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DISCOVERY OF OPTICAL EMISSION FROM THE SNR G290.1−0.8

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ABSTRACT

Photographs taken through Hα and [S II] interference filters at the prime focus of the CTIO 4 m telescope show a faint smooth ring of emission nebulosity which is coincident in position and extent with the radio supernova remnant G290.1−0.8 (MSH 11−*61*A). The remnant is unusually smooth in its optical appearance if it is at a distance of about 4 pc. We searched for, but did not find, optical nebulosity associated with the radio remnants G292.0+1.8 (MSH 11−*54*), G327.4+0.4 (Kes 27), G348.5+0.1 (CTB 37A), and G348.7+0.2 (CTB 37B).

Subject headings: nebulae: individual — nebulae: supernova remnants — radio sources: extended

I. INTRODUCTION

Two recent efforts to identify radio supernova remnants with their optical counterparts have recently been published (van den Bergh 1978; Longmore, Clark, and Murdin 1977). The search by van den Bergh employed broad-band red plates (098 + RG2) and the Curtis Schmidt at CTIO plus large reflectors, while the search by Longmore, Clark, and Murdin used the IIIa-J plates from the SRC survey with the UK Schmidt. The total number of optically known supernova remnants in our Galaxy is now 29 compared with 124 likely nonthermal radio sources. As our contribution to this effort, we obtained prime focus plates with the 4 m telescope at CTIO, using interference filters at the sites of particularly promising radio sources. This technique provides high spatial resolution and high sensitivity to emission nebulosity. As described below, we found an exceedingly faint ring of emission in Hα + [N II] and in [S II] that corresponds in position and extent with the radio SNR G290.1−0.8.

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II. OBSERVATIONS

The observations for this work are summarized in Table 1. Plates were taken in conditions of partial moonlight and superb seeing. Generally, the sky is well exposed in each, and the plates, except for that of G327.4+0.4, represent the limit of what can be done with this technique. The plates have been visually inspected, both at the site of the remnant and elsewhere, for traces of emission nebulosity. In three cases, G292.0+1.8, G348.6+0.2, and G327.4+0.4, we observed no nebulosity on nitrogen-baked 098-04 plates taken through an Hα filter ($\Delta\lambda = 100$ Å at $\lambda = 6565$ Å). In one case, that of G290.1−0.8, we detected a diffuse ring of emission, at the same location and with the same extent as the corresponding radio source (Fig. 1 [Pl. 20]). A second plate taken in the light of [S II] ($\Delta\lambda = 100$ Å at $\lambda = 6725$ Å) shows the same object (Fig. 2 [Pl. 21]). As usual, the photoionized regions (in which sulfur is principally S^{++}) nearly disappear, but the diffuse ring persists. This is particularly striking in comparison to the small, bright emission region to the west (which is MSH 11−*61*B). This indicates that the flux in the bandpass with the [S II] lines is comparable to the flux in the Hα + [N II] bandpass. In supernova remnants

TABLE 1

CTIO 4 METER PLATES

Object	Radio Name	Plate	1978 Date	Filter	Exposure (minutes)	Remark and Radio Reference
G290.1−0.8......	MSH 11−*61*A	3647	Feb 27	Hα	120	Shaver and Goss 1970
		3651	Feb 28	[S II]	120	...
		3656	Mar 1	RG570	8	For reflection
		3657	Mar 1	[S II]	120	Displaced
		3663	Mar 1	[O III]	135	...
G292.08+1.8.....	MSH 11−*54*	3652	Feb 28	Hα	120	Shaver and Goss 1970
G348.6+0.2......	CTB 37A/B	3653	Feb 28	Hα	120	Clark, Green, and Caswell 1975
G327.4+0.4......	Kes 27	3667	Mar 2	Hα	85	Caswell, Clark, and Crawford 1975

generally, the [S II]/Hα ratio is much higher than in photoionized nebulae, as shown by Daltabuit, D'Odorico, and Sabbadin (1976).

In order to avoid the possibility that the faint ring of emission observed by us might be due to reflection in the telescope corrector and filter, we obtained a [S II] plate with the object displaced from the center. The diffuse ring did not disappear. It seems reasonable to conclude that the diffuse ring seen here is a supernova remnant.

The other possibility is that the object is a reflection nebula, and that it appears of comparable brightness in the two interference filter photographs because it has a continuous spectrum. Three arguments against this idea are available. First, a plate taken with a RG570 filter shows that the ring has much lower contrast when observed with a broad band. Second, the two bright stars in the ring are HD 95933 (SAO 251234) to the north and HD 95950 (SAO 251235) to the south. The former has a MK type of F5 Ib/II (Kennedy and Buscombe 1974) and the latter is classified as Ma (Cannon and Pickering 1918–1924). Neither is likely to be the source in a reflection nebula. Third, we have a private communication from K. H. Elliott (1978) that the object has an emission-line spectrum characteristic of a supernova remnant.

An attempt to photograph G290.1 − 0.8 through an [O III] filter ($\Delta\lambda = 100$ Å, $\lambda = 5000$ Å) was not successful. The sky is not well exposed on this plate, so we cannot be certain what limit the plate places on [O III] emission.

III. DISCUSSION

As shown in Figure 3 (Plate 22), the spatial coincidence between the radio contours of G290.1 − 0.8 and the optical nebula is excellent. It seems safe to say that the optical nebulosity, which has the [S II]/Hα ratio of a supernova remnant, is identical with the radio source that has the spectrum and morphology of a supernova remnant.

The radio source G290.9 − 0.8 has been recognized as a supernova remnant since it was first identified by Kesteven (1968). It has a nonthermal radio spectrum, with spectral index −0.62 (Dickel *et al.* 1973). The radio maps by Shaver and Goss (1970) and by Dickel *et al.* show a clear shell structure about 12′ in diameter. Polarization of the source has been detected at 5 GHz by Milne and Dickel (1975).

A study of the 21 cm absorption profile against G290.1 − 0.8 by Dickel (1973) suggests that it probably lies near the spiral arm in that direction at about 3.4–4.0 kpc from the Sun. This is consistent with the lower limit of 3.4 kpc placed by Goss *et al.* (1972) on the basis of earlier 21 cm data. An independent estimate for the distance can be obtained from the observed "Σ–D" correlation between radio surface brightness and (linear) diameter for SNRs. This technique leads to values from 3.2 to 5.8 kpc, depending on which SNRs are used as distance calibrators (Clark and Caswell 1976; Ilovaisky and Lequeux 1972, and references therein).

Patches of nebulosity have been noted by Milne (1969) coincident with MSH 11 − 6*1*B, a fainter source located 14′ west of G290.1 − 0.8. This object seems not to be associated with the G290.1 − 0.8 SNR, since observations of H109α emission show it to be thermal and more distant (Dickel 1973). Figures 1 and 2 demonstrate that this object has Hα ≫ [S II], and it is presumably an H II region.

If we adopt a distance of 4 kpc for G290.1 − 0.8, then the 12′ diameter corresponds to about 14 pc. The mass of matter within that volume is

$$M = 36(n/1\ \mathrm{cm}^{-3})(D/4\ \mathrm{kpc})^3\ M_\odot\ .$$

Thus we expect that this remnant is mature, in the sense that it has encountered a mass which is substantially larger than that ejected by the exploding star, but not senescent.

The curious feature of this remnant is its optical appearance. In the morphological classification by van den Bergh (1978), this remnant would fall into the "diffuse shell" type which includes the Monoceros Ring (Kirshner, Gull, and Parker 1978), OA 184, HB 3, and HB 9. Generally, these are large, old remnants, while G290.1 − 0.8 is relatively young. One possibility is that the distance has been seriously underestimated, so that this remnant is, in fact, old and large. The way to tell will be to obtain a measure of the expansion velocity for the remnant. If the expansion velocity is low, roughly if it is less than 70 km s^{-1}, the remnant is old and more distant than estimated here. If the distance is about 4 kpc, we expect a velocity of about 200 km s^{-1}. Although the absence of filaments in this object will make the optical velocity measurements difficult, the presence of some emission at every distance from the center will make a complete velocity map possible. This object is an ideal subject for Fabry-Perot measurements of the type made by Kirshner and Taylor (1976) on the Cygnus Loop.

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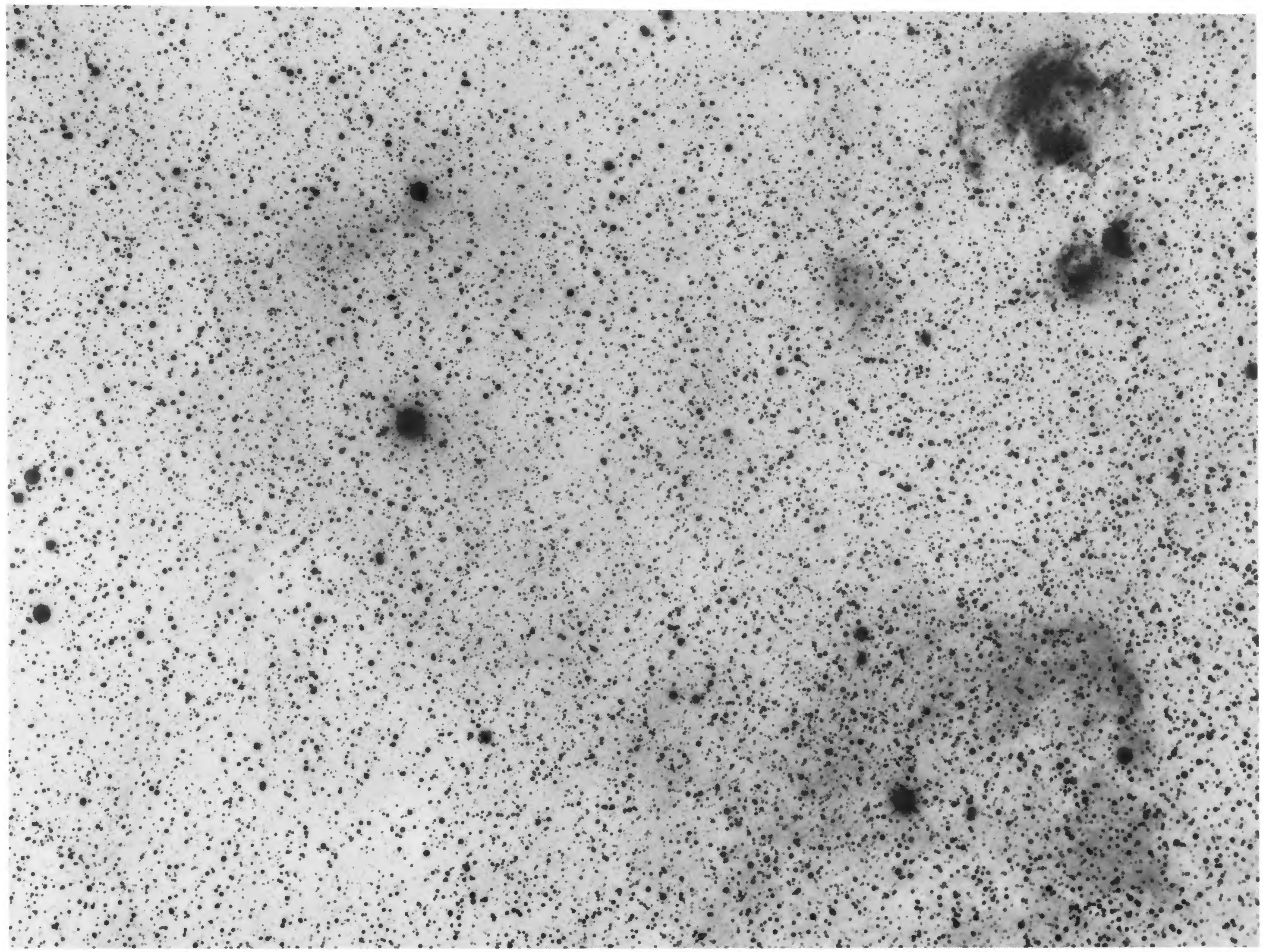

FIG. 1.—Prime focus (f/2.7) plate of G290.1−0.8 taken with the CTIO 4 m telescope on nitrogen-baked 098 emulsion through an Hα + [N II] interference filter. North is up and east is to the left. The field covered here is approximately 32′ × 25′.

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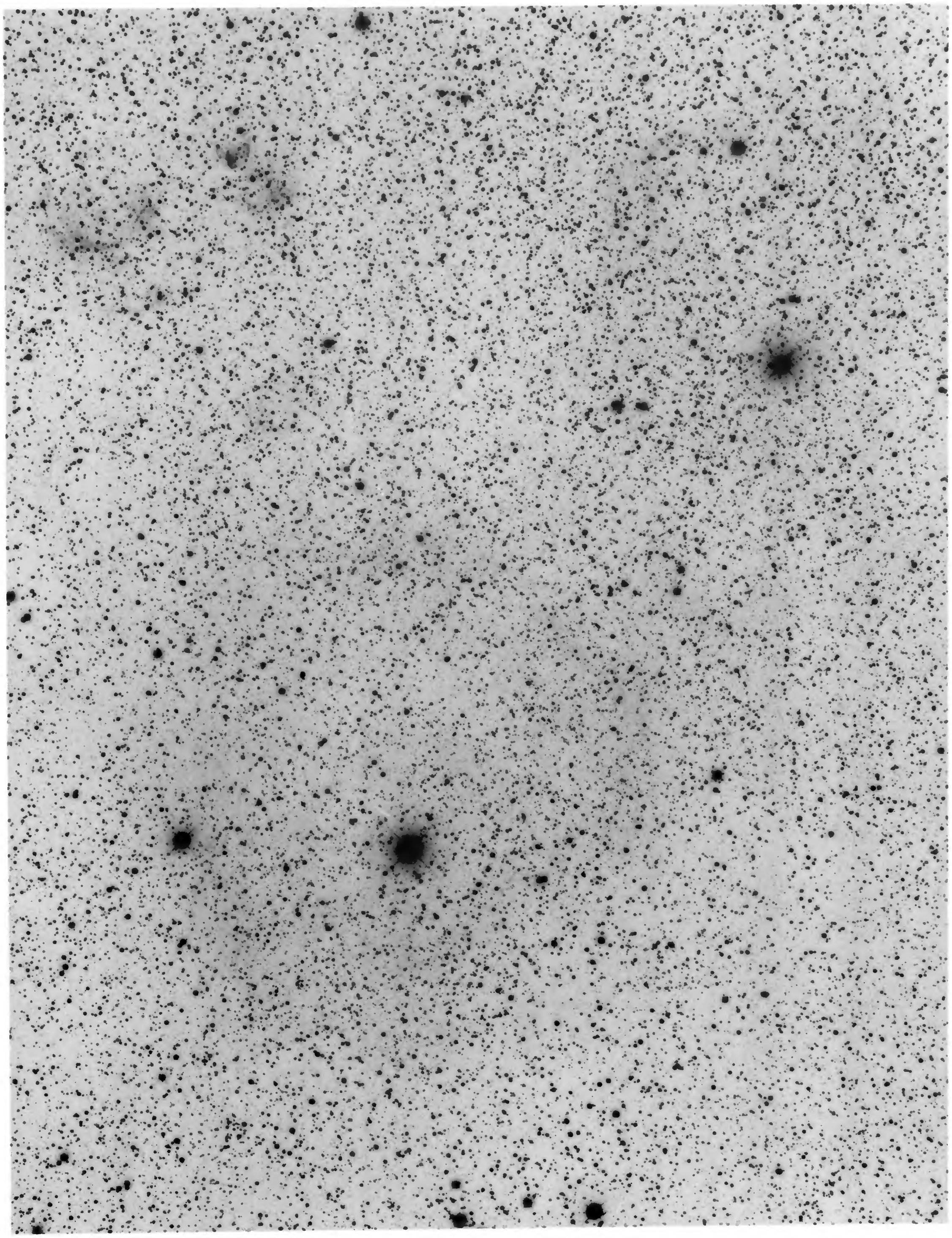

Fig. 2.—Plate of G290.1−0.8 taken with a [S II] filter. Note that the diffuse ring of emission which we associate with the supernova remnant is comparable in brightness in this plate and the Hα plate. The small bright H II region to the west of the SNR, which is identified with MSH 11−61*B*, demonstrates how well this comparison discriminates against photoionized nebulae.

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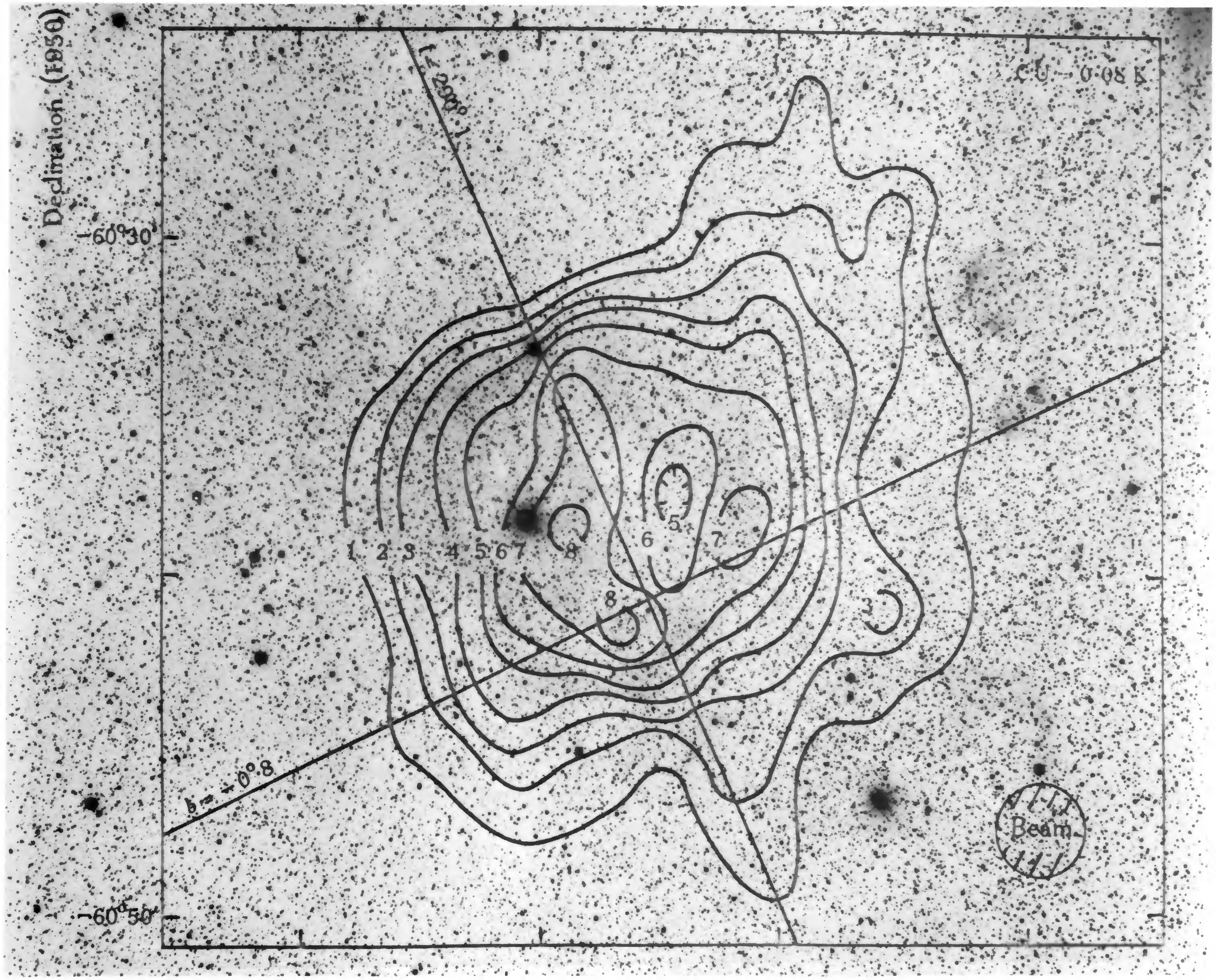

FIG. 3.—The 8.8 GHz map of Dickel *et al.* (1973) shown superposed on the [S II] plate. The two bright stars within the radio contours are HD 95933 and HD 95950, mentioned in the text.

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