FAINT Hα-EMISSION OBJECTS IN NEBULOSITIES SURROUNDING THE STAR m Cen.

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RINGKASAN:

Tudjuh puluh delapan buah bintang Hα-emisi jang baru dan dua buah kabut-planit telah diketemukan pada suatu survey dalam daerah kabut gelap dan bertjahaja, pada lingkungan bintang m Cen. Pusat daerah ini terletak pada $\alpha = 13^h04^m$; $\delta = -63°30'$ *(1875). Posisi kira*[2]*, magnitudo V dan warna V-R telah ditentukan. Peta*[2] *jang menundjukkan letak benda*[2] *itu dilampirkan.*
Diantara bintang[2] *emisi ternjata ada 12 buah jang mungkin merupakan bintang berubah. Hal ini menjokong kesimpulan bahwa sebagian daripada bintang emisi jang lemah tjahajanja mungkin membentuk asosiasi*[2]*-T jang mempunjai hubungan dengan kabut*[2] *tersebut diatas dan mungkin djuga mempunjai hubungan dengan asosiasi OB jang dinamakan I Cru.*

INTRODUCTION.

In 1961 plates were taken of the Southern Coalsack region and a region to the East of it, by the present author, for the purpose of a survey of emission Hα objects. They were taken with the Unesco, Schmidt-type telescope, Bima Sakti.

The plates covering the Coalsack region were studied by Hidajat (1962). Forty eight objects with Hα in emission are found. The region to the East of the Coalsack contains irregular bright and dark nebulosities, particularly in the surroundings of the star m Cen. It was therefore to be expected that this region probably contains T Tauri stars with Hα in emission. In the present paper the result of the survey of this region, which is about 25 square degrees, is presented. Figure 1 gives the location of the survey regions with respect to the Coalsack and the bright nebulosity surrounding m Cen.

According to Cederblad (1946) the bright emission nebulosity excited by α Cru is located at a distance of about 67 pc from the sun. This is appreciably less than the distance to the Coalsack of 165 pc

determined by Lindsay (1941) or of 175 pc, determined by Rodgers (1960).

An examination of all existing lists of Hα-emission objects shows that 4 stars of unknown spectral type, 1 Be, 1 Me, 6 W.R. stars and 1 planetary nebula are known to be situated in the present survey field.

It should be mentioned that the location of the Hα-emission stars in the survey region is just at the eastern end of the OB-association I Cru (Schmidt 1957).

POSITIONS, MAGNITUDES AND COLORS.

The positions of the Hα-emission stars were estimated on Franklin-Adams charts.

For the determination of V magnitudes and V-R colors the photoelectric sequence, on the U,B,V,-system, of Rodgers (1960), is transferred to the survey region. The flyspanker method is here employed. The V magnitudes are determined using Eastman Kodak 103a-D emulsion exposed during 10 min. behind a GG11 Schott filter. Two plates are used for the determination of the V magnitudes. The first plate was taken in 1961, and the other in 1962. The probable error of the V magnitudes was estimated to be about $\pm$ 0,1 mag.

For the determination of the R magnitudes an Eastman Kodak 103a-F emulsion in combination with an RG2 Schott filter was used. The exposure time is 20 min. In order to obtain a red magnitude sequence, Rodgers' B-V colors are transformed to V-R colors using the relation: R = V − 0.67 (B-V) given by Blanco et al. (1955).

REMARKS PERTAINING TO THE TABLES AND FINDING CHARTS.

The newly found Hα-emission stars are listed in Table I. The stars of which the Hα-emission is seen only on one plate are classified as doubtful and are collected in Table II. Table III contains the newly detected planetary nebulae and a previously known one, while in Table IV are catalogued the known Hα-emission stars. The columns of these tables are selfexplanatory; the one headed "Int" gives the strength of the Hα-emission line with respect to the continuum (s = strong, m = medium, w = weak).

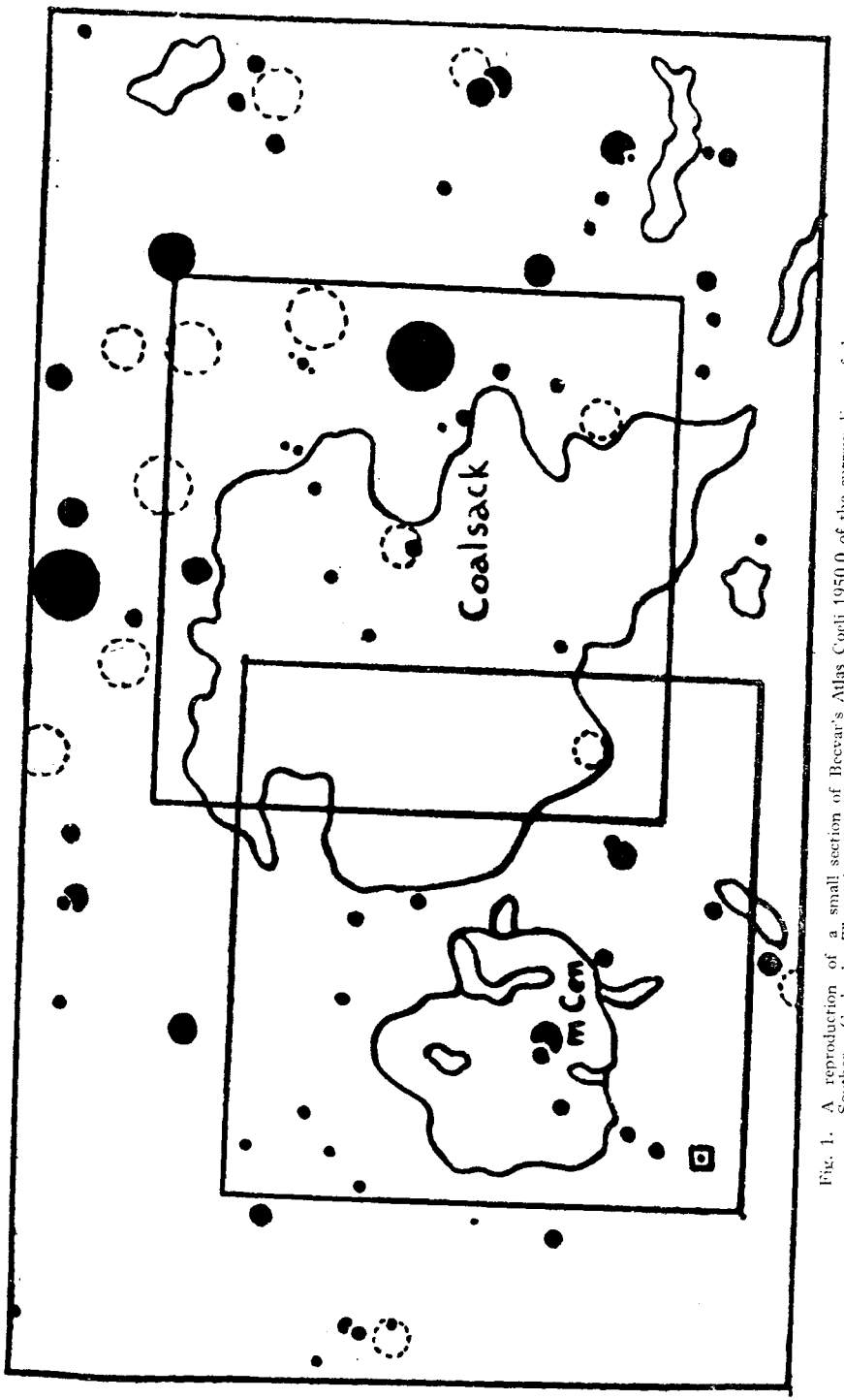

Fig. 1. A reproduction of a small section of Bevar's Atlas Coeli 1950.0 of the surroundings of the Southern Coalsack. The relative position of Hidajat's and the present survey regions is indicated by the two squares.

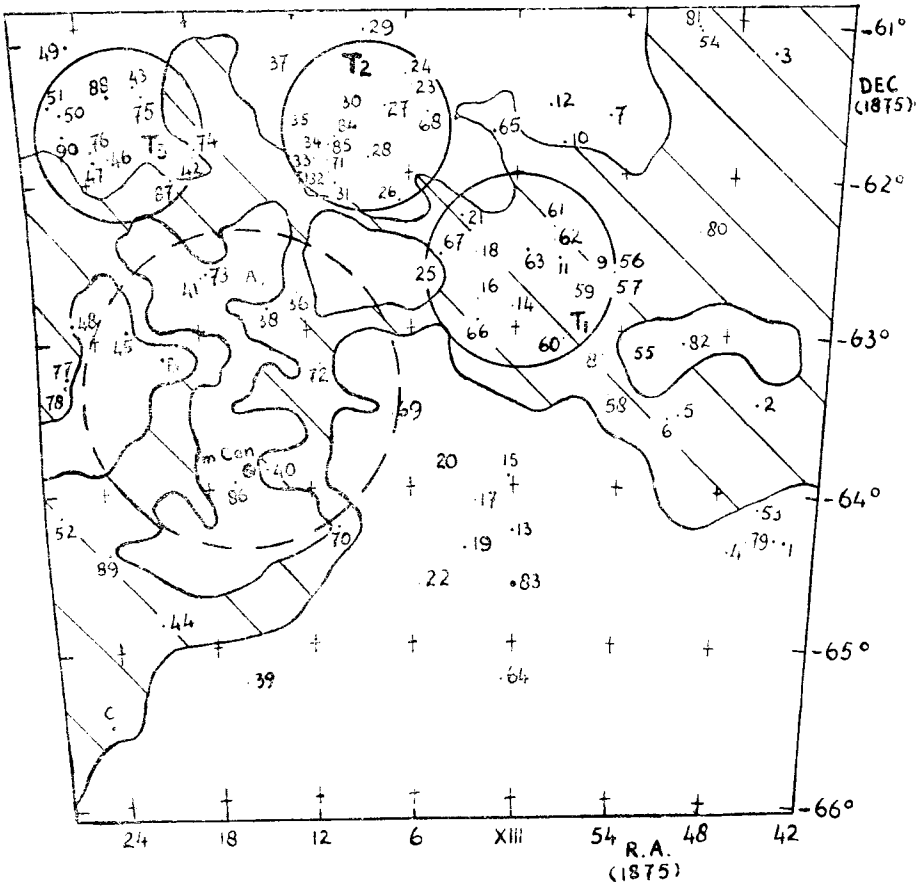

Fig. 2. The surface distribution of the Hα-emission objects with respect to dark and bright nebulosities. The dark regions are indicated by the shaded areas, while the location of the bright nebulosity is given by the dotted circle.

In order to facilitate the detection of the Hα-emission objects finding charts are presented at the end of this paper. They are reproduced from the yellow plate taken in 1961. The orientation of the charts are always: North at the top and East at the left. The size of the charts are all approximatelly 9 × 9 min. of arc.

THE SUSPECTED VARIABLE STARS.

The suspected variable stars presented in Tables I and II were all detected by comparing the V magnitudes obtained with the plates taken in 1961 and 1962. Stars were classified as variable only if the two yellow plates gave magnitudes differing by at least 0.4 magnitudes.

The suspected variables so defined are collected in Table V, where more data about these stars is given. A comparison with the Second General Catalogue of Variable stars shows that these stars have not previously been listed as variables.

THE DISTRIBUTION OF THE Hα-EMISSION OBJECTS WITH RESPECT TO DARK AND BRIGHT NEBULOSITIES.

In Figure 2 the distribution of the Hα-emission stars with respect to dark and bright nebulosities is given. The shaded area indicates the region occupied by dark nebulosities. The rest are semi dark areas, except the region of the bright nebulosity which is located approximatelly within a circle of about one degree radius, centered at $\frac{1}{2}^{\circ}$ to the North of m Cen. In Figure 2 this is indicated by a dotted circle. The region behind the bright nebulosity is exceptionally clear.

An examination of the distribution of the Hα-emission stars suggests the existence of three seperate groups of faint Hα-emission objects, which in Figure 2 are indicated by circles and designated by T1, T2 and T3 respectively. The stars constituting the group T1 are seen projected on the eastern dark portion of the Coalsack, while the two groups T2 and T3 are situated in semi clear regions.

The group T1 consists of 15 stars of which two are variables Considering the possibility that these stars are reddenend, stars No. 14. 21, 56, 57, 59, 62 and 67 may be Be-type stars, while the rest are of, later spectral type. The average V magnitude of the later type stars is 13.0.

The group T2 consists also of 15 stars of which 6 are found to be variable and one is known to be a Wolf-Rayet star. Regarding their colors No. 32 and 33 are probably background or foreground Be-type stars. Of all the other stars, the average visual magnitude is approximately 13.1.

Group T3 consists of 12 stars of which two are known Wolf-Rayet stars and one is a known Be-type star. Regarding their colors it is probable that No. 74 and 43 are also Be-type stars. Furthermore star No. 75 is very probably a foreground star. The six other stars have an average V magnitude of 12.9.

If we assume the same absorption and absolute magnitude for the late type stars of group T1, T2, and T3, then we can conclude that these groups are situated at the same distance. If the members of these groups are T Tauri stars it is probable that they are connected with the Coalsack and its extension to the East. As mentioned previously the distance of the Coalsack is about 175 pc. From Rodgers' (1960) data it can be determined that the average visual absorption A_v is about 1.5 mag. for the Coalsack region. If we assume that the lights of the stars in groups T1, T2 and T3 undergo also the same amount of absorption, we can calculate easily that the absolute magnitude M_v of these stars is about + 5.3 mag. If we take into consideration the fact that for the calculation of this absolute magnitude we did not take the magnitudes of the variables at their maximum brightness, this result is in good agreement with the absolute magnitude of T Tauri stars obtained by Herbig (1952) for other T-associations. We can thus conclude that the late type stars in groups T1, T2 and T3 are probably T Tauri stars forming a T-association with three seperate condensations.

REMARKS TO INDIVIDUAL Hα-EMISSION STARS.

THα 17-4: This star is probably of spectral type M0. On a IIa-O spectral plate it is not visible. Considering its visual magnitude this star should appear on the Franklin-Adams chart, but it is not visible on it. After comparing two direct yellow plates taken one year apart we could not draw the conclusion that the star is variable. But this does not exclude the possibility that this star is really variable.

THα 17-29: This star occurs to have an emission line at λ 6900 Å which can be detected on our 1N plate.

THα 17-41: This star may be the known variable NZ Cen. But a comparison of its magnitude on our two yellow plates does not reveal its variability. It has an emission line at λ 6450 Å, as strong as the Hα-emission line which can definitely be seen on three red spectral plates.

THα 17-43: The same remark as for star THα 17-29 applies for this star.

THα 17-70: On a 1N spectral plate this star appears to be a carbon star.

No. 79: This is Hidajat's star No. 43. It does not appear to have Hα in emission on our plate.

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REFERENCES.

Bidelman, W. P., 1954, Ap. J. Suppl., **1**, 175.
Blanco, V.M., Nassau, J.J., Stock, J., and Wehlau, W. (1955) Ap. J. **121**,637.
Cederblad, S., 1946, Medd. Lund Ser. II, Nr. 119.
Herbig, G.H., 1952, Contr. Dominion Astroph. Observatory, No. 27.
Hidajat, B., 1962, Contr. Bosscha, No. 16.
Lindsay, E.M., 1941, Contr. Armagh, No. 1.
Roberts, M.S., 1962, A. J. **67**, 79.
Merrill, P.W. and Burwell, C. G., 1933, Ap. J., **78**, 87.
Rodgers, A.W., 1960, M.N. **120**, 163.
Schmidt, K.H., 1957, A.N. **284**, 76 = Mitt. Jena, No. 33.

TABLE I.

New Hα-emission stars.

No.	R.A. (1875)	Dec. (1875)	V	V-R	Int.	Sp.
THα 17-1	$12^h 43^m.8$	— 64° 19′	14.7:	1.7	s	—
2	46.0	— 63 27	11.2:	0.1	w	—
3	46.1	— 61 11	11.1:	0.4	w	—
4	47.2	— 64 23	10.4	1.1	m	—
5	50.6	— 63 32	10.7	0.2	w	—
6	51.0	— 63 35	13.0	0.3	m	—
7	54.9	— 61 39	12.8	0.7	m	—
8	54.9	— 63 10	10.3	0.9	m	—
9	55.4	— 62 38	Var.	—	w	—
10	57.4	— 61 49	13.0	0.7	w	—
11	57.6	— 62 33	12.5	1.2	m	—
12	58.2	— 61 34	9.8	0.5	m	—
13	13 00.0	— 64 18	Var.	—	w	—
14	00.2	— 62 52	11.8	0.5	**m**	—
15	00.3	— 63 57	11.8	0.5	m	—
16	02.2	— 62 48	12.7	1.4	m	—
17	02.2	— 64 06	11.8:	0.8	w	—
18	02.3	— 62 32	14.3	1.6	s	—
19	02.9	— 64 24	12.7	1.3	w	—
20	03.0	— 63 54	13.9	1.7	w	M3
21	03.1	— 62 17	13.0	0.3	m	—
22	05.7	— 64 38	14.0	0.9	m	—
23	05.8	— 61 27	12.4	1.2	m	—
24	06.1	— 61 23	Var.	—	m	—
25	06.1	— 62 43	8.3	0.3	m	—
26	06.7	— 62 12	Var.	—	m	—
27	07.3	— 61 35	12.5	1.2	m	—
28	08.2	— 61 55	13.1	0.8	w	—
29	08.3	— 61 06	9.6:	0.2	m	—
30	09.9	— 61 36	Var.	—	w	—
31	10.1	— 62 04	Var.	—	m	—
32	10.4	— 62 00	10.4	0.5	m	—
33	11.2	— 61 54	14.5	0.2	m	—
34	11.9	— 61 49	13.9	1.3	m	—

TABLE I. *(Continued)*

No.	R.A. (1875)	Dec. (1875)	V	V-R	Int.	Sp.
THα 17-35	$13^h12^m.0$	−61°45′	Var.	—	s	—
36	12.4	−62 45	Var.	—	m	—
37	13.7	−61 18	Var.	—	m	—
38	14.1	−62 50	12.9	0.8	m	—
39	14.5	−65 15	11.0:	0.5	m	—
40	14.6	−63 53	11.2	0.9	m	—
41	17.6	−62 38	11.2:	0.7	m	—
42	17.9	−61 59	14.3	1.1	s	—
43	21.1	−61 23	9.7	0.2	m	—
44	21.3	−64 51	8.0	0.1	m	—
45	22.2	−62 58	Var.	—	w	—
46	22.8	−61 51	12.8	0.7	m	—
47	23.6	−61 51	13.2	1.9	m	M5
48	25.3	−62 53	14.2:	2.1	s	M7
49	24.5	−61 07	11.0:	0.4	m	—
50	25.2	−61 32	12.8:	0.8	m	—
51	25.7	−61 29	12.2:	1.2	m	—
52	26.8	−64 08	14.0:	1.4	s	—

TABLE II.

Possible Hα-emission stars.

No.	R.A. (1875)	Dec. (1875)	V	V-R	Int.	Sp.
THα17-53	$12^h\ 45^m.6$	$-64°\ 06'$	9.2:	—0.3	w	—
54	50.1	— 61 04	13.9	0.9	m	—
55	52.8	— 63 04	13.0	0.4	w	—
56	54.6	— 62 39	14.4	0.1	m	—
57	54.7	— 62 40	14.2	0.0	m	—
58	54.7	— 63 25	13.9	1.0	m	—
59	55.6	— 62 45	14.4	0.2	m	—
60	57.2	— 63 04	12.8	1.6	w	—
61	57.9	— 62 22	Var.	—	m	—
62	58.0	— 62 27	13.2	0.2	w	—
63	59.4	— 62 31	13.1	0.9	w	—
64	13 00.7	— 65 13	12.9	2.1	m	M5
65	01.3	— 61 45	10.4	1.0	w	—
66	02.2	— 62 57	13.5	1.3	m	—
67	04.3	— 62 32	11.3	0.6	m	—
68	05.1	— 61 37	12.5	1.8	w	—
69	07.2	— 63 33	11.7	1.2	w	M0?
70	10.4	— 64 16	12.8	2.2	w	—
71	10.5	— 61 55	13.8	1.1	m	—
72	11.3	— 63 13	12.0	0.9	w	—
73	17.4	— 62 37	10.4:	0.6	w	—
74	17.8	— 61 49	12.5	0.0	w	—
75	20.6	— 61 27	6.8	1.0	w	—
76	23.7	— 61 47	Var.	—	w	—
77	25.9	— 63 14	12.0:	2.1	m	—
78	26.0	— 63 16	12.5:	1.6	m	M5

TABLE III.

Previously known Hα-emission stars.

No.	Designation*	R.A. (1875)	Dec. (1875)	m_v**	Sp.	Int.
79	H 43	$12^h 44^m.4$	— 64° 18′	12.7	—	—
80	H 46	49.7	— 62 22	11.2	—	m
81	H 48	50.2	— 61 02	13.5	—	m
82	H 47	50.4	— 63 05	12.6	—	m
83	R 43	13 00.1	— 64 38	5.6	WC6-O9.5I	—
84	R 44	09.9	— 61 47	11.9	WC 6	s
85	R 45	10.4	— 61 49	14.2	WC 7	m
86	B — I 265	16.6	— 64 00	Var.	M6e	—
87	MB 228	19.2	— 62 00	8.8	Be	—
88	R 47	22.6	— 61 26	11.2	WC 7	s
89	R 48	24.5	— 64 23	13.0	Oa	m
90	R 49	25.2	— 61 40	11.2	WN 6	s

* The meaning of the letters in this column is: H = Hidajat (1962); R = Roberts (1962); B-I = Bidelman (1954) — First Table; MB = Merrill and Burwell (1933).
No finding charts are given for stars No. 79 — 83.

** The magnitudes in this column are those given by the various authors, except No. 84, 85 and 89.

TABLE IV.

Planetary Nebulae

Designation	R.A. (1875)	Dec. (1875)	Remarks
A	$13^h 14^m.3$	— 62° 41′	This planetary nebula has a disc shape with a diameter of about 24 seconds of arc. On a IIa-0 10 min. spectral plate the blends of emission lines of [OIII] at λ 4959 and λ 5007 are just visible.
B	20.2	— 63 11	The Hα-emission is strong. No continuum can be seen on our Hα spectral plate, The visual magnitude V is about 14.8.
C	24.7	— 65 21	NGC 5189. The shape is very irregular. Several bright knots are visible on our Hα spectral plate. On a IIa-0 10 min. spectral plate the emission-line of [OIII] at λ 4959 and λ 5007 Å and of Hβ are visible. A reproduction of this nebula from a red spectral plate is given.

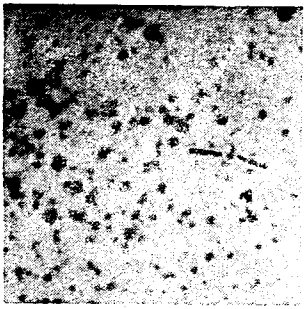
TABLE V.

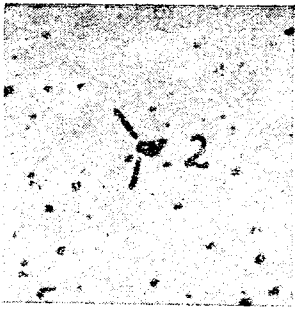
Variable stars.

No.	R.A. (1875)	Dec. (1875)	V_{mean}*	ΔV**
THα 17-9	12^h $55^m.4$	−62° 38′	11.8	0.4
61	57.9	−62 22	13.3	0.4
13	13^h 00.0	−64 18	12.2	0.7
24	06.1	−61 23	12.3	0.4
26	06.7	−62 12	14.5	0.4
30	09.9	−61 36	12.0	0.4
31	10.1	−62 04	13.4	0.6
35	12.0	−61 45	13.4	0.5
36	12.4	−62 45	9.5	0.4
37	13.7	−61 18	11.1	0.5
45	22.2	−62 58	12.7	0.6
76	23.7	−61 47	11.8	0.8

* In this column the average of the magnitudes determined on two yellow plates taken in 1961 and 1962 are given.

** ΔV is the difference in magnitudes obtained using these plates.

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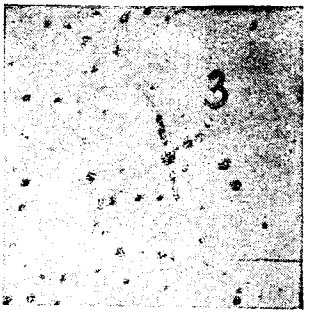
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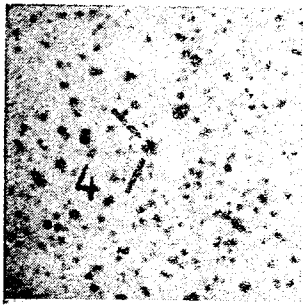
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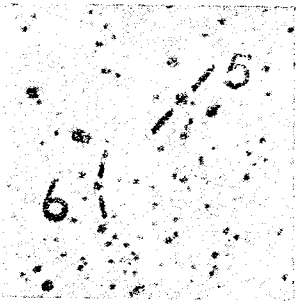
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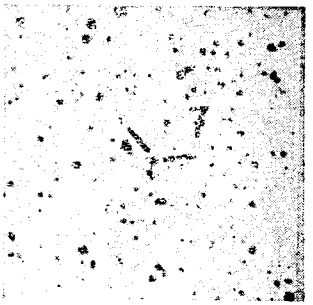

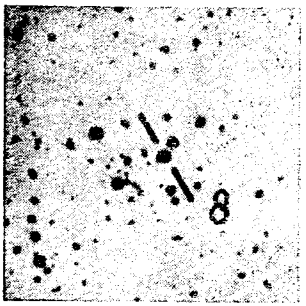
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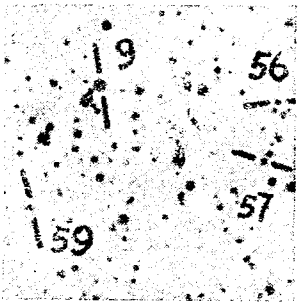
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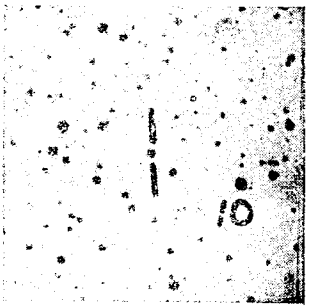
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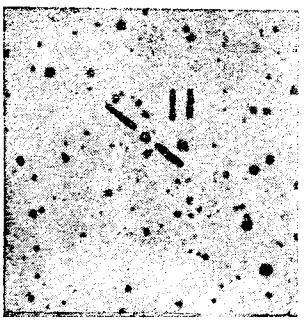
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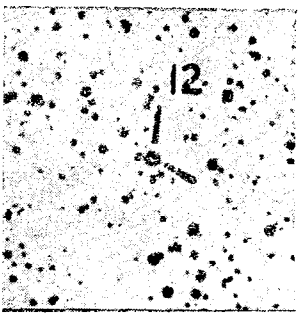
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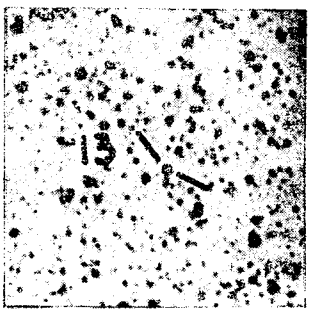
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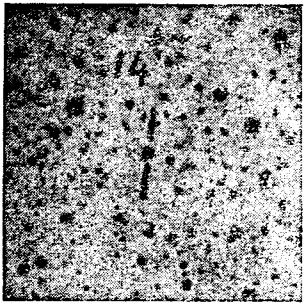
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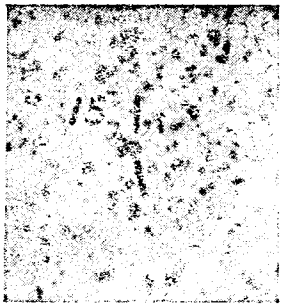
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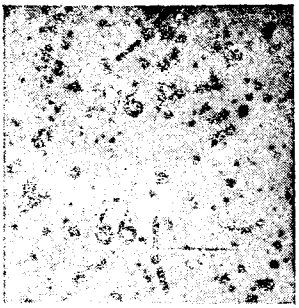
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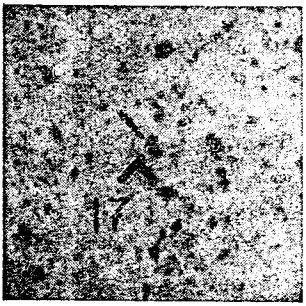
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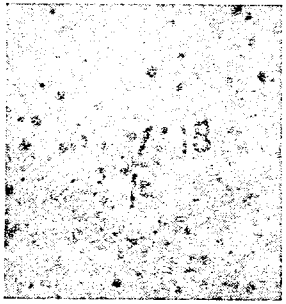
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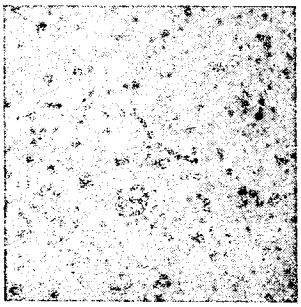

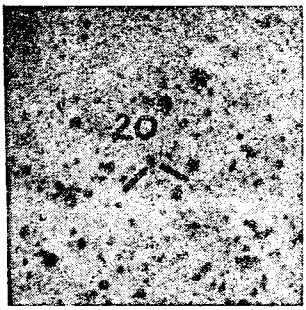
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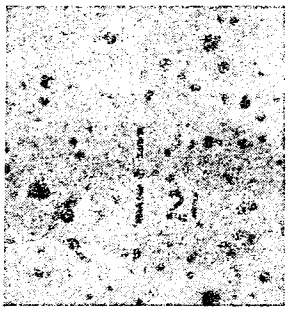
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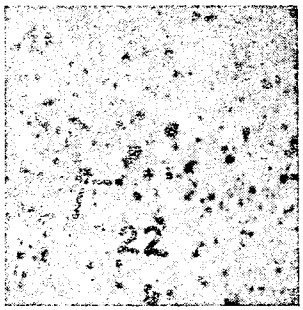
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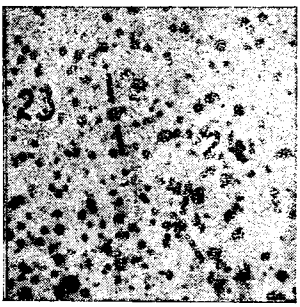
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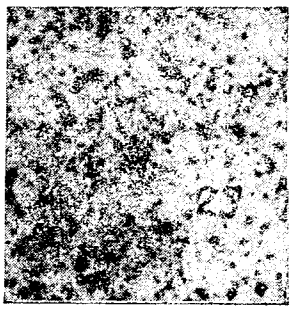
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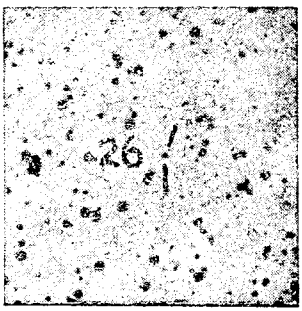
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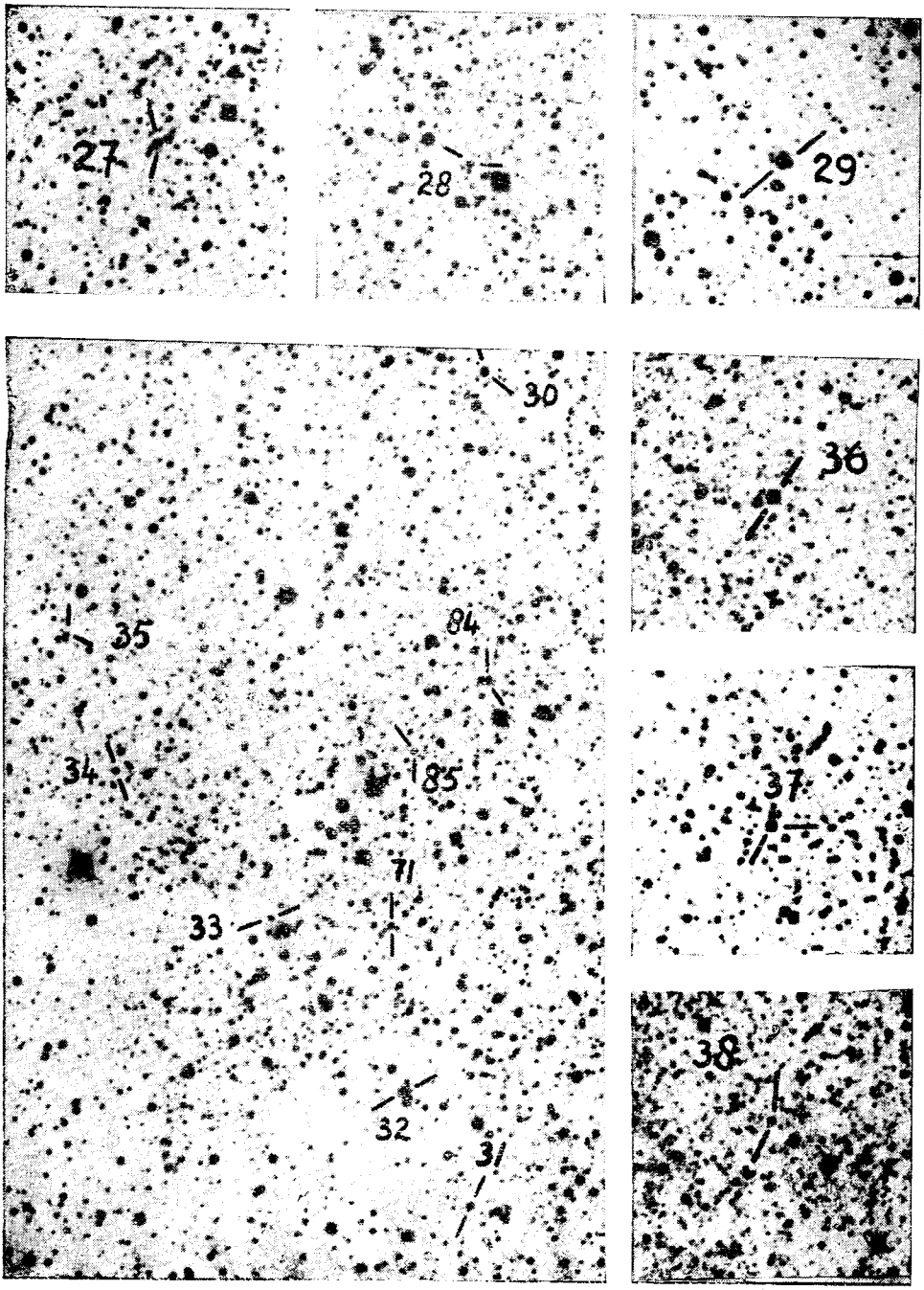
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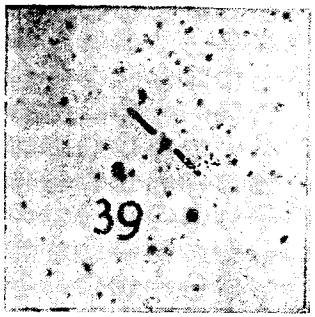
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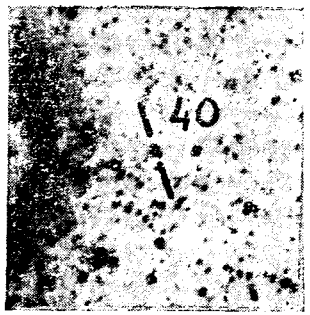
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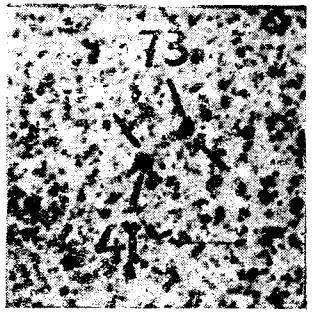
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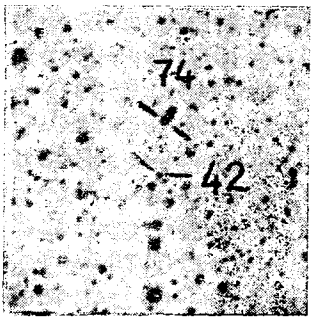
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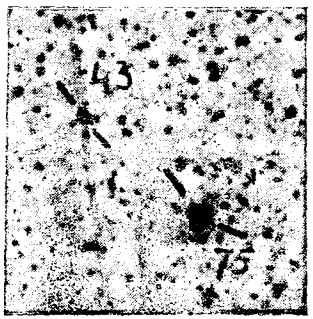
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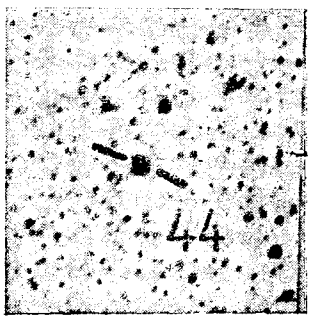
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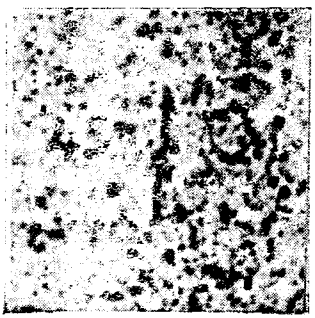

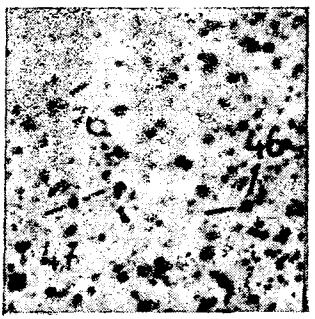
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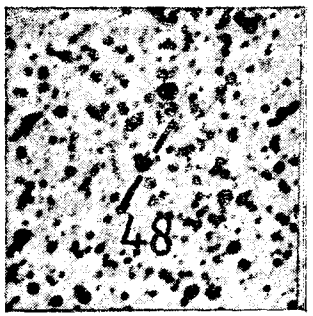
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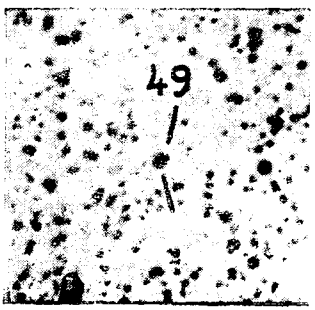
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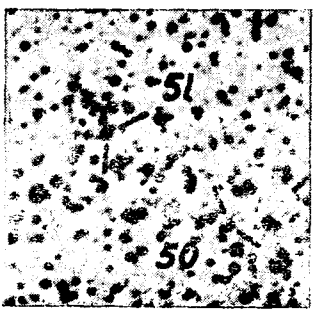
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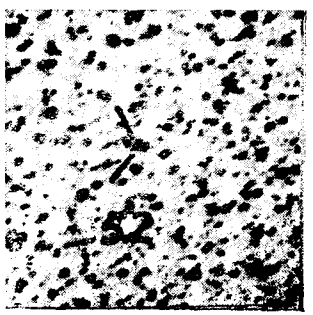
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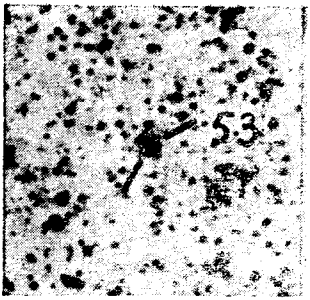
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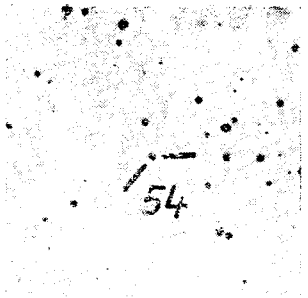
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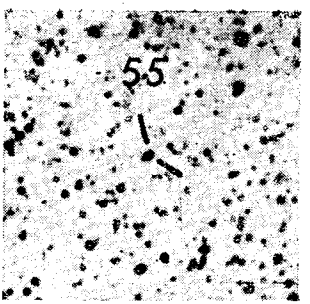
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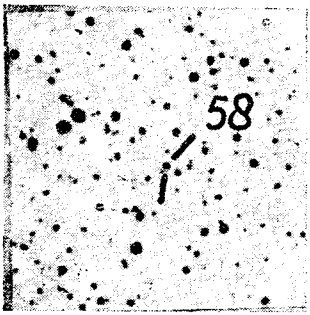
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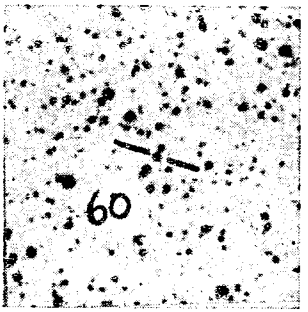
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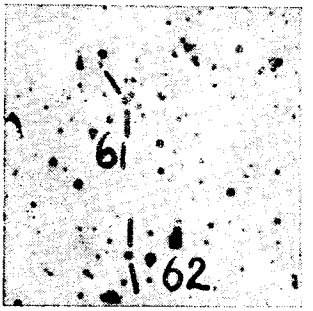
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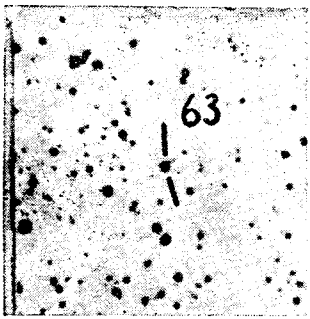
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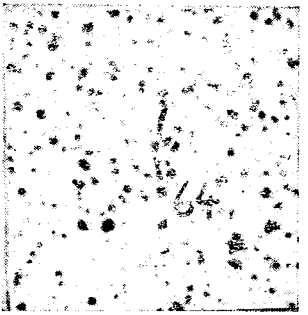
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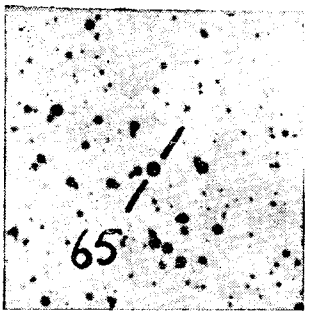
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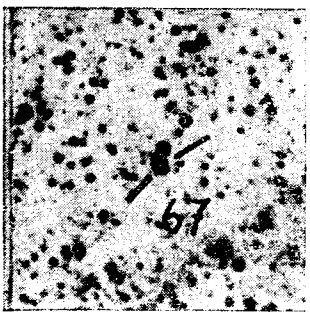
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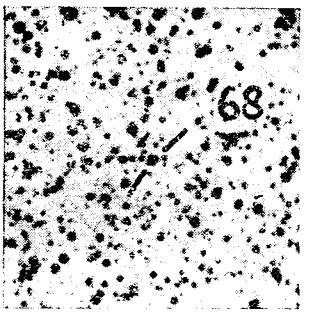
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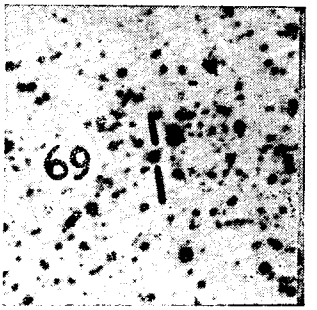
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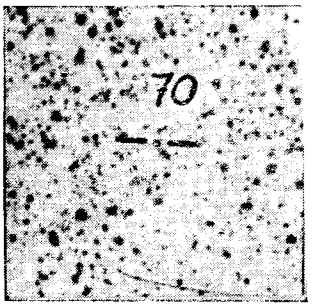
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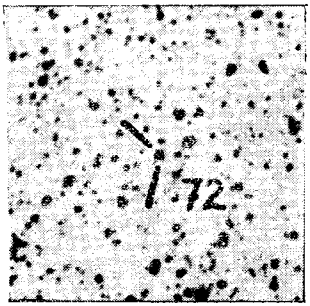
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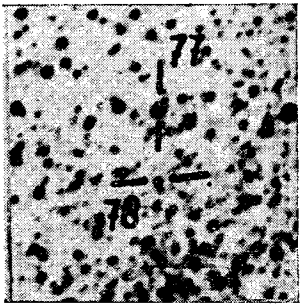
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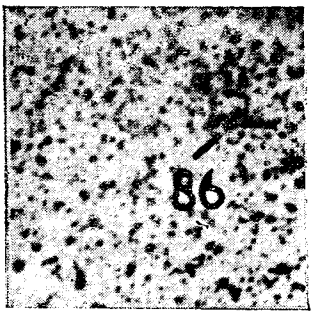
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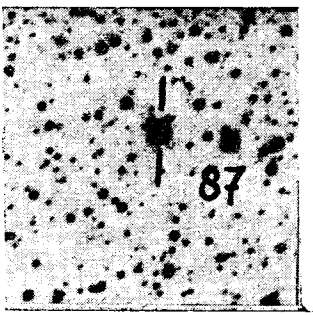
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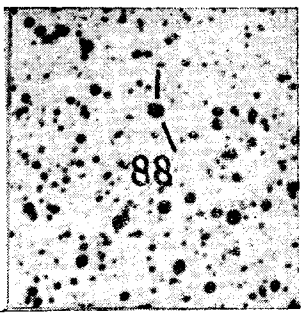
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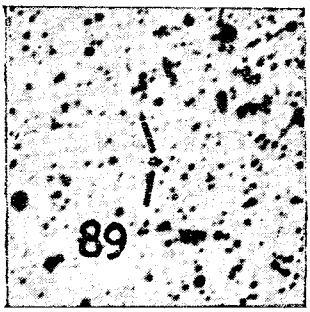
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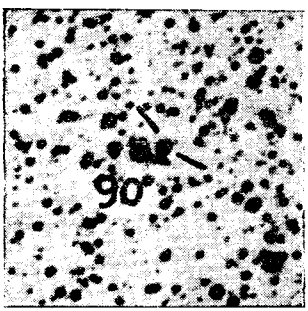
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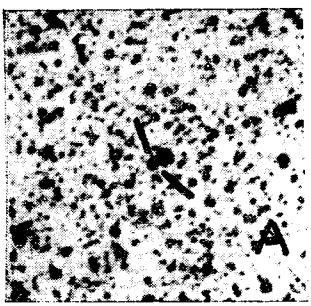
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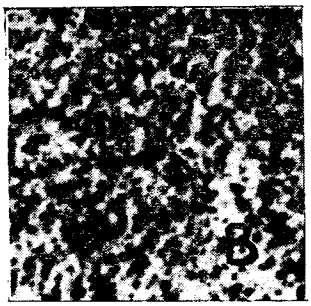
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