A SEARCH FOR T TAURI STARS BASED ON THE *IRAS* POINT SOURCE CATALOG. I.

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ABSTRACT

The results of the first part of a survey for new T Tauri stars, with spectroscopic and photometric observations of about 100 stars, are presented. A list of candidates has been selected by means of the *IRAS* Point Source Catalog, based on appropriate far-infrared colors. Coudé spectra of the selected objects in the 655–673 nm wavelength range, which includes H α and the resonance Li I line, have been obtained with the 1.6 m telescope of the Laboratório Nacional de Astrofísica at Pico dos Dias, MG, Brazil. Thirty-three new T Tauri stars, and a number of other interesting objects, like early type pre-main-sequence stars and Li-rich K giants, have been detected. Several new isolated T Tauri were found, including Hen 1, which may be the T Tauri star with the highest galactic latitude known, if its nature is confirmed.

1. INTRODUCTION

The spatial distribution and mass distribution of pre-main-sequence (PMS) stars are important clues to understanding the process of star formation and the evolution of star-forming molecular clouds, from the hierarchical fragmentation to the dispersion of the cloud remnants. In particular, the investigation of the spatial distribution and kinematics of a complete sample of T Tauri stars (TTS) could shed some light on the puzzling question of the existence of isolated TTS, at considerable distance from any molecular cloud, of which TW Hya is the prototype (Rucinski & Krauter 1983; de la Reza *et al.* 1989).

About 800 PMS stars are optically identified at present, most of which are listed in a catalog by Herbig & Bell (1988, hereafter referred to as HBC), the large majority being TTS. These objects have been discovered either by objective-prism or by grating surveys, or because they where attractive candidates for spectroscopic observations for some reason, such as the proximity to a T-association, variability, or x-ray emission. The sample of known TTS is, therefore, not complete to any given magnitude, except for limited areas of the sky.

Several authors have used the *IRAS* Point Source Catalog (1985, hereafter referred to as PSC) to produce lists of TTS candidates, without doing spectroscopic observations to confirm their nature, and more recently Kenyon *et al.* (1990) obtained low resolution spectra of candidates in the Taurus region, to reveal their nature. In the present work, we present the results of a first part of a systematic search for TTS stars, based on a complete list of candidates selected in the PSC, with colors in the same range of the known TTS. This approach takes advantage of the almost complete sky coverage of the *IRAS* Survey, of the fact that the TTS emit a large fraction of their energy in the infrared, and of the low interstellar extinction at these wavelengths. To confirm the TTS nature of the candidates, our method uses high resolution Coudé spectra. This method has been used by de la Reza *et al.* (1989) to discover new isolated TTS.

Up to the present, observations of about half the candidates have been made. The search led to the discovery of 33 new TTS, 24 probable Herbig Ae/Be stars, and a number of other interesting objects, such as Li-rich late-type giant stars. Since the information contained in the spectral range that we observe is usually not sufficient to reveal the temperature or the spectral type of the star, complementary UBVRI photometric measurements are being made. The results of spectroscopy and photometry of the same sample of objects are presented.

2. SOURCE SELECTION AND IDENTIFICATIONS

The candidate sources were selected in the color ranges $0.95 < S_{25}/S_{12} < 3.40$, and $0.50 < S_{60}/S_{25} < 3.30$, where S_{12}, S_{25}, and S_{60} are the noncolor corrected *IRAS* flux densities of the PSC. Our "TTS box," so defined in the color diagram, is similar to that used by Beichman (1986) and by Harris *et al.* (1988). We did not use the 100 μm flux in our selection, since the signal in this band is often dominated by the emission from cirrus or from dust clouds. Only sources with flux qualities 2 or 3 (i.e., excluding upper limits) at 12, 25, and 60 μm were chosen. We eliminated the sources with a galaxy or planetary nebula counterpart proposed in the PSC or in the catalog of Véron-Cetty & Véron (1989). A first list of 868 sources south of $+30°$ was produced with the version 1.0 of the PSC. Later we received version 2.0, on the optical disk "Selected Astronomical Catalogs" supplied by NASA, and made a second list containing 851 sources south of $+30°$. The two lists were found not to be exactly the same due to the flux corrections in version 2.0; there were 18 new sources introduced by version 2.0 and 36 excluded, in the declination range considered. As the program was running when the second list was prepared, we decided to maintain all the sources from both versions (886).

We estimated the probable number of optical objects observable with our equipment by correlating our sample with the Guide Star Catalog (GSC), using an optical disk sup-

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TABLE 1. Associations of our sample with the GSC and the Papadopoulos Sky Atlas.

		Papadopoulos	
		yes	no
GSC	yes	197(57)	58(20)
	no	26(4)	605(9)

plied by the Space Telescope Institute. The GSC is complete up to $V = 14.0$, but some stars may be lost in the process of its construction (Jenker *et al.* 1990). The original plates used by the GSC are of different emulsions, but the B plates dominate the sample. We believe that the completeness of red stars may be about $R = 13.5$, which is similar to our observational limit. We made correlations for different sizes of the PSC error ellipses to decide where we had to cut off the possible associations to avoid introducing too many spurious ones for this particular sample. A compromise was found at 99.9% (3.3σ), which gives about 4% spurious associations. Proper motions should not be a serious problem, as the original epochs of both catalogs are similar; misidentifications for this reason would be very rare.

To test the effect of lost stars in the GSC, we also correlated our sample with the Papadopoulos Star Atlas, which has a limiting magnitude about $V = 13.5$, a little brighter than the GSC (in doing this work, we verified that the Papadopoulos limiting magnitudes are not uniform, varying from plate to plate). We summarize our results in Table 1, giving also in parenthesis the number of associations with young stars of the HBC, for comparison. From our sample, we estimate the object-loss effect in the GSC to be about 13% up to $V = 13.5$. From the 26 lost objects, nine are bright enough not to be considered in the construction of the GSC.

If we take an all-sky sample of *IRAS* sources satisfying our criterium, then we have 1044 sources, 305 having counterparts in the GSC. The relatively small number of HBC stars associated with our sample is explained by the fact that only about 40% of the HBC stars are in the PSC, and furthermore, their fluxes are often only of high quality in one or two of the *IRAS* bands. On the other hand, many *IRAS* sources are associated with more than one HBC star.

Our correlation between the PSC and the HBC is similar to the work of Weintraub (1990), except for our *IRAS* selection criteria. We found four HBC stars in the PSC error ellipse not recognized by Weintraub, as their coordinates are incorrect in the HBC: *IRAS* 5020 − 0351 (HBC 430), *IRAS* 5358 − 0704 (HBC 489, V 883 ORI), *IRAS* 5363 + 2618 (HBC 492), and *IRAS* 6053 + 1837 (HBC 194). There are six HBC stars very near an *IRAS* source but not within our error ellipse, only one of them, HBC 286 (S Cra), being noted by Weintraub. Four other stars have been associated with an *IRAS* source by him, but we could not confirm: HBC 25 (CW Tau; but see Myers 1987), HBC 46 (ZZ Tau, see Strom *et al.* 1989), HBC 568, and HBC 596. The last star not mentioned by Weintraub is HBC 246 (CU Cha), just outside the error ellipse of *IRAS* 11066 − 7722.

In our sample, 10 sources have HR counterparts. It is important to consider the nature of these stars before investigating the rest of the sample, because of the possibility of the observed sources being similar to them. In Table 2 we give their *IRAS*, HR, and constellation names, the spectral type, the visual magnitude, and *IRAS* 12 μm flux (which is the weakest flux for all these sources). The source *IRAS* 17121 − 3822 has an association proposed by the PSC, HR 6398, but this star is just outside our error ellipse, if the proper motion is taken into account. As we can see, all of them but the well known β Pic are B stars with relatively weak flux at 12 μm; none would be selected if they were twice as distant (or 1.5 mag weaker). This means that it is very improbable to find similar stars, with $V > 7$, in our sample, the same being true for β Pic-like objects. Indeed, the seven stars with $6.5 < V < 8.0$ in our sample are different kind of objects.

3. OBSERVATIONS

As the simultaneous presence of H α emission and Li I resonance line absorption at 670.7 nm is a good criterium to decide the T Tauri nature of a star, we took spectra in the region 651–673 nm with a CCD camera at the Coudé spectrograph of the 1.6 m telescope of the Laboratório Nacional de Astrofísica, located at Pico dos Dias (Minas Gerais, Brazil). In this first part of the search our method consisted in pointing the telescope at the PSC position to look for the presence of an optical object. When an optical object was found within about 70″ of the pointed position, a 10 min exposure was taken. We estimate that a S/N of about 20 is obtained for a 13 mag star. As we are working in the red region, near the highest sensitivity of the equipment, it is not surprising that we found some objects that were neither in the GSC, nor in Papadopoulos. Possibly a few of the objects that we observed are serendipitous discoveries of stars situated close to the *IRAS* positions.

Our plan is to observe each object on at least three different nights in order to be able to detect radial velocity variations in eventual spectroscopic binaries with single or double Li line. The spectral resolution is of about 0.4 Å per pixel ($r = 10\,000$); we estimate the uncertainty in our radial velocities to be about 2 km s^{-1}. The photometric observations

TABLE 2. Sources of our sample associated with bright stars.

IRAS	Identifications	S.Type	V	12 microns
03433+2347	HR 1156, 23 Tau	B6 IVe	4.2	1.31
04259+0116	HR 1415	B3 V	5.6	0.35
05293+1701	HR 1847	B7 III	5.5	0.43
05460-5104	HR 2020, Beta Pic	A5 V	3.9	3.46
14229-4459	HR 5395, Tau 1 Lup	B2 IV	4.6	0.65
15504-2001	HR 5902, Lambda Lib	B2.5 V	5.0	0.56
16280-3435	HR 6143	B2 III-IV	4.2	0.66
19340+2228	HR 7452	B9p	6.3	0.49
19366+0517	HR 7474, Sigma Aql	B3 V	5.2	0.68
20363+2356	HR 7894, 28 Vul	B5 IV	5.0	0.27

TABLE 3. List and photometry of observed stars.

PDS	IRAS	V	U-B	B-V	V-R	R-I
1	(02084 -5544)V	9.87	0.69	1.03	0.60	0.57
2	01156 -5249	10.82	-0.01	0.36	0.22	0.22
3	03062 -6538	9.32	0.94	1.09	0.56	0.52
4	03359 +2932	10.69	0.22	0.34	0.20	0.26
5	04112 +2803					
6	04161 +2859					
7	04187 +1927	16.2	--	--	1.8	1.7
8	04188 +2819					
9	04217 +1303	11.30	0.19	0.65	0.39	0.40
10	04324 +2408	12.82	0.47	1.60	1.12	1.14
11a	04451 -0539	14.76	--	1.51	1.06	1.15
11b	04451 -0539	15.34	--	1.34	1.06	1.19
12	04571 -6954	11.10	-0.62	0.14	0.18	0.16
13	05263 +1149					
14	05267 -0610					
15	05394 -0801					
16	05407 -0501	9.02	-0.03	0.04	0.07	0.08
17a	05464 +0106	12.59	0.69	1.25	0.75	0.76
17b	05464 +0106					
18	05513 -1024 V	13.36	0.68	1.47	1.07	1.10
19	05555 -1405	13.90	0.38	1.03	0.67	0.69
20	05560 +1639	10.61	-0.08	0.05	0.03	0.00
21	05598 -1000	10.38	-0.42	0.31	0.26	0.26
22	06013 -1452	10.24	0.01	0.15	0.09	0.08
23	06245 -1013	13.51	0.29	1.37	0.95	0.99
24	06464 -1644	13.26	0.31	0.36	0.28	0.30
25	06523 -2458 V	12.48	0.16	0.54	0.33	0.37
26	07106 -2625					
27	07173 -1733	13.03	0.28	1.30	1.00	1.00
28	07388 -4747 V	12.62	0.24	1.18	0.81	0.76
29	07458 -4652 V	11.92	0.26	0.84	0.50	0.50
30	08131 -4432	10.74	0.08	0.60	0.35	0.35
31	08277 -3826					
32	08296 -2735					
33	08469 -4037	12.34	0.21	0.28	0.18	0.19
34	08482 -4541	13.98	0.02	0.76	0.55	0.62
35	10001 -5857 V	9.73	0.28	0.62	0.45	0.49
36	10028 -5825					
37	10082 -5647	13.53	0.5	1.52	1.18	1.15
38	10552 -7656					
39	10570 -7701					
40	10577 -7706					
41	10578 -7645					
42	10594 -3426					
43	11011 -7717	11.52	0.64	1.17	0.75	0.69
44	11027 -7611					
45	(11058 -2946)	11.06	1.10	1.48	1.07	1.06
46	11059 -7721	10.70	0.59	1.20	0.81	0.81
47a	11068 -7717	12.82	1.31	1.52	1.01	0.99
47b	11068 -7717					
48	(11070 -7738)					
49	11078 -7607					
50a	11080 -3715	12.04	0.69	1.48	1.38	1.55
50b	11080 -3715					
51	11091 -7716	14.31	--	1.91	1.38	1.26
52	11108 -7627					
53	11108 -7620	11.52	0.83	1.11	0.66	0.67
54	11195 -2430	8.89	1.12	1.25	0.77	0.74
55	(11295 -3420)V	11.37	0.92	1.47	1.11	1.29
56	11331 -1418					
57	11373 -5953					
58	11385 -5517					
59	11472 -7834 V	12.90	0.99	1.49	1.05	1.11
60	11547 -7904 V	12.12	1.16	1.46	0.87	0.87
61	11575 -7754					
62	12345 -6910 V	14.31	-0.19	1.21	1.06	1.12
63	12366 -7850	15.05	--	0.87	0.45	0.56
64	12535 -7623	15.06	--	--	1.54	1.46
65	12584 -7621 V	13.36	0.14	1.28	0.94	0.97
66	13185 -6922	10.36	0.57	1.01	0.62	0.57
67	13491 -6318					
68	13539 -4153	12.80	1.9	1.58	0.88	0.85
69	13547 -3944					
70	14050 -4109	12.14	1.00	1.30	0.80	0.77
71	14422 -8021					
72	15354 -6950	10.58	0.39	0.83	0.47	0.45
73	15420 -3408	10.40	0.92	1.28	0.76	0.76
74	15459 -3529	11.71	0.16	1.12	0.79	0.78
75	15528 -3747	11.97	1.01	1.37	0.86	0.89
76	15537 -2153					
77	15573 -4147 V	11.58	0.73	1.12	0.67	0.66
78	16038 -2735					
79	16086 -1830 V	11.73	-0.22	1.21	1.00	0.96
80	16102 -2221					
81	16112 -1930 V	11.77	0.77	1.19	0.74	0.73
82a	16126 -2235 V	12.42	0.17	1.29	0.96	0.96
82b	16126 -2235					
83	16225 -2607 V	11.68	0.84	1.30	0.82	0.83
84	16267 -4437					
85	16284 -2418					
86	16392 -4628	14.86	0.21	1.78	1.29	1.31
87	16424 -2457	11.04	0.73	1.10	0.66	0.63
88	(16430 -1509)					
89	16443 -1509 V	12.01	1.19	1.43	0.91	0.90
90	(16450 -1406)	13.46	1.60	1.94	1.30	1.24
91	16455 -1405					
92	16464 -1416					
93	16514 -3648					
94	17028 -1004					
95	17277 -3506	10.98	-0.19	0.61	0.48	0.44
96	17306 -3921	11.03	-0.38	0.32	0.25	0.32
97	17554 -3822	13.30	--	1.82	1.23	1.27
98a	18577 -3701					
98b	18577 -3701					
99	19063 -3709 V	13.34	0.88	1.61	1.05	0.99
100	19285 +0517	10.44	1.44	1.51	0.82	0.73
101	19558 -1405 V	12.07	0.27	1.23	0.86	0.83
102	20160 +2734					
103	23198 -0230 V	12.35	0.72	1.41	0.68	0.63

are being performed with a 60 cm telescope located at the same observatory, using Cousins *UBVRI* filters. The spectral data reduction is performed with the Vax computer of the Instituto Astronômico e Geofísico, University of São Paulo.

4. RESULTS AND DISCUSSION

Up to the present, the telescope has been pointed towards more than 200 candidates. In many cases, no visible counterpart bright enough to obtain a spectrum was found at the pointed position, and also for a number of sources the spectra obtained are not of good enough quality, so further observations are needed. We present here the results of 104 stars, listed in Table 3, in order of right ascension; the sequential number (with PDS standing for "Pico dos Dias Survey") with labels (a), (b), when a binary system was found, will be used throughout the paper. Known TTS were included in the list, to test for radial velocity variations, and also two emission-line stars, which are not in the PSC. When an object is not in the PSC, the aproximate coordinates are given in parentheses, using the same format. The results of our photometric measurements are also presented in Table 3. The stars for which we detected variability larger than 0.05 mag in one band between different nights are indicated by the symbol "V". Only for about half of the sources have three or more spectra been obtained; on the other hand, several sources have been observed six or more times.

4.1 Previously Known TTS

Many previously known TTS have been observed. Most of these were included in our search list following our *IRAS* selection, but a few additional objects were taken from the HBC, without obeying our selection criterion. Our new spectroscopic measurements of known TTS are of interest due to their high resolution, which allows a good determination of

TABLE 4. Observations of known T Tauri.

PDS (1)	IRAS (2)	identification (3)	GSC (4)	l (5)	b (6)	obs. (7)	Eq.W. (H) (8)	Eq.W. (Li) (9)	Vr (10)	Notes (11)
5	04112 +2803	CW Tau, hbc25	1827-1207	168.25	-16.33	2	98	-0.26	6	1
6	04161 +2859	BP Tau, hbc32	1827-554	168.33	-14.92	2	86	-0.37	25	
8	04188 +2819	RY Tau, hbc34	1828-129	169.25	-15.94	6	12	-0.21	18	
10	04324 +2408	DN Tau, hbc65	1829-26	174.59	-15.45	1	18	-0.78	22	
13	05263 +1149	GW Ori, hbc85	708-1901	192.58	-12.26	1	30	-0.21	31	
14	05267 -0610	hbc432	4765-608	197.61	-15.10	1	6	-0.11	26	2
15	05394 -0801	hbc182, San 6	5346-193	212.26	-19.04	1	40	-0.26	28	
38	10552 -7656	SY Cha, hbc565	9414-266	296.58	-15.76	4	14	-0.52	18	
39	10570 -7701	SZ Cha, hbc566	9414-599	296.71	-15.80	6	8	-0.28	18	
40	10577 -7706	TW Cha, hbc567	9414-289	296.79	-15.87	6	21	-0.40	23	3
41	10578 -7645	CR Cha, hbc244	9414-186	296.63	-15.55	3	44	-0.30	17	
42	10594 -3426	TW Hya, hbc568	7208-347	278.68	22.96	10	225	-0.42	14	
43	11011 -7717	CS Cha, hbc569	9414-574	297.04	-15.95	3	34	-0.48	17	
44	11027 -7611	CT Cha, hbc570	9410-2536	296.65	-14.91	5	43	-0.40	22	3
46	11059 -7721	hbc245, Sz19	9414-743	297.33	-15.91	8	21	-0.19	13	
48	(11070 -7738)	VW Cha, hbc575	9414-754	297.39	-15.96	6	64	-0.33	22	
49	11078 -7607	VZ Cha, hbc578	9410-2375	296.92	-14.72	3	70	-0.30	19	4
52	11108 -7627	CV Cha, hbc247	9410-60	297.23	-14.98	3	58	-0.26	19	
53	11108 -7620	hbc588, Sz41	9410-300	297.18	-14.87	3	2	-0.31	16	
60	11547 -7904	T Cha, hbc591	9419-1065	300.34	-16.76	6	2	-0.27	16	5
73	15420 -3408	hbc248, NSV7226	7336-552	339.18	16.08	5	5	-0.33	0	5
74	15459 -3529	hbc250, GQ Lup	7340-177	338.93	14.51	3	86	-0.34	1	
75	15528 -3747	hbc605, Sz82	7838-962	338.49	11.87	3	17	-0.47	-2	
79	16086 -1830	hbc254, AS205	6205-1297	355.19	23.33	3	126	-0.12	-1	6,7
88	(16430 -1509)	hbc651	6217-202	3.71	18.94	3	117	-0.28	1	8,3
90	(16450 -1406)	hbc652	5641-493	4.85	19.26	1	1	-0.58	-12	
92	16464 -1416	V1121 Oph, hbc270	5641-480	4.84	18.96	2	77	-0.29	-7	4
93	16514 -3648	AK Sco, hbc271	7371-870	347.38	4.20	1	3	-0.01	0	
98a	18577 -3701	S CrA, hbc286	7421-213N	359.87	-17.70	1	73	-0.19	0	1,9
98b	18577 -3701	S CrA, hbc286	7421-213S	359.87	-17.70	1	61	-0.20	6	1,9

Notes: 1- outside IRAS position error ellipse 2- H-alpha emission with central absorption reaching below the continuum 3- discrepant radial velocities 4- He emission 5- variable H-alpha profile (see text) 6- binary system, both components observed together 7- He and Fe II emission 8- 7.5' from no.89 9- binary with about 1.3" separation; He, Fe II, S II emission in North component, Fe II, S II emission in South component.

the Li line equivalent width and velocity. The results are summarized in Table 4. In column 1, our sequential number is given; in column 2, the *IRAS* PSC coordinates, or the coordinates in the same format, if the star is not an *IRAS* source; in column 3, other identifications; in column 4, the GSC identification; in columns 5 and 6, the galactic coordinates; in column 7, the number of spectra obtained; in column 8, the observed H α equivalent width in Å, adopting positive sign for emission and negative sign for absorption; in column 9, the Li 670.7 nm equivalent width; in column 10, the heliocentric velocity obtained from the Li line, with typical errors less than 3 km s^{-1}; in column 11, we refer to the footnotes of the table.

In Fig. 1, we present the spectra of four previously known TTS listed in Table 4. Figures 1(a) and 1(b) illustrate the remarkable variability of the H α profile of HBC 591 (T Cha, our No. 60). In one spectrum, H α is seen in about normal photopheric absorption, while in the other spectrum, H α appears in emission. A separate paper on this star is in preparation. HBC 248 [our No. 73, Figs. 1(c) and 1(d)] also presents a strongly variable H α profile, which sometimes has a P Cyg component. CW Tau [No. 5, Fig. 1(e)] is an example of an object with He emission and strongly blueshifted [S II] 671.7 and 673.1 μm emission, which indicates the presence of gas outflow and of a circumstellar disk (e.g., Edwards *et al.* 1987). HBC 254 [No. 80, Fig. 1(f)] is a case of TTS with strong He I 667.8 nm emission.

4.2 New TTS

In Table 5 we present the observations of the new TTS detected in this work. The table is organized as Table 4. Since the HBC is a recent compilation, we regard as "new" the TTS which are not contained in this catalog. Two objects which do not originate from our *IRAS* selected search list, but were known emission-line stars in which we detected the Li I line, are included in this table (Nos. 1 and 55). The spectra of the new TTS are shown in Figs. 2–7, and comments on some individual stars are given in Sec. 5.

4.3 Suspected TTS

When a star presents H α in emission but no visible Li line, it can still be a TTS, because the star can be veiled. These cases are presented in Table 6 as suspected TTS. Stars with low quality spectra are also included in this list. In many cases, the typical H α absorption profile or the photometry permit to infer an early type nature of the star; these are excluded from Table 6, and included in Table 7, or in Table 8, and are discussed later.

4.4 Probable Herbig Ae/Be Stars

The stars listed in Table 7 are early type, based on the photometry, and present the characteristic H α profile of Ae and Be stars, with emission superimposed on a broad photospheric absorption. Due to these profiles, the H α equivalent widths that we present are not always meaningful. Many of the stars listed, and in particular those identified with Henize stars or with stars of the Merril & Burwell (1950) catalog, designated as "AS," are previously known emission-line objects. It is not always easy to distinguish classical Ae/Be stars from Herbig Ae/Be stars, based on the H α profile, and on the photometry. However, classical Be stars do not usual-

TABLE 5. New T Tauri stars.

PDS (1)	IRAS (2)	identification (3)	GSC (4)	l (5)	b (6)	obs (7)	Eq.W.(H) (8)	Eq.W.(Li) (9)	Vr (10)	Notes (11)
1	(02084 -5544)	Hen 1	8483-1210	280.58	-59.07	2	0.2	-0.09	4	1
11a	04451 -0539		4744-1367	203.14	-30.00	6	20	-0.71	21	2
11b	04451 -0539		4744-1367	203.14	-30.00	6	42			
17a	05464 +0106		116-419 N	204.65	-13.32	1	68	-0.44	28	3,4,5
17b	05464 +0106		116-419 S	204.65	-13.32	1	19	-0.40	32	3,5,6
28	07388 -4747	WRA 54	8137-2426	260.83	-12.25	3	63	-0.37	22	
29	07458 -4652	Mc158	8138-1250	260.59	-10.77	3	15	-0.21	23	6
30	08131 -4432	CoD-44 4208	7672-563	261.06	-5.49	3	2.3	-0.13	17	7
35	10001 -5857	WRA 488	8611-1847	282.70	-3.17	3	8	-0.13	11	7
45	(11058 -2946)	Cod-298887	7201-27	277.96	27.83	1	2	-0.53	10	1,8
47a	11068 -7717	Glass#I	9414-640	297.34	-15.83	8	22	-0.30	15	1
47b	11068 -7717	Glass#I	9414-640	297.34	-15.83	6	1.4	-0.42	14	1
50a	11080 -3715	Hen600	7726-11	281.67	21.14	2	12.5	-0.47	10	1,8
50b	11080 -3715	Hen600B	7726-11	281.67	21.14	2	8	-0.48	8	1,8
51	11091 -7716	Glass#Q		297.46	-15.76	4	3	-0.35	34	9
54	11195 -2430	HD98800	6654-219	278.39	33.80	2	< 0.1	-0.37	13	1
55	(11295 -3420)	Cod-337795	7223-275	284.87	25.46	1	10	-0.52	2	1
59	11472 -7834		9419-1065	299.85	-16.35	3	5	-0.50	18	10
62	12345 -6910			301.71	-6.61	3	108	-0.27	39	11
64	12535 -7623			303.27	-13.80	3	3	-0.29	21	
65	12584 -7621	CM Cha	9413-2340	303.57	-13.77	3	42	-0.40	24	12
66	13185 -6922	Hen 892	9246-971	305.61	-6.92	3	47	-0.37	13	13
70	14050 -4109	CoD-40 8434	7811-1917	318.06	19.21	3	2.	-0.40	9	
77	15573 -4147	CoD-41 10484	7859-1039	336.49	8.29	3	2.	-0.32	4	6
81	16112 -1930		6209-923	354.83	22.21	3	0.7	-0.34	-1	9,14
82a	16126 -2235	VV Sco	6793-806 N	352.64	19.88	2	9	-0.42	-6	1,3
82b	16126 -2235	VV Sco	6793-806 S	352.64	19.88	6	29	-0.41	-6	1,3
83	16225 -2607	V896 Sco	6798-364	351.52	15.83	3	10	-0.40	-2	1
87	16424 -2457	CoD-24 12809	6813-143	355.43	13.18	3	9	-0.50	-5	12
89	16443 -1509		6217-126	3.78	18.84	3	2.2	-0.55	-5	1
91	16455 -1405			4.87	19.25	2	54	-0.39	15	1
99	19063 -3709			0.39	-19.36	2	5	-0.35	3	15
101	19558 -1405	BZ Sgr, SS444	5750-1246	27.61	-21.08	2	52	-0.33	-8	1

Notes: 1- see comments in text 2- binary with about 6" separation; only North (a) component presents Li abs. 3- binary with about 1.5" separation 4- He emission 5- Fe II emission 6-H-alpha profile with central absorption reaching below continuum 7- F or G spectral type 8- belongs to TW Hya group 9- weak H-alpha vanishing in some spectra 10- Near T Cha (no.60); variable He emission 11- variable emission lines 12- discrepant radial velocities 13- early K; previously classified as B star 14- situated in the same cloud of no.79 15- previously discovered as emission line star by Marraco and Rydgren (1981).

ly present strong infrared excess, as shown for instance by the study of *IRAS* colors of Be stars by Coté & Waters (1987). The fact that they are in our *IRAS* "T Tauri box" indicates that the objects of our list are probably Herbig Ae/Be stars. In addition, in many cases the pre-main-sequence nature of the object can be inferred from the proximity to a young association or from other characteristics.

An example of new Herbig Ae/Be star is No. 61, shown in Fig. 8(d). This star is identified with HD 104237, an A0 star in the Chamaeleon region. It presents Li I absorption; the reason for not classifying it as a TTS in agreement with our working definition is its early spectral type. Independently, Hu *et al.* (1989) also considered it as a Herbig Ae star. Another example is No. 96 = AS 232, [Fig. 8(e)]; its spectrum is very similar to that of HD 250550 or of AB Aur, which are recognized as Herbig Ae/Be stars (e.g., Finkenzeller & Mundt 1984). Since the objects of our list are not in the HBC, or in the catalog of Herbig stars of Finkenzeller & Mundt (1984), they can be regarded as new Herbig Ae/Be stars.

Stars Nos. 18, 23, 27, 37, 67, 69, and 103 form an interesting group with similar characteristics. They have anomalous colors, with small $U-B$ compared to their large $B-V$. Although we have no photometric measurements yet for Nos. 67 and 69, broadband spectra, obtained at the Cassegrain focus of the 1.6 m telescope, show that the energy distribution of these two stars is similar to the others. These stars present strong H α emission, without broad photospheric absorption [see Figs. 8(a), 8(c), and 8(f)], which might indicate that they are late-type stars. In this hypothesis, the color anomaly could be due to an UV excess, which might be attributed, for instance, to the boundary layer of an accretion disk (e.g., Basri & Bertout 1989). These stars could then be considered as suspected TTS, according to our criterion. We remark that strong H α emission is often accompanied by a UV excess in TTSs (see for instance the new TTSs Nos. 17, 28, and 62). However, an opposite interpretation of the color anomaly would be to consider the stars of this group as being early type stars deeply embedded in circumstellar matter. Manchado *et al.* (1990) argue that this is the case for our star No. 27. For the moment, we keep all the stars of this group in the list of probable Herbig Ae/Be stars, but a deeper study of their nature is in preparation.

4.5 Other Stars with Hα Emission

The remaining seven emission-line stars observed in this first part of the survey, which are not pre-main sequence stars, are listed in Table 8. Number 12 [Fig. 9(a)] is a LBV (Luminous Blue Variable) of the LMC; No. 31 is a visual binary with only one component showing H α emission; Nos. 32, 58, and 94 are symbiotic stars or planetary nebulae; No. 36 is a peculiar Be star, and No. 102 is a *Srb* variable. References concerning the nature of these stars are given in the footnotes of Table 8.

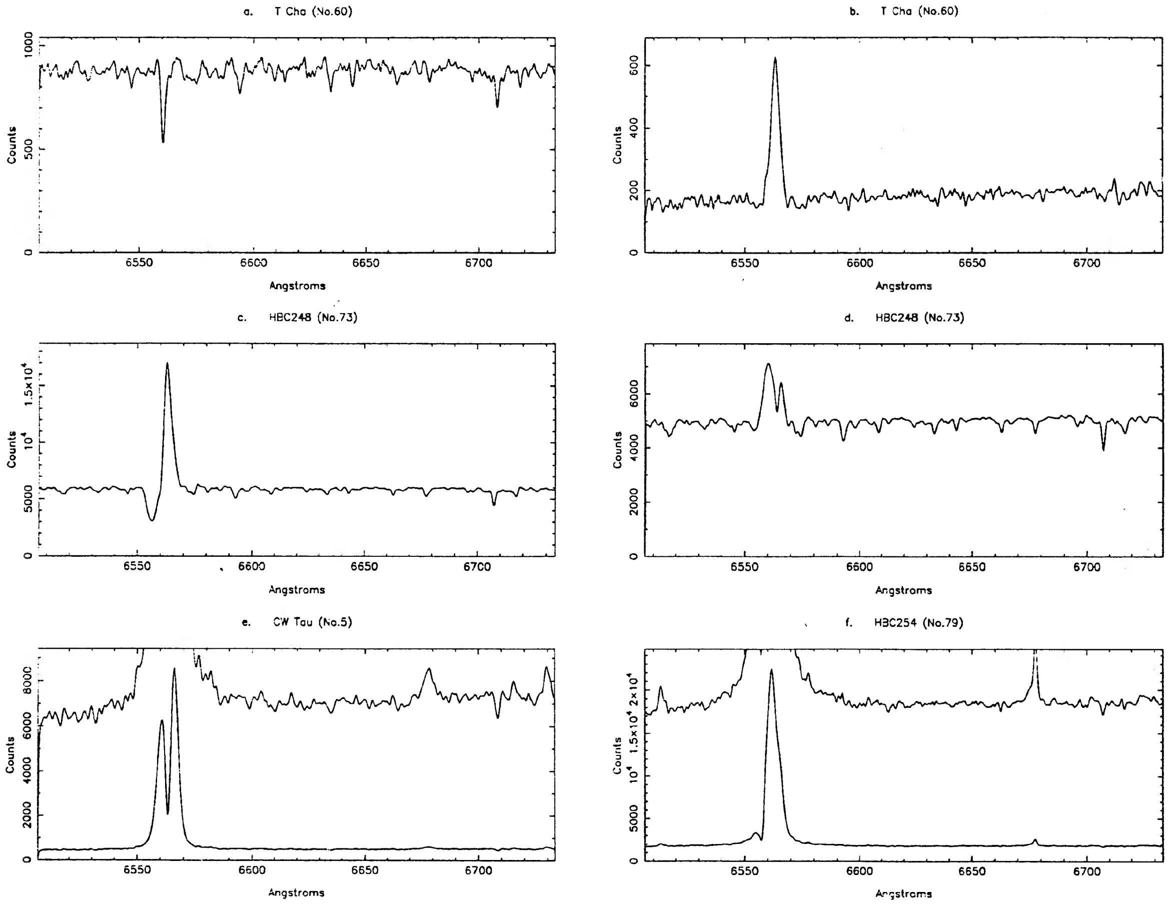

FIG. 1. Spectra of known TTS; (a) and (b) T Cha on two different nights; (c) and (d) HBC 248 on two different nights; (e) CW Tau, and the same multiplied by 14; (f) HBC 254, and the same multiplied by 10.

4.6 Stars with no Hα Emission

Only 10 stars, which represent 10% of the present sample of stars from the "T Tauri color box," did not present H α emission. The spectroscopic measurements of these stars are presented in Table 9. Of these, four stars (Nos. 3, 68, 97, and 100) are very interesting discoveries of this survey, being Li-rich late giants, further discussed in the last section. The spectra of Nos. 3 and 97 are shown in Figs. 9(b) and 9(c). One star (No. 56) is a carbon star, presenting no line in the spectrum. One star [No. 9, Fig. 9(d)] is a shell star, but could also be a pre-main-sequence star; the other stars (Nos. 26, 71, 84, 86) seem to be field stars that happened to be contained in the *IRAS* error ellipses.

TABLE 6. Suspected T Tauri stars.

PDS (1)	IRAS (2)	identification (3)	GSC (4)	l (5)	b (6)	obs (7)	Eq.W.(H) (8)	Notes (9)
7	04187 +1927			176.16	-20.91	2	14	1
19	05555 -1405		5360-1033	219.84	-18.13	2		2
63	12366 -7850			302.38	-16.26	3	39	
72	15354 -6950	CoD-691428	9264-1795	316.52	-11.73	3	2.5	3
85	16284 -2418			353.85	16.03	3	28	4

Notes: 1- classified as TTS by Kenyon et al.(1990); Li abs. uncertain due to weak continuum 2- variable H-alpha profile 3- H-beta in absorption; broadenned absoption lines suggest high rotational velocity; G spectral type 4-binary; weaker component at about 5" also presents H-alpha emission; pointed as probable TTS by Ishikawa and Nishida (1980).

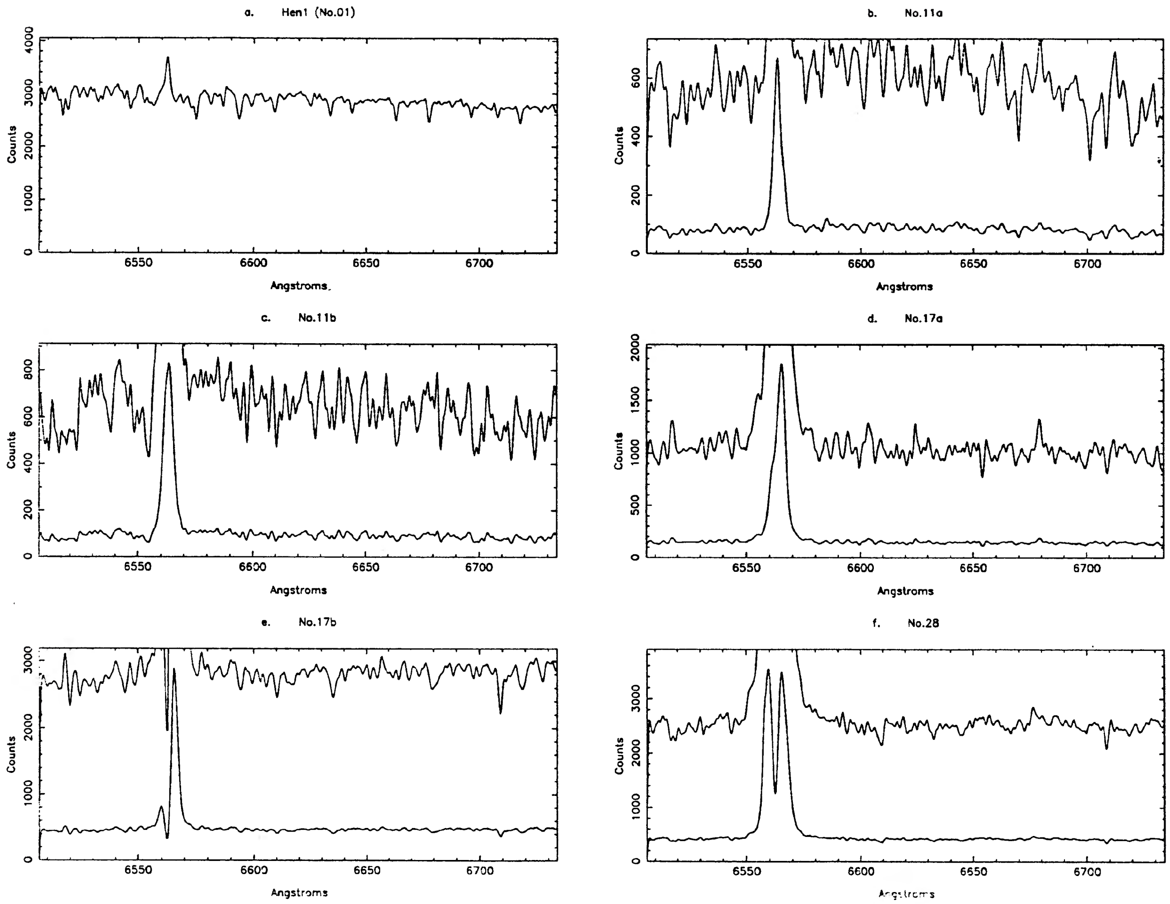

FIG. 2. Spectra of new TTS; (a) No. 1 (Hen 1); (b) No. 11a, and the same spectrum multiplied by 7; (c) No. 11b, and the same multiplied by 7; (d) No. 17a, and the same multiplied by 7; (e) No. 17b, and the same multiplied by 6; (f) No. 28, and the same multiplied by 6.

5. REMARKS ON INDIVIDUAL STARS

Number 1 (Hen 1) is a high galactic latitude object ($b = -59°$), which was classified as a K star by Henize (1976). This TTS was not discovered according to the search criterium adopted in this work, since it is not an *IRAS* source. Besides the *UBVRI* photometry, we made *JHKL* measurements, using the standard infrared photometer installed at the 1 m telescope of the European Southern Observatory at La Silla, Chile. We obtained $J = 7.91$, $H = 7.30$, $K = 7.13$, $L = 6.95$, on 1991 January 1. The visible-near-infrared energy distribution looks like a blackbody, with almost no infrared excess. We observed this star in *UBVRI* on five different nights, and detected a flare of about two magnitudes in band *U* and affecting all the bands, on JD 2448232.51. Besides the flare, variability ($\Delta V = 0.07$) was observed in the remaining nights. The possibility of Hen 1 being a Li-rich main-sequence star with active chromosphere cannot be excluded. However, since we can find stars with similar characteristics among the known TTS, such as HBC 651 for instance, which has a similar spectrum and no *IRAS* counterpart either, we think that Hen 1 is more probably a pre-main-sequence star.

Number 27 (DW CMa, SS 103) presents strong H α emission with variable P-Cygni profile and Fe II 651.6 nm emission line. The $B - V$ index, the featureless spectrum, the broad He absorption, and the fact that it is a strong *IRAS* source are consistent with the interpretation of Manchado *et al.* (1990), of this object being a deeply embedded early type star. On the other hand, its spectrum is typical of TTS with strong H α emission, many of which show no detectable photospheric absorption lines, as discussed by Mundt (1984). We classify it as a probable Herbig Ae/Be star as explained in the text.

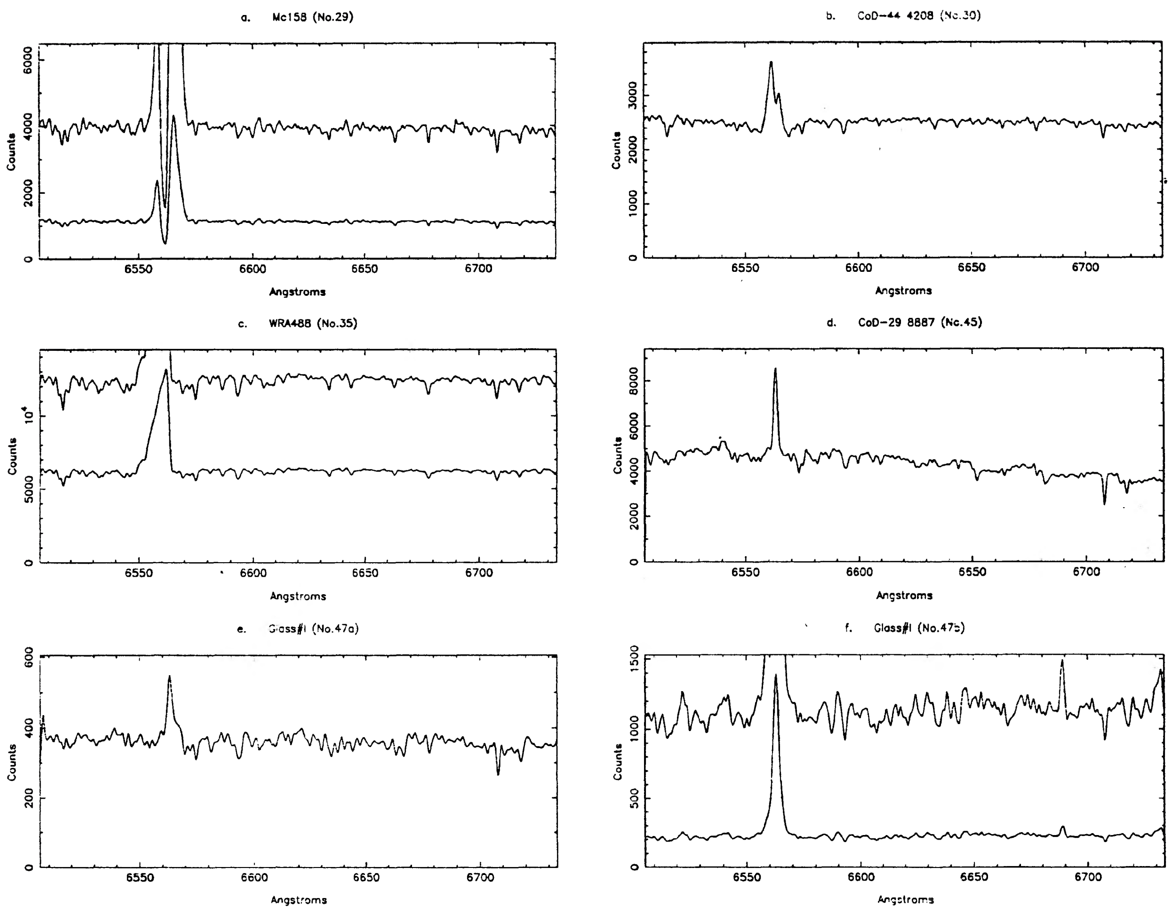

FIG. 3. Spectra of new TTS; (a) No. 29 (Mc 158), and the same multiplied by 3.5; (b) No. 30 (CoD-44 4208); (c) No. 35 (WRA 488), and the same multiplied by 2; (d) No. 45 (CoD-29 8887); (e) No. 47a (Glass No. I); (f) No. 47b (Glass No. I) and the same multiplied by 5.

Number 28 (WRA 54) is a new TTS with strong H α emission and UV excess; it presents strong photometric variability, with observed changes up to 2.4 mag in V. The magnitudes given in Table 2 correspond to the brightest that we observed.

Number 47 (Glass I) is a visual binary with about 2.5″ separation, belonging to the Cham I association; we call 47(a) the E-component and 47(b) the W-component; 47(a) may be a spectroscopic binary, since discrepant velocities have been found from the Li line. It has already been detected as a visual binary TTS by Chelli *et al.* (1989). Whittet *et al.* (1987) found large infrared excess, and emission in the H and K lines.

Number 54 (HD 98800, K4V) is an *IRAS* source which lies slightly outside the TTS "color box" used in this work; it is a visual binary with about 0.2″ separation, so that both stars were observed together. It has a relatively high galactic latitude and the spectrum resembles that of object No. 1 (Hen 1), with very weak H α emission. The narrow absorption lines may indicate a subgiant luminosity type. It is situated at about 6° from No. 45.

Number 55 (Cod-33 7795) was selected because of its similarity with our object No. 50 in the catalog of emission-line stars of Stock & Wroblewsky (1971); it is not an *IRAS* source. This is a new member of the TW Hya group discussed by de la Reza *et al.* (1989), being at about 7° from TW Hya. Its spectrum resembles that of Nos. 45 and 50, except for the wide absorption lines. It is variable ($\Delta V = 0.1$ in three nights).

Number 61 (HD 104237) is an A0e star, with H α and He emission, and with Li absorption. It is classified as a shell B/Ape in the Michigan Spectral Catalog, so that the Li could originate in the shell. However, it is situated in the neighborhood of young stars like T Cha, with similar radial velocity, and it is probably a Herbig Ae star.

Number 69 (Hen 949) is a probable Herbig Ae/Be star

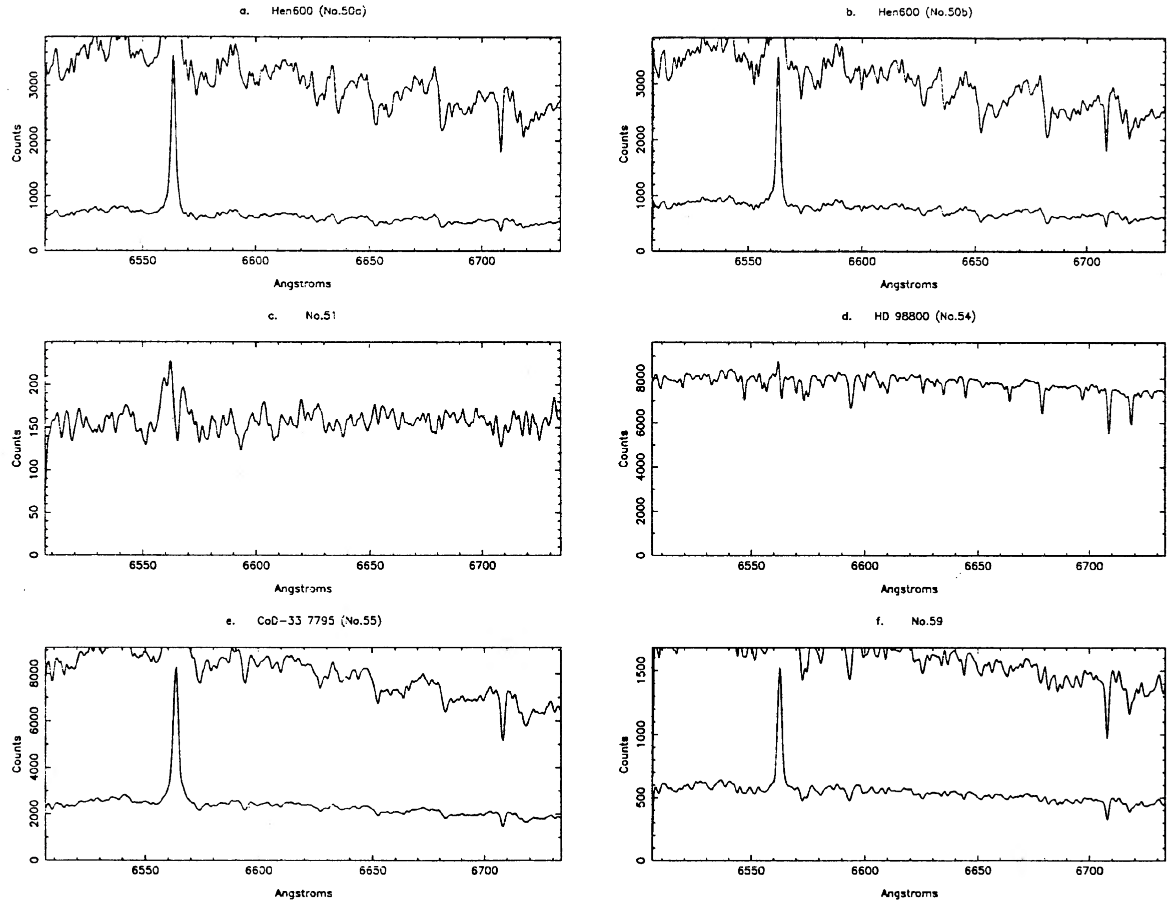

FIG. 4. Spectra of new TTS; (a) and (b) Nos. 50a and 50b (two components of Hen 600), and the same multiplied by 5 and by 4, respectively; (c) No. 51; (d) No. 54 (HD 98800); (e) No. 55 (CoD-33 7795) and the same multiplied by 3.5; (f) No. 59, and the same multiplied by 3.

with strong H α, H β and Fe II emission. It is associated with the bright nebula NGC 5367; about this nebula see Odenwald (1988). It is relatively high latitude and isolated, but at about 2° from the new TTS No. 70.

Number 78 (Hen 1141) presents a strong shortward absorption on H α emission, superimposed on a broad photospheric absorption, and H β in absorption. It is a probable Herbig Ae star of the ρ Oph region; however Pottasch & Parthasarathy (1988) suggest a late evolutionary stage, and spectral type F 3 IIIe.

Number 80 (V 718 Sco) is a possible pre-main-sequence eclipsing binary (Parthasarathy 1989), in the direction of the ρ Oph association.

Number 82 (VV Sco) is a visual binary with about 1.5″ separation, situated to the north of the ρ Oph molecular cloud. The H α emission was noted by Ishikawa & Nishida (1989). We were able to observe each component; 82*b* (the south component) presents He 667.8 nm emission. It is photometrically variable ($\Delta V = 0.5$).

Number 83 (V 896 Sco) like No. 82 was known as a variable star, but its TTS nature is now revealed. There is H α emission from the sky around it. It belongs to the ρ Oph association, and is situated at about 1° from α Sco.

Number 89 is a serendipitous discovery of a new TTS, since it lies outside the *IRAS* error box as we later noted. A weak H α emission star exists at the *IRAS* position. It is close to the known TTS HBC 651 (No. 88) and to the clouds L137 and L152 situated at the north of the ρ Oph molecular cloud.

Number 91 is a new TTS lying about 1′ from HBC 652 (No. 90), and associated with the molecular cloud L162, located at the north of ρ Oph. It presents strong H α and weak He emission.

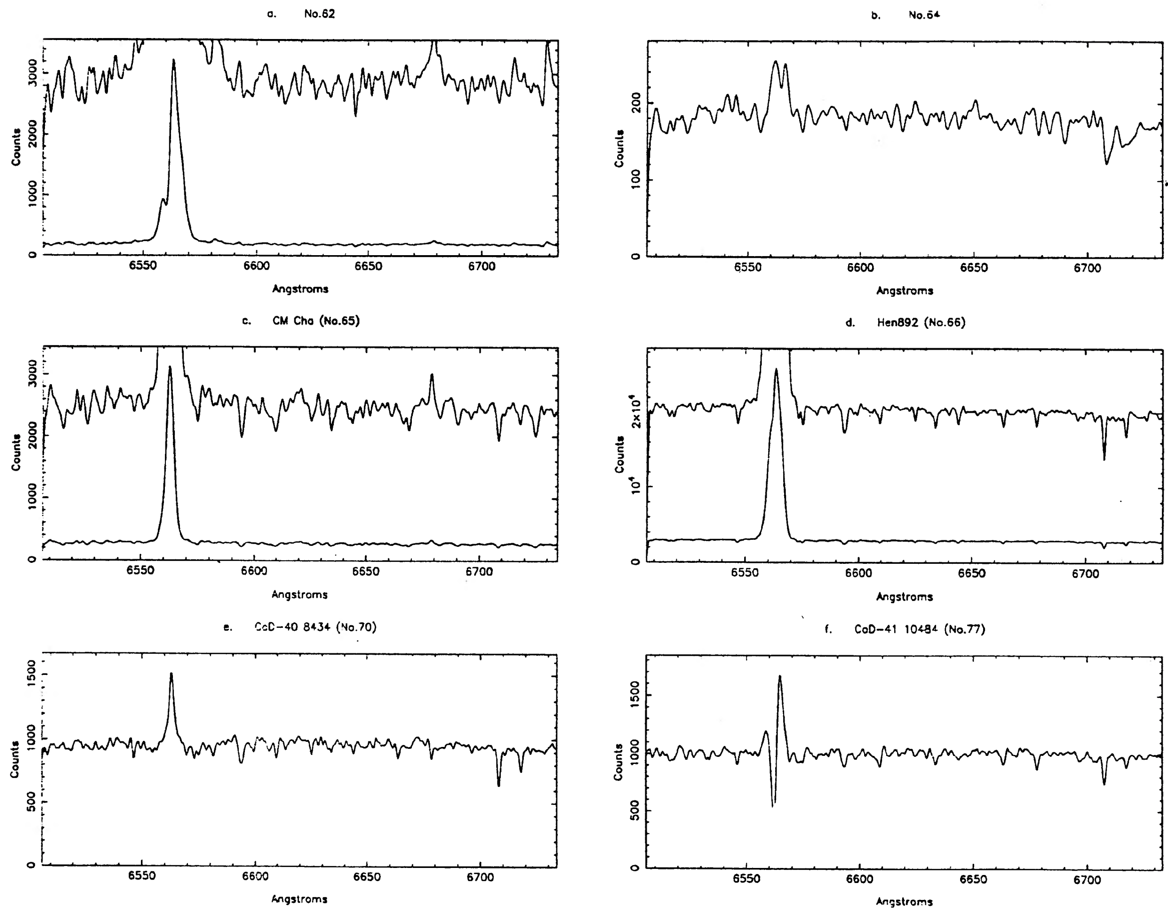

FIG. 5. Spectra of new TTS; (a) No. 62, and the same multiplied by 15; (b) No. 64; (c) No. 65 (CM Cha), and the same multiplied by 9; (d) No. 66 (Hen 892), and the same multiplied by 7; (e) No. 70 (CoD-40 8434); (f) No. 77 (CoD-41 10484).

Number 101 (BZ Sgr) was previously classified as a Cepheid, its TTS nature is revealed in this work. It has a weak companion at about 5″. It is a new TTS, associated with the high latitude molecular cloud No. 159 of Magnani *et al.* (1985). It is variable in magnitude and color ($\Delta V = 1.5$).

Number 103 (ST 202) is a probable Herbig Ae/Be star. In addition to H α emission, it presents N[II] and S[II] forbidden lines [Fig. 8(f)]. It is situated at a high galactic latitude ($b = 57°$). It has been classified as a TTS by Downes & Keyes (1988). It is photometrically variable ($\Delta V = 0.4$ in five nights).

6. CONCLUSIONS

At the present stage of the ongoing TTS search, the results can be summarized as follows:

Previously known T Tauri observed	30,
New T Tauri discovered	33,
Suspected T Tauri	5,
New Herbig Ae/Be stars	24,
New Li-rich giants	4.

Among the new TTS, seven are in binary systems (Nos. 11, 17, 47, 50, 54, 82, and 101), but only when both components were observed were they counted separately. We can expect that about 60 new TTS will be discovered in this survey, when completed. Besides the increase in the number of known TTS, the large sample of stars of this class observed in the same conditions, with repeated observations of many stars, constitutes a database which will allow the investigation of correlations between observed parameters. We are conscious, however, that our search is biased towards the discovery of classical TTS having an infrared excess.

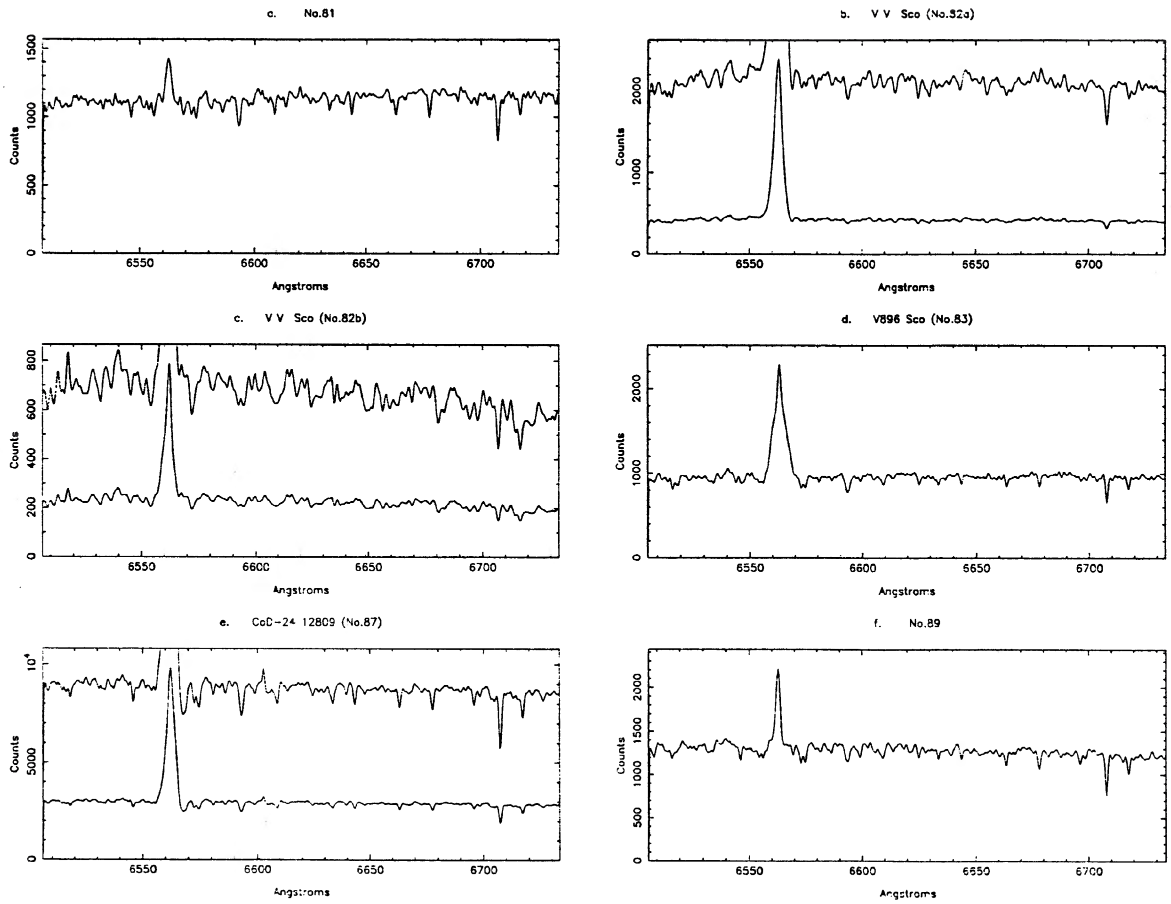

FIG. 6. Spectra of new TTS; (a) No. 81; (b) and (c) Nos. 82a and 82b (two components of VV Sco), and the same multiplied by 5 and by 3, respectively; (d) No. 83 (V 896 Sco); (e) No. 87 (CoD-24 12809), and the same multiplied by 3; (f) No. 89.

One of the main interests of an unbiased survey over a large part of the sky like this one lies in the possibility of finding TTS outside the known sites of star formation. In this respect, we have revealed the probable TTS nature of Hen 1 (No. 1), which would be the TTS with the highest galactic latitude ($b = 59°$) known, situated far from any molecular cloud. Other new relatively isolated TTS are No. 70 (Cod-40 8434) and No. 101 (BZ Sgr). On the other hand, we have found several TTS around TW Hya, which was considered as the prototype of isolated TTS. The cases of Cod-298887 (No. 45) and Hen 600 (Nos. 50a and 50b) have already been discussed by de la Reza *et al.* (1989). The new TTS in this region are HD 98800 (No. 54) and Cod-337795 (No. 55). With the exception of HD 98800, which is distant about 10° from TW Hya, the other stars are situated within about 6°. This result seems to exclude the hypothesis of TW Hya being a "runaway" star, and indicates that a T association probably existed in that direction and is now being dissipated; the remnants of the parent molecular cloud have possibly been dispersed in the form of diffuse clouds, which are difficult to observe.

In addition to the TTS, we have identified with high probability 24 new Herbig Ae/Be stars. Although the presence of H α emission was known for many of them, their pre-main sequence nature is indicated by their *IRAS* colors, which are different from those of classical Be stars. This result is consistent with the fact that the Herbig Ae/Be stars constitute the extension of the TTS class to early types. Since the catalog of Herbig Ae/Be stars and Herbig Ae/Be star candidates of Finkenzeller & Mundt (1984) contains 57 objects, if our results are confirmed this would represent a substantial increase of this number.

Concerning the by-products of our search, we remark that serendipitously we have detected, with a relatively high effi-

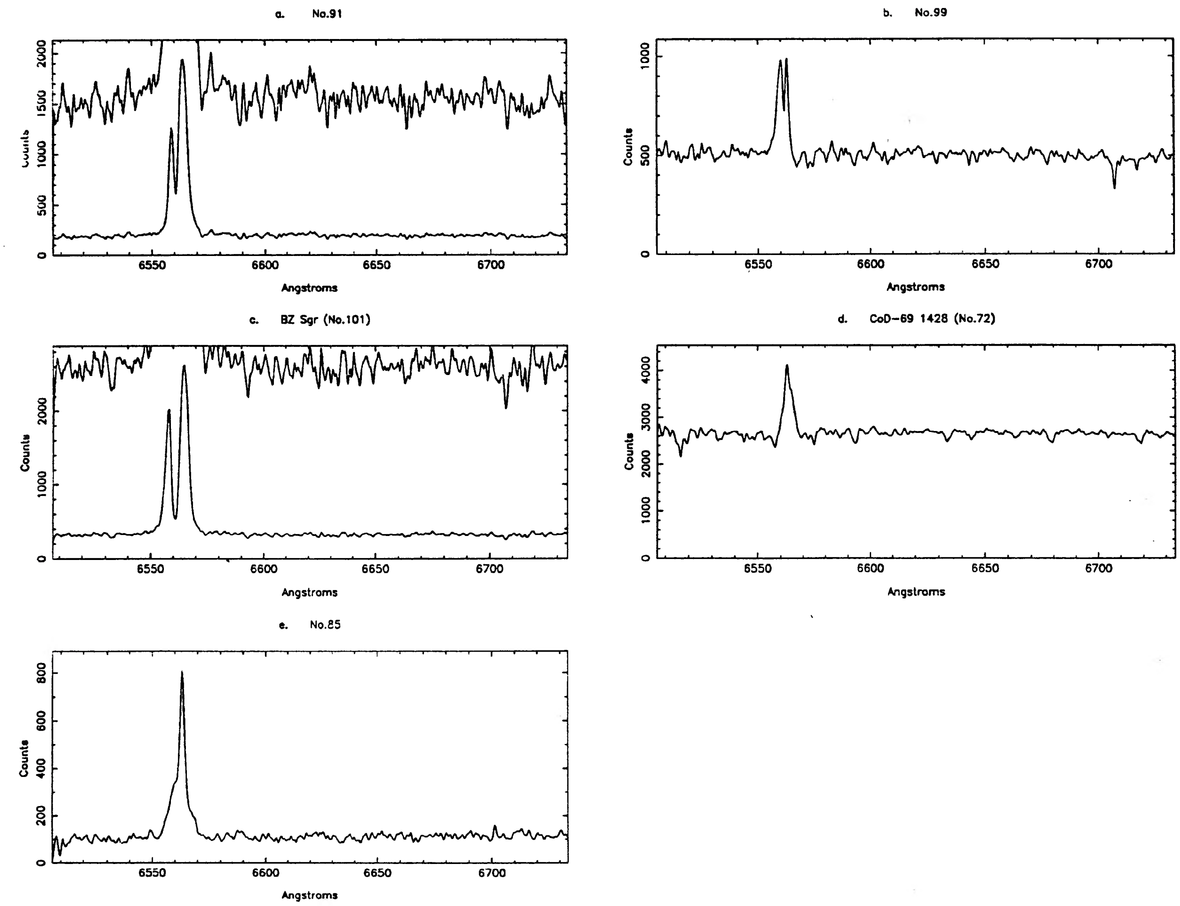

FIG. 7. Spectra of new TTS and of suspected TTS; (a) No. 91, and the same multiplied by 8; (b) No. 99; (c) No. 101 (BZ Sgr), and the same multiplied by 8; (d) No. 72 (CoD-69 1428); (e) No. 85.

TABLE 7. Probable Herbig Ae/Be stars.

PDS (1)	IRAS (2)	identification (3)	GSC (4)	l (5)	b (6)	obs (7)	Eq.W.(H) (8)	Notes (9)
2	01156 -5249	CP-53 295	8474-24	293.77	-64.1	4	5	1
4	03359 +2932		1811-767	161.18	-20.46	1	7	2
16	05407 -0501	HD 38120	4775-193	209.57	-17.45	1	26	3,4
18	05513 -1024		5352-159	215.87	-17.49	1	42	5
20	05560 +1639		1312-805	192.13	-3.6	1	36	
21	05598 -1000	AS116		216.45	-15.43	1	102	2,3
22	06013 -1452	AS117	5361-1651	221.2	-17.17	1	27	
23	06245 -1013	NSV 2968, SS43		219.38	-10.07	1	39	2,3,5,6
24	06464 -1644		5990-21	227.68	-8.16	1	36	3
25	06523 -2458	NSV 3275	6526-1178	235.80	-10.51	3	13	7
27	07173 -1733	DW CMa, SS103	5969-2200	231.80	-1.97	1	88	2,3,5,6
33	08469 -4037		7679-293	261.62	1.84	3	15	1
34	08482 -4541			265.69	-1.21	4	51	
37	10082 -5647	Hen 373	8607-1509	282.30	-0.78	1	89	2,6,8
57	11373 -5953	HD 101412	8972-1154	294.12	1.47	1	14	1,9
61	11575 -7754	HD 104237, Hen741	9416-1289	300.23	-15.59	1	24	5
67	13491 -6318	Hen 938		309.69	-1.48	1	77	2,6,8
69	13547 -3944	Hen 949		316.48	21.14	1	26	2,5,6,8
76	15537 -2153	HD 142666	6199-618	349.9	23.51	1	0.8	2
78	16038 -2735	HD 144432, Hen1141	6788-508	347.4	17.82	1	5	1,5,10
80	16102 -2221	HD 145718, V718 Sco	6213-70	352.42	20.45	1		5
95	17277 -3506	HD 319896, Hen1418	7383-99	353.1	-0.72	1	41	10
96	17306 -3921	HD 323771, Hen1425	7888-127	349.87	-3.53	1	51	2,6,11
103	23198 -0230	ST202	5244-148	78.58	-57.22	5	19	5

Notes: 1- H-beta in absorption 2- H-alpha with P Cygni profile 3- He emission 4- Extended emission around the star 5- see comments in the text 6- Fe II emission 7- variable H-alpha profile 8- H-beta in emission 9- classified as B9-A0 v(e) 10- Pottasch and Parthasaraty (1988) suggest late evolutionary stage 11- H-beta with P Cygni profile.

TABLE 8. Other emission-line stars.

PDS (1)	IRAS (2)	identification (3)	GSC (4)	l (5)	b (6)	obs (7)	Eq.W.(H) (8)	Notes (9)
12	04571 -6954	HDE 268835	9165-859	281.24	-35.11	1	38	1,2,3
31	08277 -3826	HD 72106	7661-1915	257.62	0.25	3		4
32	08296 -2735	AS201, Hen172	6578-1754	249.08	6.97	2	61	5
36	10028 -5825	HD87643	8611-1191	282.66	-2.53	1	288	6
58	11385 -5517	HD 101584	8634-1166	293.03	5.94	1	6.5	7
94	17028 -1004	M2-9	5647-690	10.9	18.06	1		8
102	20160 +2734	AU Vul	2163-1467	67.33	-4.51	1	0.2	9

Notes: 1- Luminous Blue Variable belonging to the LMC 2- H-alpha with P-Cygni profile 3- Fe II emission 4- binary with 0.8" separation; only the weaker component presents H-alpha emission 5- simbiotic star, [N II] and He emission 6- peculiar B[e] star surrounded by reflection nebula (de Freitas Pacheco et al., 1985) 7- F0 I Ape, bright IRAS source, presents many emission lines; may be a proto-planetary nebula (Volk and Kwok, 1989, Loup et al., 1990) 8- planetary nebula; no continuum; see e.g. Calvet and Cohen, 1978 9- semi-regular variable; molecular bands present.

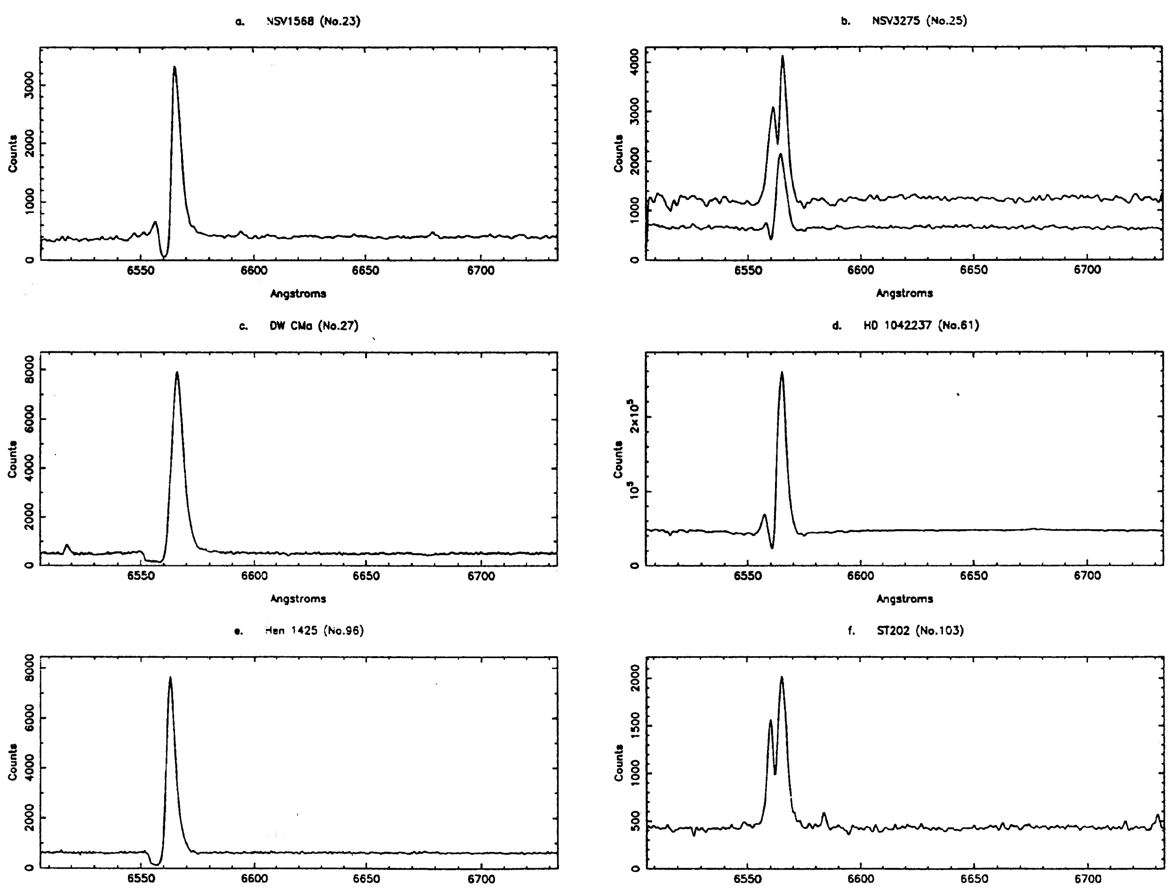

FIG. 8. Spectra of probable Herbig Ae/Be stars; (a) No. 23 (NSV 1568); (b) No. 25 (NSV 3275), two different observations; (c) No. 27 (DW CMa); (d) No. 61 (HD 1042237); (e) No. 96 (Hen 1425); (f) No. 103 (ST 202).

TABLE 9. Other stars.

PDS (1)	IRAS (2)	identification (3)	GSC (4)	l (5)	b (6)	obs (7)	Eq.W.(H) (8)	Eq.W.(Li) (9)	Vr (10)	Notes (11)
3	03062 -6538	HD 19745	8866-425	283.37	-46.19	2	-0.5	-0.41	-9	1
9	04217 +1303	HD 286746	680-549	181.98	-24.46	1	-5.8	-0.11	23	2
26	07106 -2625		6532-327	238.95	-7.46	1	-2.0			
56	11331 -1418	HD 100764	5516-872	276.86	44.41	1				3
68	13539 -4153		7798-578	315.72	19.10	7	-1.0	-0.60	-86	4
71	14422 -8021		9436-239	307.82	-18.83	1	-1.2			
84	16267 -4437			338.42	2.53	1	-0.5			
86	16392 -4628		8326-1029	338.54	-0.33	1	-5.1			
97	17554 -3822			353.24	-7.15	2	0.8	-0.54	-151	4,5
100	19285 +0517	V859 Aql	486-666	42.30	-6.28	2	-1.3	-0.28	5	6

Notes: 1- K1-III giant with strong Li absorption 2- classified as shell star; shell-like H-alpha profile and Li absorption 3- carbon star 4- high velocity giant with strong Li absorption 5- incorrect identification in PSC; KL Cra is 78" to east of no.97, outside error ellipse 6- late Li-rich giant.

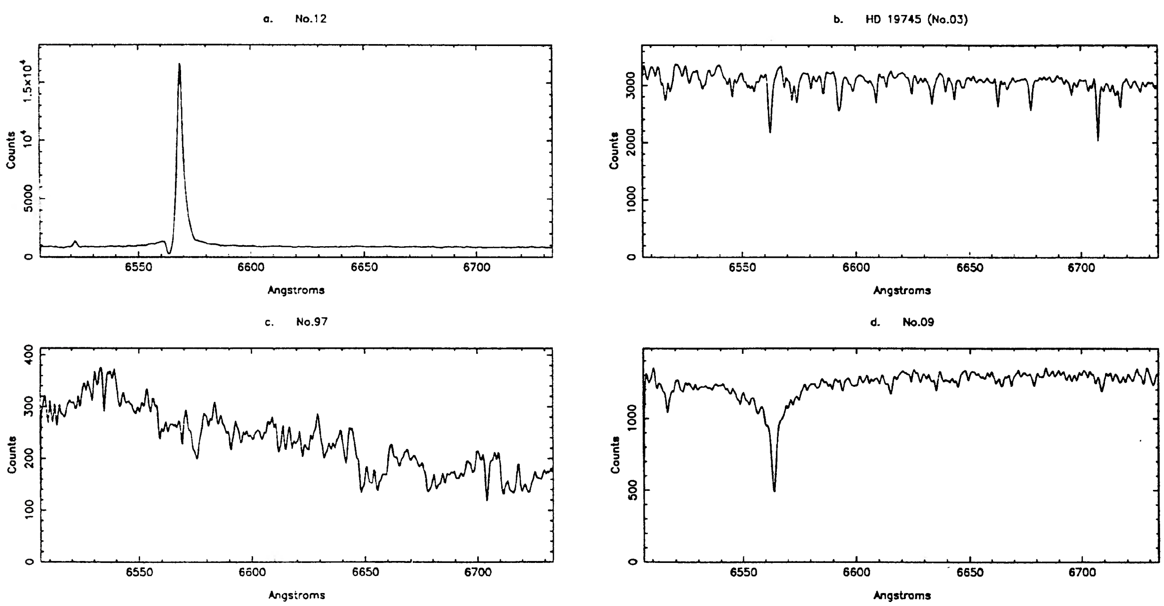

FIG. 9. Spectra of other stars observed in the survey; (a) No. 12; (b) No. 3 (HD 19745); (c) No. 97; (d) No. 9.

ciency, several Li-rich giants, especially of the K type. In fact, these objects represent a minority class of about 1% among the bright K giants (Brown *et al.* 1989). The origin of these Li-rich objects is not clearly established since the classical theory of evolution argues against the maintenance of photospheric Li in single K giants.

Up to the present, our efforts have not been successful in detecting new spectroscopic binary TTS systems like V 4046 Sgr or V 826 Tau. In a few cases, the velocity obtained from the Li line seems to be variable, but additional observations are needed.

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