FAINT NEW WOLF-RAYET STARS IN CARINA*

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Nine new faint Wolf-Rayet stars were found on objective-prism plates of the Carina region taken with the Curtis-Schmidt telescope at Cerro Tololo. Ultimately, these stars may help to define spiral structure in that direction at distances perhaps in excess of 10 kpcs from the sun.

Introduction

Bok, Hine, and Miller (1969) have summarized the considerable and still-mounting evidence of a major spiral structure feature extending along the line of sight in the direction of Carina which many consider to be the true extension of the Cygnus arm. These writers have used kinematically determined distances of H I and H II regions to define the location of this structure in the range between 5 and 12 kpcs from the sun. Their result is shown by the dashed line in Figure 1.

When their intrinsic color indices and absolute magnitudes are accurately determined, Wolf-Rayet (WR) stars serve as excellent optical tracers of spiral structure at great distances from the sun both because of their high luminosities and because they can be detected to at least photographic magnitude 16 on the deepest objective-prism plates (Stephenson 1966). Smith (1968*c*), using new spectroscopic and photometric observations, has made the first well-founded attempt to study the detailed distribution of WR stars

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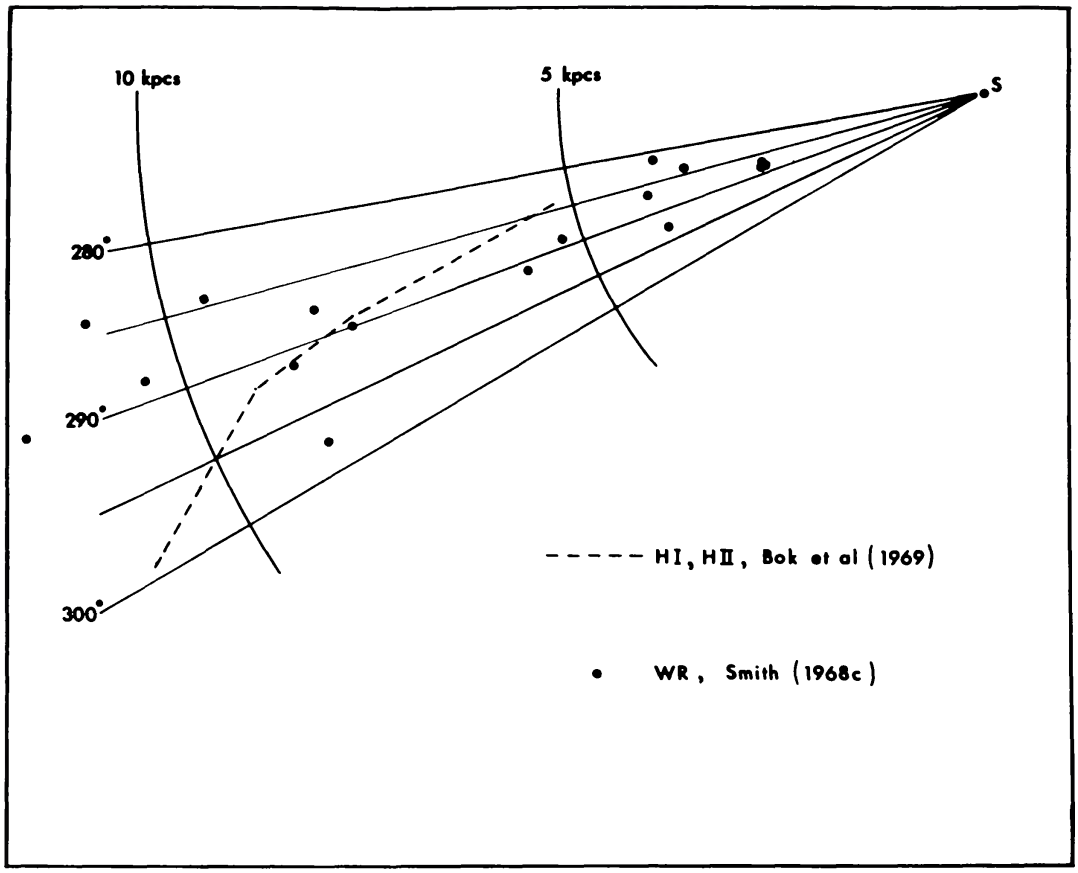

FIG. 1 — Distribution of Wolf-Rayet stars in the Carina direction compared with the spiral feature defined by hydrogen concentrations.

in the Galaxy. In Figure 1 we have plotted the positions of the WR stars in the Carina direction according to Smith (1968*c*).

As is often the case, the correlation between the stars and the gas is rather poor. But clearly, WR stars are present in this region at distances of 10 kpcs or more. Their detection at such distances undoubtedly is made possible by the relatively low interstellar absorption encountered at $282° < \ell^{II} < 305°$ which Bok et al. (1969) state to be 0.5 mag. kpc^{-1}. These considerations prompted us to make a systematic survey in Carina in hopes of detecting faint new WR stars that might be associated with the gaseous structure shown in Figure 1.

Observations

Because of the importance of the Carina region in galactic structure studies, a number of long-exposure objective-prism plates of

TABLE I

PLATE SPECIFICATIONS

Plate No.	α (1968)	δ	Prism	Emul.	Filter	Exp.
1760	10^h45^m	$-59°4$	4°.5	IIa-O	—	60^m
1781	10 45	−59 .3	4°	103a-F	GG14	47^m
1841	10 58	−59 .5	4°	103a-F	GG14	9^m
1901	11 05	−59 .8	4°.5	IIa-O	—	60^m
1963	10 45	−59 .4	4°.5	Ia-O	GG5	45^m
3627	10^h42^m	$-59°.6$	2°	103a-O	GG5	90^m

various types have been taken by the writers over the past two years using the 24-36 inch Curtis-Schmidt telescope of The University of Michigan at the Cerro Tololo Inter-American Observatory in Chile. Table I describes the plates, each of which covers an area of $5° \times 5°$ with a scale of about 97″ mm^{-1}. The dispersions given by the respective prisms are: 4°.5 (580 Å mm^{-1} at Hγ), 4° (1000 Å mm^{-1} at Hα), and 2° (560 Å mm^{-1} at Hγ). This material made it possible to survey the region bounded by $284° < \ell^{II} < 293°$ and $b^{II} = \pm 2°.5$, a total of about 45 square degrees.

Results and Discussion

The criteria for the identification of WR stars in the blue and red spectral regions at the above dispersions are discussed by Nassau and Stephenson (1960) and Stephenson (1966). Careful scanning of all the plates in Table I resulted in the detection of 25 stars showing definite or probable WR characteristics. Of these, nine are not listed in the catalog of WR stars compiled by Smith (1968*a*) and presumably have not been recognized previously as WR stars. The catalog of emission-line stars kindly made available to us in prepublication form by Wackerling (1969) shows, however, that three of the nine stars were detected in Hα emission-line surveys by The (1966) and Wray (1966).

Table II lists the approximate positions and photographic magnitudes of the new WR stars. The positions were measured on the Union Observatory Charts and should be accurate to ±1′. The magnitudes are the results of eye estimates of the image densities on the objective-prism plates and have estimated probable errors of $\pm 0^m.5$. The sequence in NGC 3496 given by Sher (1965) was used for calibration purposes. Identification charts are given in Plate I.

TABLE II

NEW WOLF-RAYET STARS IN CARINA

MS	α (1900)	δ	Sp.	m_{pg}
1	10^h40^m6	$-57°19'$	WN	15.5
2	45.0	−58 32	WN	14.0
3	46.8	−59 57	WN	13.5
4	47.8	−60 24	WR::	14.0
5	55.7	−59 20	WN:	15.5
6	56.3	−60 42	WN	15.0
7	11 01.1	−60 48	WR	15.5
8	01.7	−60 41	WR	15.5
9	11^h02^m2	$-60°42'$	WR	15.0

NOTES TO TABLE II

MS 2 = THα35-112, The (1966).
MS 3 = THα35-117 = WRA 663, Wray (1966).
MS 6 = THα35-159.

These were drawn by hand from the IIa–O plates and thus correspond to photographic magnitudes.

It should be acknowledged that the first three stars in Table II were independently discovered by Stephenson (1969) on shorter-exposure plates used for a survey of high-luminosity stars in the southern Milky Way.

In Figure 2 we have plotted in galactic coordinates all of the WR stars found in our survey. These include the 16 previously known stars which are denoted by their MR number (Roberts 1962) or LS number (Smith 1968*a*). Also shown by the dashed line is the position of the relatively nearby η Car nebula at 2.7 kpc. Note that about two-thirds of the WR stars lie below the galactic equator. The same tendency is also shown by the OB stars, H I, and H II regions in this direction according to Bok et al. (1969).

The insert in the upper right-hand corner of Figure 2 shows the apparent magnitude distribution for all 25 WR stars. This histogram combines our photometry with that given by Smith (1968*b*) for the brighter stars. There is a sharp rise in the number of stars fainter than $m_{pg} \sim 14$. All of these fainter stars lie close to the galactic plane and within the longitude range of 286° to 291°. Precise spectroscopic and photometric data are required for these

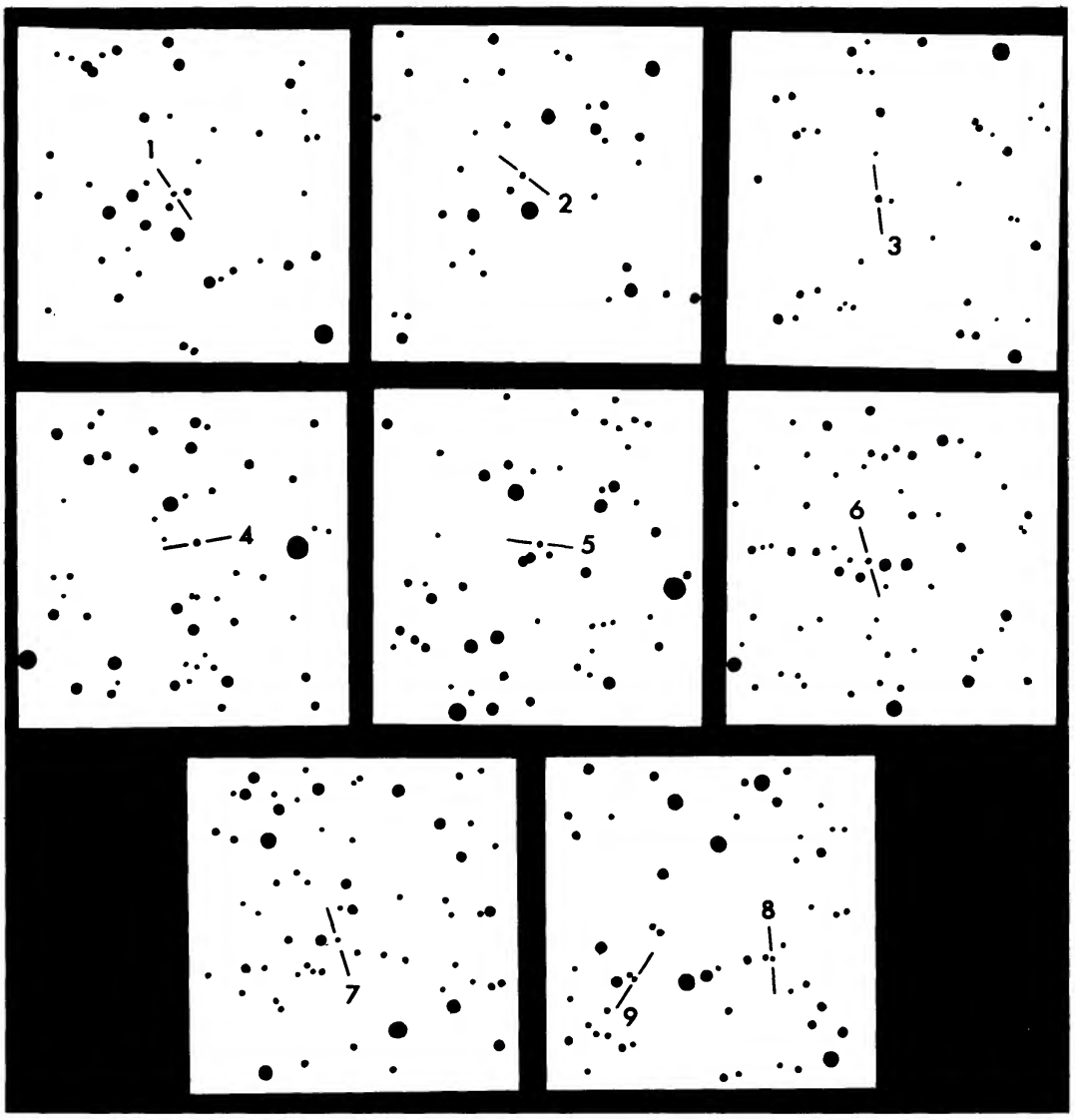

PLATE I

Identification charts for the new Wolf-Rayet stars. Each field is 10 minutes of arc square with north at the top and east at the left.

very faint stars in order to estimate their distances and determine their relationship to the distant gas concentrations.

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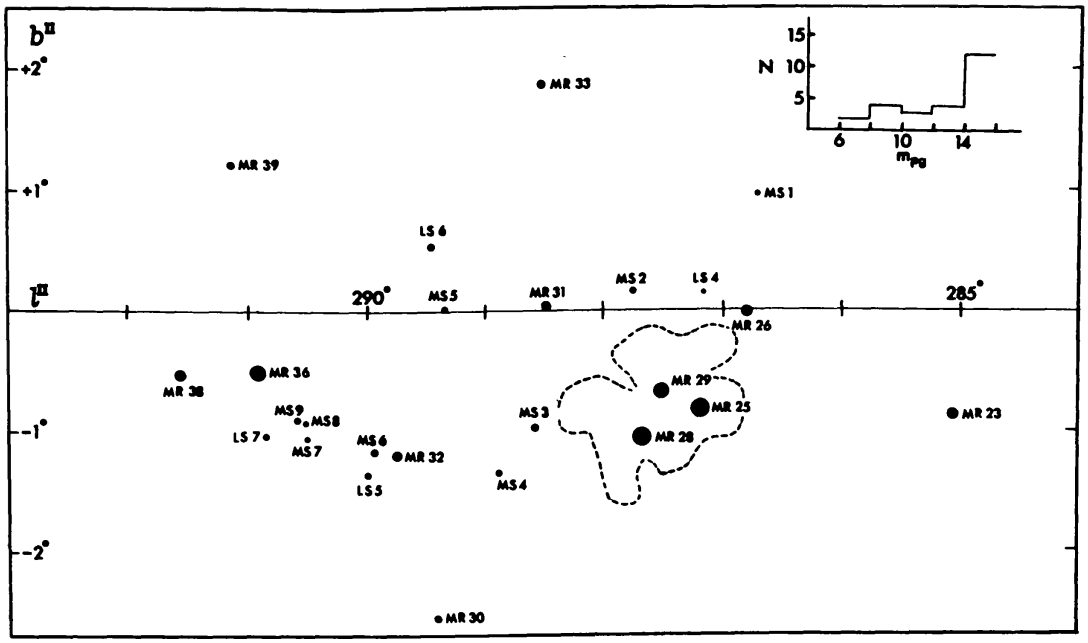

FIG. 2 — Surface distribution of Wolf-Rayet stars in Carina. The insert in the upper right is explained in the text.

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