CORRECTIONS TO:

Lick Observatory Bulletin, No. 658 (1974)

DRAFT CATALOG OF HERBIG-HARO OBJECTS

Dr. S. E. Strom has kindly called my attention to an error in the coordinates given in Bulletin 658 for the nuclei of HH-24. The error (which attains about 2^s in α and 11" in δ) has been traced to the Astrographic Catalog positions for the reference stars, which have now been redetermined with respect to 7 SAO stars. The following revised coordinates for all HH Objects in the NGC 2068 field replace those given in Table 1, Bulletin 658:

	α (1950)			δ		
HH-19	5^h	43^m	$16^s.0$	-0°	06'	20"
20	5	43	21.5	-0	04	14
21	5	43	22.0	-0	05	36
26	5	43	31.1	-0	15	42
25	5	43	33.4:	-0	14	31:
24A	5	43	35.6	-0	11	32
24B	5	43	34.4	-0	11	12
24C	5	43	34.2	-0	10	50
24D	5	43	36.1	-0	11	02
22	5	43	40.3	-0	06	36
23	5	43	40.9	-0	04	37
HH-27	5	43	49.4	-0	14	45

The revised coordinates of the nebulous star south of HH-24 (p. 8) are: (1950) $5^h\ 43^m\ 34^s.3$, -0° 13' 04".

The "small, red, diffuse spot" near HH-31 (p. 9) and identified by an arrow on Fig. 3 but without coordinates given has now been measured at the position: (1950) $4^h\ 24^m\ 53^s.3$, +26° 12' 43".

I shall be grateful if any other corrections to Bulletin 658 are called to my attention.

G. H. Herbig

June 1974

This Draft Catalog of Herbig-Haro (HH) Objects gives accurate coordinates, rough indication of apparent brightness, a summary of the spectroscopic information available, and identifications for 41 small nebulae that certainly or probably are members of that class. Most of the Lick data given here were collected in the years 1946-1965 but remained largely unpublished. This Catalog appears now because of increasing interest in HH Objects, and in order to prevent unnecessary duplication of this work by others. Work in this area is currently going forward elsewhere, but since most of the new results by Schwartz, Strom, Gull, and their associates are available at the moment only in preprint form, I have chosen to limit this compilation to the information that was available to me only up to 1972, with few exceptions. Most of the hitherto unpublished data rests on Lick observations, except for some unpublished information kindly supplied by Dr. G. Haro, which is acknowledged at the proper place.

Most of the HH numbers of this Catalog were assigned long ago, approximately in order of recognition of the nature of the entry. I have resisted the temptation to renumber the Objects in order of right ascension because of the fact that over the past decade identification charts bearing these numbers have been supplied to a number of interested astronomers, and there is no good reason to risk confusion. Table 1 is the main Catalog, arranged in order of right ascension. Table 2, containing notes on the entries of Table 1, is arranged in order of HH number and thus provides cross-reference.

The Lick work on HH Objects, represented by the information given here, was not completed for several reasons. The strongest was the increasing difficulty of continuing with this kind of work on Mount Hamilton after the mid-1960's. A second was the failure of a program at the 120-inch prime focus that was intended to measure the radial velocities of most of the known HH Objects. A substantial effort was devoted to this project, which did establish that HH-11 near NGC 1333 had the remarkably high radial velocity of -150 km sec^{-1} [9] (reference numbers are given in square brackets), but otherwise led only to the disappointing conclusion that the velocities of such emission-line objects could be determined with that unflattened thick-mirror Schmidt spectrograph system to no better than perhaps $\pm$ 30 km sec^{-1}, for reasons that remain mysterious to me.

As a consequence, this Catalog contains no radial velocity data, nor has it been possible spectroscopically to confirm a number of examples whose membership in the HH class is only probable. A further serious gap is the lack of monochromatic total magnitudes or surface brightnesses. In their stead, Table 1 contains a crude index of the image density on plates of the Palomar Sky Survey.

It will be noted that for only a few entries are spectrograms in the blue-violet region available, yet information on that region is essential if a positive assignment to the HH class is to be made. It was only after the anomalous character of the emission-line spectrum shortward of 5000 Å had been recognized, on account of the presence of such disparate ions as [Ne III], [O II] and [O III], Fe II, [Fe II] and [Fe III], and Ca II, that the red region was observed. Between 6000 and 7000 Å, Hα, [N II], [S II], and [O I] are prominent but their relative intensities are not unique to the HH Objects, being found as well in some planetary and peculiar nebulae. Thus the presence of these ions in comparable intensities in a nebulous or semi-stellar object lying in a heavily-obscured field, often with T Tauri stars nearby, is very strong evidence for an HH identification, but not so conclusive as would be provided by a spectrogram of the photographic region. However, the amount of reddening in some areas (as NGC 1333) is so large as to preclude observation of the blue-ultraviolet with conventional equipment. A particularly interesting example of a non-HH Object which exhibits the red lines with relative intensities like those

found in HH Objects is the large reflection nebula NGC 2068, illuminated by a B1 V star. In this case, however, the continuous background is strong, a circumstance not encountered in the HH Objects listed here.

It will be seen that a number of the fainter entries in Table 1 have no spectroscopic observations at all, a result of the truncation of the original program. They have been regarded as probable members of the class on the basis of structure, color, and the presence of confirmed HH Objects nearby. These identifications must be regarded as provisional; in cases such as HH 15 and 16 they could, for example, be heavily obscured background galaxies although that possibility can usually be eliminated if an infrared exposure is available, on which true HH Objects essentially disappear.

A number of examples can be given in which an otherwise very plausible candidate was eliminated once an adequate spectrogram was obtained. For example, in NGC 2264, W166 resembles a fuzzy star with a short curved tail extending to the south. Although Hα is in emission and possibly [O I] as well, there are no bright lines in the blue-ultraviolet and the continuous spectrum in both blue and red is very strong; this is clearly not a conventional HH Object. In other cases, the classification remains uncertain: also in NGC 2264, there are two faint nebulous spots that lie about 1' in 195° from LHα 48 (they were first called to my attention many years ago by M. F. Walker and W. A. Baum). That Hα is in emission in both is shown by slitless spectrograms, and [S II] $\lambda\lambda$6717, 6730 is weakly in emission in the brighter one, but there is no detectable continuum in the red. Little more can be said on account of the strength of the emission lines of the H II region upon which they are projected. They could be HH Objects although certainly not in the same category as HH1 or HH2 because of the faintness of [S II] and [O I] with respect to Hα.

Description of Table 1

Col. 1 HH- : these numbers refer to the whole Object, while the following letters refer to separate nuclei or features which are identified on the accompanying photographs. The letter A has been omitted for Objects of numbers up to 14 (except for HH-2A) for fear of confusion with the numbering system of Haro [5]. The position for the center refers to the approximate photocenter or symmetry center of an extended Object. The nebulae 1, 2, and 3 have the same numbers in the present HH-system and in the original reference [8].

Col. 2 Other designations: numbers assigned by Haro [5].

Cols. 3, 4 α (1950) δ: these coordinates were measured on Crossley (Cr), 120-inch without coma-corrector (120) plates, or glass copies of 48-inch Sky Survey (48) negatives with respect to reference stars from the SAO or Astrographic (AC) Catalogs, or from the list of accurate coordinates for stars in the region of the Orion Nebula compiled by Parenago, Table III of Publ. Sternberg Astr. Inst., 25 (1954). The coordinate system thus established seems to be internally consistent to about 1" - 2", although the positions of very faint or poorly-defined Objects are not this reliable. In those fields where AC stars were used for reference, the internal accuracy was lower than for SAO-established fields even after clearly deviant stars were rejected. This is to be expected on account of the accumulation of proper motions since the epoch of the AC exposure. The following table gives the detailed information for each field. The last column is the mean r.m.s. error in seconds of arc determined by the agreement of the catalog positions of the reference stars and those calculated from measured rectangular coordinates and the adop-

ted plate constants.

Region	HH numbers	Source of ref. stars	No. ref. stars	Telescope	ϵ
NGC 1333	4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18	SAO	6	48, 120	0".6
B218	31	AC	7	Cr	1.8
	28, 29, 30	AC	6	Cr	0.4
	33, 34, 40	Parenago	8	Cr	0.7
Orion Nebula	41, 42	Parenago	6	Cr	0.6
NGC 1999	1, 2, 3, 35, 36	Parenago	5	120	0.8
IC 430	38, 43	Parenago	5	Cr	0.4
NGC 2068	19, 20, 21, 22, 23, 24 25, 26, 27	AC	6	Cr	2.0
NGC 2261	39	AC	9	120	1.4
AS 353	32	SAO	8	48	0.6

Col. 5 Brightness R/B: this is a rough index of the density of the image on the red (R) and blue (B) exposures of the Palomar Sky Survey. For extended Objects, the numbers are an expression of the surface brightness; for small unresolved Objects, they express the total magnitude in that color. The numbers have the following significance:

5 = exceedingly bright, densely overexposed
4 = bright, dense image
3 = well exposed
2 = clearly visible, somewhat thin
1 = faint image
0-1 = marginal, almost invisible
0 = not visible

Col. 6 Spectrum: a condensed description of the spectroscopic information on hand. The first letters give the type of spectrogram:

S r = slit spectrogram of red region, usually a 120-inch prime-focus plate, dispersion 374 Å mm^{-1}.

S b = slit spectrogram of the blue-near ultraviolet region, usually Crossley nebular spectrograph, prismatic dispersion, 430 Å mm^{-1} at Hγ.

sl r = Crossley grating slitless spectrograph of red region, dispersion 450 Å mm^{-1}. On occasion, these plates were obtained behind a Schott RG2 filter which suppresses [O I] λ6300. The [S II] pair at $\lambda\lambda$6717, 6730 are usually not resolved, nor are the [N II] lines separated from Hα on these slitless spectrograms. Slitless data are given only if no slit spectrogram is available.

Following a colon, for r plates a sequence of letters list the relative strengths of the principal emission lines in descending order of intensity. The coding is: h = Hα; n = [N II] λ6583; o = [O I] λ6300; s = [S II] λ6730. An (o) indicates that λ6300 was masked by the airglow line or cut off by the filter.

An ! indicates that that line was exceedingly strong with respect to the others. The coding is the same for the r slitless plates, except that unresolved lines are indicated by + signs. For b plates, the system is the same except that the coding is : h = Hβ; s = [S II] λ4068; o = [O II] λ3726 + λ3729; c = Ca II λ3933. An "invis" indicates that no image of that Object is visible on the longest exposure Crossley slitless spectrogram available for that field.

Col. 7 Chart: this number is either a figure number, referring to one of the numbered photographs of this Catalog, or a bracketed reference number to one of the papers listed in the bibliography. Extensive notes to the Objects of Table 1 are given in Table 2.

During portions of the long observational program represented by these data, I was very ably assisted by Dr. K. Hunger (in 1956-57) and by Mr. E. A. Harlan (since 1968). It is also a pleasure to acknowledge the essential support provided by the National Science Foundation, initially of Dr. Hunger's visit to Mount Hamilton and more recently of computer time and other activities necessary to the compilation of this Catalog. I am also indebted to Dr. S. Vasilevskis for advice on astrometric matters.

Table 1

List of Known or Very Probable Herbig-Haro Objects

HH-	Other desig.	α (1950)	δ	Brightness R/B	Spectrum	Chart: Figure no. or ref.
14B		$3^h 25^m 45^s.0$	+30° 50' 50"	2/0-1	see note	
14C		3 25 44.1	+30 50 29	2/0		
14D		3 25 44.8	+30 51 05	2/0-1		
14E		3 25 44.4	+30 50 56	3/1		
12G		3 25 53.1	+31 10 26	1/0	invis.	
12B		3 25 53.4	+31 10 11	3/0-1	sl r: h+n s (o)	1
12C		3 25 52.4	+31 10 04	3/0	S r: h=s n (o)	1
12D		3 25 52.1	+31 09 51	3/0-1	S r: h s n (o)	1
12E		3 25 53.6	+31 09 49	3/0-1	sl r: h+n o (s)	1
12F		3 25 53.7	+31 09 29	3/0-1	sl r: h+n s=o	1
15		3 25 53.5	+30 57 43	0-1/0	invis.	2
11		3 25 59.0	+31 05 35	4/1	S r: h=s=o n	2
10		3 25 59.8	+31 05 28	3/1	S r: s h o	2
8		3 26 00.7	+31 05 19	3/0-1	S r: s h o	2
9		3 26 00.9	+31 05 35	0-1/0	invis.	2
7D		3 26 02.7	+31 05 11			
7B		3 26 02.5	+31 05 10	3/1	S r: s o h	2
7C		3 26 02.3	+31 05 08			
7 center		3 26 02.5	+31 05 13			
16		3 26 02.8	+30 58 52	0/0	invis.	2
6F		3 26 07.0	+31 08 23	0-1/0		
6B		3 26 07.2	+31 08 28	0/0		
6C		3 26 06.5	+31 08 15	0/0	invis.	1
6D		3 26 05.8	+31 08 10	0/0		
6E		3 26 06.6	+31 08 24	0/0		
17		3 26 14.7	+31 08 17	1/0	invis.	1
5		3 26 14.8	+31 02 34	2/0	sl r: h+n s o	2
4 star		3 26 18.3	+31 09 41	-	invis.	1
4 neb		3 26 18.6	+31 09 41	1/0		1
18A		3 26 21.0	+30 57 21	1/0	invis.	2
18B		3 26 20.8	+30 57 00	0-1/0	invis.	2
31A		4 25 15.2	+26 11 33	3/2	S r: h s o=n	3
31B		4 25 13.8	+26 11 35	3/1	S r: h n o=s	3
31C		4 25 14.3	+26 10 24	3/1		3
31 center		4 25 14.4:	+26 11 04:	-		3
28		4 28 13.5	+17 57 02	2/1	S r: h! s n (o)	4
29		4 28 33.6	+18 00 03	3/2	S r: h! n=s o	4
30		4 28 43.6	+18 06 03	4/2	S r: h s n (o)	4
33		5 32 51.5	- 6 19 35	2/1	see note	5
40	Haro 9a	5 32 54.5	- 6 20 16	4/3	S b: o h=s c	5
34		5 33 05.4	- 6 30 28	2/1	invis.	
41	Haro 3a	5 33 34.1	- 5 04 40	3/2	invis.†	[5]
42	Haro 4a	5 33 37.3	- 5 06 31	3/1	invis.†	[5]
3	Haro 10a	5 33 45.9	- 6 44 55	4/3	sl r: h+n s=o	6
1	Haro 11a	5 33 54.9	- 6 47 02	5/5	S r: h n=s=o S b: o=h s c	6

Table 1 (continued)

HH-	Other desig.	α (1950)	δ	Brightness R/B	Spectrum	Chart: Figure no. or ref.
35		$5^h 33^m 56.6^s$	- 6° 43' 40"	1/0-1	invis.	6
2A		5 33 59.4	- 6 49 00	5/4	S r: h n s=o S b: o h s c	
2B		5 33 59.9	- 6 48 56	4/3	S r: h o n s	
2C		5 33 59.6	- 6 48 53	*	S r: h n s o	
2D		5 33 59.4	- 6 49 04	*	S r: h n=s o	
	Haro 12a					6
2E		5 34 00.7	- 6 49 00	2/1	S r: h=s o	
2G		5 34 00.1	- 6 48 56	4/3	S r: h o n s	
2H		5 33 59.7	- 6 49 02	5/4	S r: h n o=s	
2I		5 33 59.7	- 6 49 07	*	S r: h n	
2L		5 34 00.8	- 6 49 15	2/0-1		
36		5 34 20.7	- 6 46 01	1/0	invis.	see note
43	Haro 14a	5 35 45.4	- 7 11 04	4/3	S r: s h o S b: h s o	7
38		5 35 56.5	- 7 13 18	1/0-1	see note	7
19		5 43 13.9	- 0 06 26	2/0-1	S r: h! s n=o	8
20		5 43 19.5	- 0 04 17	1/0	invis.	8
21		5 43 20.0	- 0 05 40	0-1/0	invis.	8
26		5 43 29.2	- 0 15 53	1/0	invis.	8
25		5 43 31.5:	- 0 14 41:	1/0	invis.	8
24A		5 43 33.8	- 0 11 40	4/3	S r: h s n o	
24B		5 43 32.5	- 0 11 20	2/1		
						8
24C		5 43 32.4	- 0 10 58	3/1		
24D		5 43 34.3	- 0 11 10	3/1	S r: h	
22		5 43 38.6	- 0 06 41	1/0	invis.	8
23		5 43 39.1	- 0 04 40	1/0	invis.	8
27		5 43 47.7	- 0 14 56	1/0-1	invis.	8
39A		6 36 21.8	+ 8 54 11	2/1	S r: h n=s o	
39B				1/0-1		
39C		6 36 21.2	+ 8 53 48	3/2	S r: h n=s o	
39D		6 36 21.6	+ 8 53 39	2/1		
39E		6 36 21.8	+ 8 53 47	2/0		9
39F		6 36 22.8:	+ 8 53 35:	1/0		
39 center		6 36 21.6:	+ 8 53 58:	-		
32A		19 18 07.9	+10 56 21	4/2	S r: h n=s=o	10
32B		19 18 08.4	+10 56 17	2/0-1	S r: h	10

* Not resolved on Palomar Survey plates.

† Emission Hα and [O I] were observed by Haro [5].

Table 2

Notes and Remarks to Table 1

HH-1 ($5^h\ 33^m\ 55^s$) is the brightest known HH Object, discovered independently by Herbig [8] and by Haro [4, 5]. It has the form of an ellipse, about 4" x 8", with much internal structure some of which varies slowly with time [13]. It has been observed at dispersions up to 33 Å mm^{-1}. Quantitative analyses or observations of the spectrum have been published by Böhm [1], Böhm, Perry and Schwartz [2], Böhm and Schwartz [3], Haro and Minkowski [6], Osterbrock [15], and Schwartz [16]. The infrared spectrum out to about 1.1 μ has been observed with lower resolution; it is known to contain lines of He I, [Ca II], [S II], [Fe II], [Ni II], [O II]. Low-dispersion blue spectrograms are reproduced in [7], red exposures in [16].

HH-2 ($5^h\ 33^m\ 59^s$) contains a number of semi-stellar nuclei and considerable amorphous nebulosity, all superimposed on an extensive emission background south of NGC 1999. The slow variations of the nuclei since 1964 are described in [12]; a chart identifying the individual nuclei appears here and in [12]. The R/B brightnesses of the nuclei given in Table 1 refer only to the epoch of the Palomar Sky Survey plate, 1955. The spectroscopic information is derived from 120-inch red spectrograms of 1961-63, but the data in the blue for nucleus A are from a 1951 plate. That low-dispersion blue spectrogram (of low angular resolution) is reproduced in [7]. Additional details on the spectra of the individual nuclei are given by Böhm and Schwartz [3].

HH-3 ($5^h\ 33^m\ 46^s$) is a complex structure containing at least 4 distinct condensations within an area of about 3" x 6". A faint wisp extends about 15" northwest.

HH-4 ($3^h\ 26^m\ 18^s$) is a faint nebulosity 7" - 8" in diameter with a sharp condensation or faint star on the west edge. Table 1 gives coordinates for both star and nebula.

HH-5 ($3^h\ 26^m\ 15^s$) is a bright sharply-defined bar about 2" x 5". elongated in p a. 70°. A very faint streamer extends about 25" northwest, in the direction of the HH-7 group. There may also be faint nebulosity immediately to the south.

HH-6 ($3^h\ 26^m\ 06^s$) is a very faint elongated smudge, about 3" x 7".

HH-7 ($3^h\ 26^m\ 02^s$) is triangular or fan-shaped, about 10" on a side, with the eastern tip bright and well-defined. There is much internal structure. A bridge of very faint nebulosity seems to connect it with HH-8. These two Objects, together with HH-9, -10, -11 all lie in an elongated area of about 17" x 60".

HH-8 ($3^h\ 26^m\ 01^s$) consists of an arc with sharp central nucleus; the overall size is about 4" x 9".

HH-9 ($3^h\ 26^m\ 01^s$) is a slightly elongated semistellar spot about 2" across.

HH-10 ($3^h\ 26^m\ 00^s$) is about 5" x 8", with considerable structure. The coordinates refer to the center, where there is an intensity minimum.

HH-11 ($3^h\ 25^m\ 59^s$) is a tiny, very bright comma-shaped Object about 1".5 long. The tail extends to the southwest. The radial velocity is about -150 km sec^{-1}

HH-12 ($3^h\ 25^m\ 52^s$) is a very complex mass of semistellar condensations upon a fainter nebulous back-

Table 2 (continued)

ground, arranged in the form of the number '3'. The overall dimensions are 45" x 65".

HH-13 is marked on Fig. 2 but is not listed in Table 1. It is a very faint smudge of uncertain type.

HH-14 ($3^h\ 25^m\ 44^s$) is a group of about 6 nebulous spots distributed over an area of about 20" x 60". No slit spectrogram has been obtained, but a red slitless plate shows a confused group of overlapping emission lines. Nor is a good direct photograph yet available to provide a finding chart, but the object is unmistakeable on the red exposure of the Palomar survey.

HH-15 ($3^h\ 25^m\ 53^s$) is only a very faint wisp about 3" x 10".

HH-16 ($3^h\ 26^m\ 03^s$) is a faint elongated smudge about 3" x 7".

HH-17 ($3^h\ 26^m\ 15^s$) is a very faint nebulosity 5" to 10" across, with a sharp condensation or star at the northern edge.

HH-18 ($3^h\ 26^m\ 21^s$) is a group of at least 5 faint nebulous spots distributed over an area of about 20" x 35".

HH-19 ($5^h\ 43^m\ 14^s$) consists of a small condensation, with a fainter about 13" northwest, and faint nebulosity between and to the south. The dark cloud extending south and west from NGC 2068 contains a large number of such very small nebulous spots. Only the brightest are listed here, as HH-19 through -27.

HH-20 ($5^h\ 43^m\ 19^s$) is a very small (about 1".5 by 2".5), slightly elongated diffuse spot.

HH-21 ($5^h\ 43^m\ 20^s$) is a faint amorphous smudge 3" to 4" in diameter.

HH-22 ($5^h\ 43^m\ 39^s$) is a pair of diffuse spots about 7" apart, the southern being the brighter.

HH-23 ($5^h\ 43^m\ 39^s$) is a very small (about 1".5 diameter) diffuse spot.

HH-24 ($5^h\ 43^m\ 32^s$) is a complex nebulosity discovered by Herbig and Kuhi [10]. It covers a triangular area about 2' in greatest dimension, and contains one especially bright, small, slightly elongated nucleus (HH-24A). HH-24 lies about 100" north of a nebulous star (1950 coordinates: $5^h43^m32^s.5$, -0°13'13") from whose image emerges a curious curl of bright reflection nebulosity.

HH-25 ($5^h\ 43^m\ 31^s$) and HH-26 ($5^h\ 43^m\ 29^s$) are the brightest of a series of faint nebulous spots extending south of the nebulous stars mentioned above. The symmetric distribution of HH Objects north and south of this star suggests that the arrangement is in some way significant. HH-25 is only an elongated amorphous spot about 5" x 8", but HH-26 has a very sharp nucleus and an extension to the north.

HH-27 ($5^h\ 43^m\ 48^s$) is a binuclear mass of nebulosity within an area of about 5" x 10"; the northern part is the brighter.

HH-28 ($4^h\ 28^m\ 13^s$) is also LP 415-1166 [14]. It is an elongated nebulous blob about 15" across, accompanied by a fainter condensation about 20" east. The nearby star has no emission lines and presumably is not associated.

HH-29 ($4^h\ 28^m\ 34^s$) is also LP 415-171 [14]. It is a semistellar nucleus having a curved tail extending about 12" southeast. About 2' east is a large complex nebulosity (approximate center at [1950]: $4^h28^m26^s$, +18°01'.1) having no obvious illuminating star; it was apparently first noted by W.

Table 2 (continued)

Baade (unpublished).

HH-30 ($4^h\ 28^m\ 44^s$) is a small, almost stellar spot 2' south of XZ and HL Tau. There is fainter nebulosity immediately northeast. The small fuzzy spot of very similar appearance at 35" in 250° from HL Tau is not an HH Object, but a star having Hα in emission.

HH-31 ($4^h\ 25^m\ 14^s$) is a series of nebulous condensations which appear to lie around the periphery of an ellipse about 60" x 80". The coordinates of the center given in Table 1 are of the estimated center of this ellipse. HH-31A, B, and C are the brighter of these condensations. It lies on the southern edge of the small dark cloud Barnard 218. There is another small, red, diffuse spot in the dark cloud about 5' west and slightly north of HH-31. It is indicated by an arrow in Fig. 3. It could be another HH Object. No slit spectrogram has been obtained.

HH-32 ($19^h\ 18^m\ 08^s$) lies about 24" in 286° from the T Tauri star AS 353A (1950: $19^h18^m09^s.3$, +10°56'15"), which itself is double, with $\Delta m \approx 2$, d = 6", p.a. = 175°. HH-32A resembles a slightly diffuse star having faint nebulosity extending a few seconds to the east and southwest. A rather bright protuberance extended about 2"eastward from the image of HH-32A on a 120-inch plate of 1970, but was not seen in 1963. A much fainter nebulous blob, about 1".5 x 2" in size, is about 8" southeast of A; it is here called HH-32B. Spectroscopically, HH-32A is an excellent example of a HH Object, but B shows only Hα in emission and may well be something else. A faint loop of nebulosity extends south of AS 353B; it also shows only bright Hα.

HH-33 ($5^h\ 32^m\ 51^s$) was discovered by Haro (private communication, Jan. 1959). It is a twisted filamentary structure 15" to 20" long, connected with HH-40. No slit spectrogram has been obtained, but threshold Hα and [S II] emission appear on a 1953 slitless plate.

HH-34 ($5^h\ 33^m\ 05^s$) was also discovered by Haro (private communication, 1959). It is an irregular nebulous spot about 15" across, the brightest of a series of such condensations in an arc of nebulosity extending to the north and west.

HH-35 ($5^h\ 33^m\ 57^s$) is a very small diffuse spot lying just outside the edge of NGC 1999. It has a 5" tail extending southeast, in the direction of the nebula.

HH-36 ($5^h\ 34^m\ 21^s$) is a small arc of nebulosity about 3" x 9", with the northern end being the brightest point. No identification chart is given here for this Object, which lies just outside Fig. 6.

HH-38 ($5^h\ 35^m\ 56^s$) was discovered by Haro (private communication, 1959). It is a very faint nebulous spot 10" x 15" in diameter, having some structure. A 1953 slitless spectrogram shows faint line emission, probably Hα and [S II].

HH-39 ($6^h\ 36^m\ 21^s$) is a complex Object containing at least 6 condensations distributed over an area of about 25" x 45" [11]. It lies 7' north of R Mon, very nearly on the symmetry axis of NGC 2261 and, unlike all other recognized HH Objects, in a region where obscuration is not very conspicuous.

HH-40 ($5^h\ 32^m\ 54^s$) has a sharp nucleus like a slightly diffuse star, which is slightly displaced from a streamer about 1' long which extends to HH-33. A weak continuum and [O III] λλ4959, 5006 in greater strength than usual were present on a 1957 slit spectrogram in addition to the other usual

HH-type lines.

HH-41 ($5^h\ 33^m\ 34^s$) is a small nebulous spot, about 8" x 12", having a sharp nucleus at the eastern edge. It lies together with HH-42 in the complex nebulous field between the Orion Nebula and NGC 1977.

HH-42 ($5^h\ 33^m\ 37^s$) is a small triangular nebulosity about 15" in diameter, lying about 2' from HH-41. A sharp, nearly central nucleus is visible in the red.

HH-43 ($5^h\ 35^m\ 45^s$) is a small, bright S-shaped Object having much internal structure. The overall dimensions are about 6" x 18". The star at the southwest edge has no Hα emission, and presumably is only aligned. HH-43 is apparently the HH Object for which the earliest large-scale reflector photograph exists, a Crossley plate of the nearby IC 430 (=Haro 13a) exposed in 1919. Comparison with a 1956 plate taken with the same telescope shows that no major change took place in the Object between those years, although small structural differences are suspected. A low dispersion blue-ultraviolet spectrogram is reproduced in [7].

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FIGURES

All the Figures accompanying this Catalog are reproduced with north at the top and east to the left. The angular scale is indicated in each case. The Figure number appears in a circle in one corner. Further details of the original negatives are as follows:

Figure	Region	Telescope	Color	Date
1, 2	NGC 1333	120-inch	red	1959 Dec. 6
3	HH 31	Crossley	blue	1956 Nov. 30
4	XZ, HL Tau	Crossley	blue	1951 Feb. 25
5	HH 33, 34, 40	Crossley	blue	1956 Jan. 12
6	NGC 1999	120-inch	red	1959 Dec. 6
7	IC 430	120-inch	red	1959 Dec. 6
8	NGC 2068	Crossley	red	1957 Jan. 1
9	NGC 2261	120-inch	blue	1960 Oct. 21
10	AS 353	120-inch	red	1963 July 1

In col. 4, "red" signifies a spectral pass-band of approximately 6000-6700 Å and "blue", about 3500-5000 Å.

In Figs. 1 and 2, the 3-digit numbers beside certain stars are LkHα numbers for emission-Hα stars - presumably T Tauri stars - in the area shown. LkHα 270 and 271 were identified by Herbig and Rao (Ap.J. 174, 401, 1972) while all the others are published here for the first time. Several other stars that were noted as variable in light during this program are marked "var" in Figs. 1 and 2.