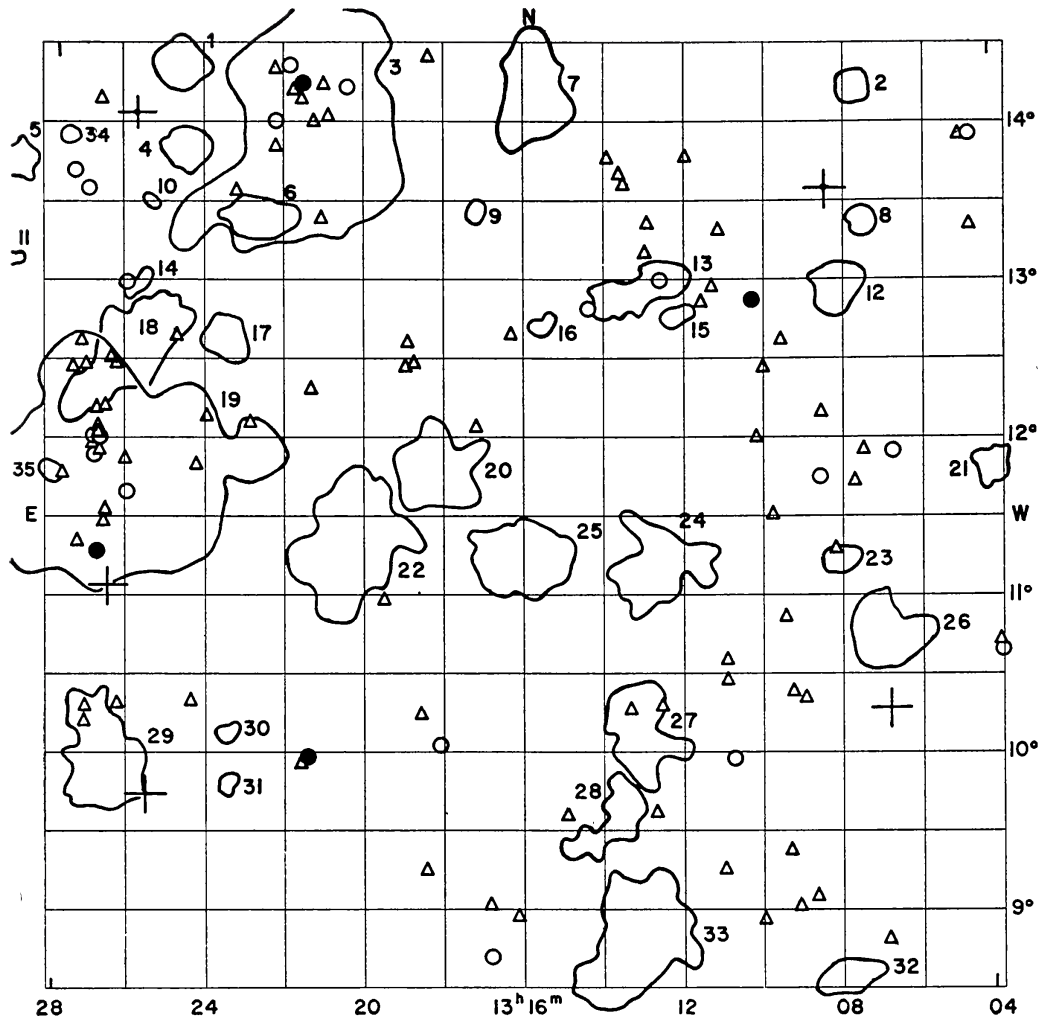Cluster No. 19 is identical with No. 21 on next chart east.

FIGURE 4

such as size and varying surface brightness of the galaxies, brightness of the sky glow, nonuniformity of the sensitivity of the emulsions and other effects. The magnitudes given in the catalogue are believed to be correct within ±0.2 mag. for the brighter and ±0.1 mag. for the fainter objects, provided that their diameters are not much larger than 1 minute of arc. Galaxies fainter than about $m_p = +15.3$, whose squares do not appear clearly delineated on the Schraffier films, have been spotted on the 48-inch Schmidt plates, and their magnitudes were estimated from the direct images with an accuracy of about ±0.2 mag.

THE CLUSTERS OF GALAXIES

The observations listed in this catalogue refer only to *rich clusters* of galaxies. Denoting with m_{max} the apparent photo-

TABLE IV

CLUSTERS OF GALAXIES IN 48-INCH SCHMIDT FIELD
CENTERED AT $\alpha = 13^h16^m$, $\delta = +11°30'(1950)$

Cluster	Character	Population	Diameter in cm (1 cm = 672″)	Distance	Number on Chart
1304.0 + 1150	Open	108	1.4	D	21
1306.7 + 1046	Med. compact	115	2.8	D	26
1307.2 + 1324	Med. compact	77	1.1	VD	8
1307.5 + 1415	Open	59	1.3	D	2
1307.8 + 0835	Med. compact	71	1.8	D	32
1307.9 + 1258	Open	92	1.9	D	12
1307.9 + 1114	Med. compact	60	1.2	D	23
1312.0 + 1248	Open	59	0.9	VD	15
1312.5 + 1113	Open	123	3.0	D	24
1313.0 + 1256	Med. compact	175	2.5	VD	13
1313.0 + 0849	Open	156	4.5	MD	33
1313.1 + 1008	Open	87	3.3	MD	27
1313.6 + 0935	Med. compact	94	2.4	D	28
1315.5 + 1244	Med. compact	55	0.9	VD	16
1315.7 + 1411	Open	103	3.0	MD	7
1316.1 + 1115	Med. compact	166	3.0	D	25
1317.3 + 1327	Med. compact	43	0.8	VD	9
1318.2 + 1149	Med. compact	173	2.0	MD	20
1320.4 + 1121	Med. compact	155	4.6	D	22
1321.4 + 1358	Open	278	8.0	Near	3
1322.7 + 1325	Open	127	1.8	VD	6
1323.5 + 1239	Compact	107	1.6	VD	17
1323.6 + 0949	Compact	44	0.7	VD	31
1323.7 + 1008	Med. compact	42	0.6	VD	30
1324.7 + 1351	Med. compact	106	1.6	D	4
1324.8 + 1423	Open	151	2.0	D	1
1325.6 + 1331	Compact	46	0.6	ED	10
1326.0 + 1300	Med. compact	59	1.1	VD	14
1326.1 + 1236	Med. compact	430	4.5	VD	18
1326.7 + 1000	Open	116	3.5	MD	29
1327.3 + 1145	Open	449	10.5	Near	19
1327.7 + 1355	Compact	46	0.6	ED	34
1328.1 + 1148	Med. compact	62	0.8	ED	35
1329.0 + 1347	Open	71	1.5	MD	5
1329.2 + 1309	Med. compact	53	0.6	VD	11

Total number of cluster galaxies = 4158.

Average number of galaxies per cluster = 118.8.

Cluster No. 21 is identical with No. 19 on next chart west.

graphic magnitude of the brightest member galaxy of a cluster, we define a rich cluster as one containing more than fifty members in the brightness range m_{max} to $m_{max} +3$. Also, for purposes of a preliminary classification we distinguish between compact, medium compact, and loose or open clusters. Aggregates with one single pronounced concentration of galaxies, which are practically in contact with one another, are called *compact clusters*. Many of these are spherically symmetrical. Clusters with a single concentration within which the galaxies appear separated by several of their diameters, or clusters containing several pronounced concentrations, are classed as *medium compact*. And, finally, clouds of galaxies not containing any outstanding concentration of population are designated as *open* or *loose*. The clusters and clouds in Coma Berenices, Virgo, and Ursa Major are, respectively, examples of compact, medium compact, and open clusters of galaxies. Further, we have considered for our catalogue only aggregates containing regions that are populated by more than about 10 $\bar{n}_{mF}$ galaxies per square degree, where $\bar{n}_{mF}$ is the number per square degree of field galaxies of the same apparent magnitude as the cluster galaxies in question. The contour lines

Explanation of symbols used in the charts and tables:

$+$ Boss General Catalogue star

The apparent photographic magnitudes of individual galaxies are shown by the following symbols:

✖	$m_p \leqslant 11.0$
■	$11.0 < m_p \leqslant 12.0$
☐	$12.0 < m_p \leqslant 13.0$
●	$13.0 < m_p \leqslant 14.0$
○	$14.0 < m_p \leqslant 15.0$
△	$15.0 < m_p \leqslant 15.7$

⬭   Contour of cluster of galaxies

shown on the charts are isopleths or equal population contour lines along which the number of galaxies per square degree is equal to about $2\,\bar{n}_{mF}$. As has been shown elsewhere, the clusters are actually very much larger than shown in these charts.[1,2] If the periphery of a cluster is explored to distances from the center where the cluster population represents a density of the order of $0.2\,\bar{n}_{mF}$, the diameters of the clusters may become five times those shown in our charts and tables.

The population of a cluster is the number of galaxies counted in the area A enclosed by the drawn contour minus $2\,A\,\bar{n}_{mF}$.

The distance designations given are only crudely estimated. On Hubble's old distance scale (apparent velocity of recession, corresponding to the universal nebular redshift, of 550 km/sec per million parsecs) our designations mean: "Near" denotes distances smaller than seventy million light years (for instance the well-known clusters in Virgo, Cancer, Perseus, Coma Berenices, etc.); MD = "Medium Distant" is equivalent to the approximate range from 70 to 150 million light years (Corona Borealis cluster); D = "Distant," VD = "Very Distant" (Hydra II cluster), and ED = "Extremely Distant" describe successively the ranges from 150 to 250, 250 to 350, and greater than 350 million light years.

CONCLUSION

Our decision to plot on the same charts the clusters of galaxies that are identifiable with the 48-inch Schmidt and also the individual galaxies brighter than $m_p = +15.5$, has allowed us to establish two useful correlations, namely: (1) concentrations of many of the brighter galaxies often coincide with regions near the centers of the larger clusters shown and therefore indicate their proximity, and (2) wherever there are concentrations among the brighter galaxies, we find few distant clusters of galaxies, which points strongly toward the existence of relatively local accumutions of intergalactic dust.[2,3]

If continued support can be secured, it is estimated that the new catalogue can be completed within the next five years. Also, if the means for the publication of the catalogue can be found, we plan to publish it in several instalments. The first instalment, cov-

ering the strip from $\alpha = 7^{h}$ to 16^{h} and $\delta = -3° 30'$ to $+14° 30'$, is expected to be ready for publication early in 1958.

The work on the positions and magnitudes of the galaxies listed was jointly done by the three authors of this paper. For the tables and charts of the clusters of galaxies, F. Zwicky is solely responsible.

In conclusion we wish to thank the Office of Naval Research, which has given us continued support for our program of measuring the magnitudes of all galaxies brighter than $m_p \cong +15.5$.

[1] F. Zwicky, *Pub. A.S.P.*, **63**, 61, 1951.

[2] F. Zwicky, *Morphological Astronomy* (Berlin, Göttingen, Heidelberg: Springer, 1957).

[3] F. Zwicky, "Statistics of Clusters of Galaxies," in *Proceedings of the Third Berkeley Symposium on Mathematical Statistics and Probability*, Vol. III (Berkeley and Los Angeles: University of California Press, 1956), p. 113.