It is much brighter photographically than visually—like all the novæ, really, when at or near the end of their decline. This is strikingly shown on the accompanying photograph, where the nova appears much brighter than star *C*. This is also shown on the Wolf-Palisa Chart No. 175 (1905 May 10, exposure $2^h\ 16^m$), where it is very much brighter than *C*. The relatively greater brightness of the nova on these plates is mostly a photographic effect, but on my own photographs the relative brightness is less than on Wolf-Palisa Chart 175, showing that the star was really less bright on 1919 May 8 than on 1905 May 10. On Wolf's photograph, however, the star is outside the field of best definition, which makes the comparisons somewhat uncertain. The photographs show that *D* is red (it is only just discernible on the photograph, and will not show in the reproduction), while *E*, a fainter star visually, shows clearly.

The only reference to Hind's nova that I have found since the observations of 1848 is that in *Ann. H.C.O.*, **55**, 49: "The magnitude had decreased to 8 by June 1849. Fluctuations of a magnitude or more were found by Hind when the star had become fainter. It is believed that the magnitude has been constant at about 12·5 since 1867."

Yerkes Observatory,
Williams Bay, Wisconsin,
1920 *November* 26.

Further Observations of the Spectrum of Nova Cygni III., 1920.
By Major W. J. S. Lockyer, M.A., Ph.D., and D. L. Edwards, D.I.C., A.R.C.S. (Plate 7.)

General Remarks.

Since the date of our last communication to the Society on the spectrum of this nova, further photographs have been secured. The same instrument was employed, namely, the McClean 12-inch prismatic camera, having a 12-inch prism of 20° angle. The following table gives details of the exposures:—

Date.	Number of Neg.	G.M.T. Times of Exposure. Beginning.	G.M.T. Times of Exposure. End.	Length of Exposure.	Mag. of Nova.
		h m	h m	h m	
1920 Nov. 2	1178	7 40	12 0	4 20	9·25
5	1179	8 48	12 18	3 30	9·12
11	1183	7 30	11 40	4 10	9·14
Dec. 9	1203	5 41	7 41	2 0	9·02
1921 Jan. 5	1207	6 39	8 12	1 33	9·10

We are indebted to Dr. A. A. Rambaut for communicating at our request the magnitudes of the nova on the above dates.

The photographs had to be taken as soon as possible after darkness had set in, owing to the fact that the nova was towards the west, and atmospheric refraction tended to move the image slightly in declination on the plate during the exposure; this had the effect of broadening the lines in the spectrum. There was therefore no gain in giving long exposures, as there was no sufficiently fine adjustment in declination on the telescope to correct this movement. Thus the long exposures first employed gave way to exposures of about two hours' duration.

In photographing the spectrum of the nova the telescope was run at as near sidereal rate as possible, a guiding star being kept on a wire in the illuminated field of view of the finder, corrections in right ascension being made occasionally with the electric slow motion.

Similar photographic plates to those employed in the earlier photographs were used, namely, Marion's "Record" (H and D 500).

Some of the above photographs are reproduced here in Plate 1, and two comparison photographs have been added: one of α Cygni, which the nova resembled in its early stages, and the other of a planetary nebula, *N.G.C.* 6210 (taken with the same instrument), to indicate the positions of the chief nebular lines. An attempt was made to produce a series of up-and-down enlarged photographs, but in some of the photographs sufficient contrast was not obtained to make a satisfactory plate.

Discussion of the Spectra.

The spectrum of the nova on each of the later photographs obtained was practically the same except for changes in relative intensities of some of the lines, but showed very great differences from the spectra obtained at earlier stages. The continuous spectrum, together with the absorption lines, had apparently disappeared entirely, and the spectrum was purely one of bright lines and bands. The most conspicuous of these were the hydrogen lines of the Balmer series and λ4686, the "λ4640" band, and the nebular lines N_1, N_2, λ4363 and λ4068. These were all very strong, and little doubt can be entertained of their identity. There were in addition, however, several rather faint nebulous bands, occasionally of great breadth, which were of doubtful origin. These rarely showed any well-marked maxima, and covered so wide an area (sometimes over 50 A.U.) that any assignment of possible origins to these bands can only be regarded as tentative. In view of other identifications, however, and the numerous coincidences which occur, it is thought that the most probable origins for the greater part of these bands is to be found in lines, or groups of lines, of nitrogen.

The following table gives the wave-lengths of all the bright

lines and bands observed in our photographs. In the case of some broader bands wave-lengths have been given of both edges; but these are only approximate, since the edges are in general so faint and nebulous as to make accurate measurements impossible. The probable origins of the more prominent lines have been inserted in the second column. The third column gives suggested possible origins of the fainter lines and bands. The identification of the two nitrogen lines in the "λ4640" band is due to Lunt and Fowler, and may be regarded as well established, though there are no definite maxima on our photographs to check the identification. The symbol p denotes an "enhanced" line.

Wave-Lengths and Probable Origins.

λ and Intensity of Bright Lines and Bands.		Probable Origins.		Possible Origins		Remarks.
λ.	Int. (Dec. 9) (Max. 10).	Element.	λ.	Element.	λ.	
5007	7	neb.	5007			N_1.
4959	5	neb.	4959			N_2.
4861	9	H_β	4861	pN pN	4867 4859	H_β broad, and distinctly "winged" on red side.
4750–4800	1			N N N	4803 4788 4780	Faint band. Not visible in some photos. Best seen in neg. of Oct. 25.
4686	5	H	4686			Strong. Well separated from λ4640.
4640	8	pN pN	4641 4634	N	4643	Very strong band. Probable origins given by Lunt and Fowler. λ4643 doubtful.
4601	2			N	4602	Strong line. Separated from λ4640.
4542	1			H	4542	H_γ. Extremely faint.
4510–4530	1			N pN N N	4531 4524 4515 4511	Faint band with slight max. near λ4516.
4430–4475	1	He	4471	N N	4447 4433	Faint band. Max. near λ4471 with considerable extension towards violet.
4417	1			pTi	4417	Faint line.
{4363} {4341}	10 6	neb. H_γ	4363 4341	pN	4379	Strong band. Max. at λλ4363, 4341. Covers position of λ4379 which may be present.

Photograph of the Region of Hind's Nova of 1848.
1919 May 8^{d} 20^{m} 52^{s} G.M.T.
10 Bruce Telescope, Yerkes Observatory.
Exposure 0^{h} 49^{m}.

Wave-Lengths and Probable Origins—continued.

λ and Intensity of Bright Lines and Bands.		Probable Origins.		Possible Origins.		Remarks.
λ.	Int. (Dec. 9) (Max. 10).	Element.	λ.	Element.	λ.	
4302	1			pFe	4303	Faint band.
				pTi	4300	
4235	1			N	4242	Hazy band.
				N	4237	
				pFe	4233	
4201	1			H	4201	Extremely faint. Attributed to $H_{\delta'}$, but may be compound.
				pN	4200	
				pN	4196	
4102	6	H_δ	4102	pN	4103	N lines may be present, but masked by $H\delta$.
				pN	4097	
4068	2	neb.	4068			
4026	1			H	4026	V. faint. Possibly $H_{\epsilon'}$ + He.
3970	3	H_ϵ	3970			

Attention may be drawn to the group of lines near λ4640, which appear to vary in character in different novæ. In the present case there are undoubtedly three prominent and well-separated lines or bands at λλ4686, 4640 and 4601. Of these the band at λ4640 is the most prominent, followed by λ4686. The remaining line at λ4601 is considerably fainter. Lunt, in the case of Nova Aquilæ (3), found a continuous band, with maxima at λλ4686, 4650, 4641, 4634, and 4604. The maximum at λ4604 possibly corresponds with our line at λ4601, in which case the origin suggested (viz. nitrogen) would be rather doubtful. Adams and Pease in the later spectra of Nova Geminorum (2) described three well-separated lines at λλ4686, 4641, and 4610. There appears to have been no line at λ4601 or λ4604, and on our negatives there is nothing near enough to correspond with their line at λ4610.

On the presence of Nitrogen in Nova Cygni.

The work of Fowler * on the spectrum of nitrogen, together with Lunt's † observations of Nova Aquilæ (3), presents fairly conclusive evidence as to the presence of nitrogen in that star. An investigation was therefore made with a view to determine what nitrogen lines, if any, were present in Nova Cygni; and if the somewhat vague bands already mentioned could be attributed, at least in part,

* *M.N.*, 80, 692. † *M.N.*, 80, 519.

to that element. It was found that there were faint lines or bands in nearly all the positions indicated by the wave-lengths in Fowler's list. These were mostly rather nebulous; but the coincidences throughout the spectrum are rather striking, and in many cases the evidence seems to be strongly in favour of nitrogen as the origin. Both enhanced and unenhanced lines seems to be present, the strongest of the latter being the line at λ4601·66, which is suggested as the probable origin of the line already mentioned at λ4601 on our negatives. The stronger enhanced lines unfortunately occur, in many cases, so near to some strong broad line of hydrogen or nebulium that it is difficult to make a definite statement as to their presence or absence in the nova. The line at λ4867 is most probably present, since H_β is quite definitely "winged" on the red side. λ4859 may also be present, but is too near H_β to give any definite evidence. The lines at λλ4641 and 4634 have already been shown by Lunt and Fowler to be, most probably, the chief constituents of the "λ4640" band. The group of lines from λ4524 to λ4511 is represented in the nova by a comparatively strong band. There are distinct indications of a maximum near λ4515, showing that the nitrogen line at λ4515·04 is probably present, and the remaining lines of the group may also be concerned in producing this band. The next important enhanced line of nitrogen is at λ4379. This occurs near the nebulium line at λ4363, which is very strong and broad in the nova spectrum, extending well over the position of the nitrogen line. The latter may therefore be present in the nova, and its occurrence may account for the great breadth of the nebulium line. The region near λ4200 is rather underexposed in our photographs, but there is a faint rather broad line at about λ4201 which we attributed to $H_{8'}$. The nitrogen line at λ4200 may, however, also be present, and possibly also λ4196. The rather strong pair of enhanced lines at λ4103 and λ4097, if present in the nova, are masked by H_δ. Nothing definite can be said as to their presence or absence.

The above conclusions are embodied in our table under the heading "Possible Origins." If they are correct it will be seen that practically all the otherwise puzzling bands are accounted for, and the spectrum as a whole is greatly simplified. It is reduced, in such a case, to one of hydrogen, nebulium, nitrogen, and possibly helium, with perhaps a trace of the earlier enhanced metallic stage.

Variations in Relative Intensities of the Lines.

As already mentioned, all the spectra dealt with in this paper were very similar in character, but there were considerable variations in the relative intensities of the lines which are summarised below. In this table the relative intensities are given for each day, the intensities ranging from 10 to 1, 10 being the strongest line in each case. The change of the actual intensity of any line is thus not directly indicated.

	Intensities.							
				1920.				1921.
Date:	Oct. 24.	Oct. 25.	Oct. 26.	Oct. 27.	Nov. 5.	Nov. 11.	Dec. 9.	Jan. 5.
λλ								
5007	3	3	3	3	3	3	7	7
4959	1	1	1	1	1	1	5	4
H_β	10	10	10	10	8	10	9	8
4686	1	2	2	3	4	3	5	3
4640	8	8	8	8	10	9	8	5
4601	...	trace	...	...	...	...	2	2
4363	...	...	...	...	...	7	10	10
H_γ	7	6	6	6	7	7	6	5
H_δ	4	3	4	4	5	5	6	4

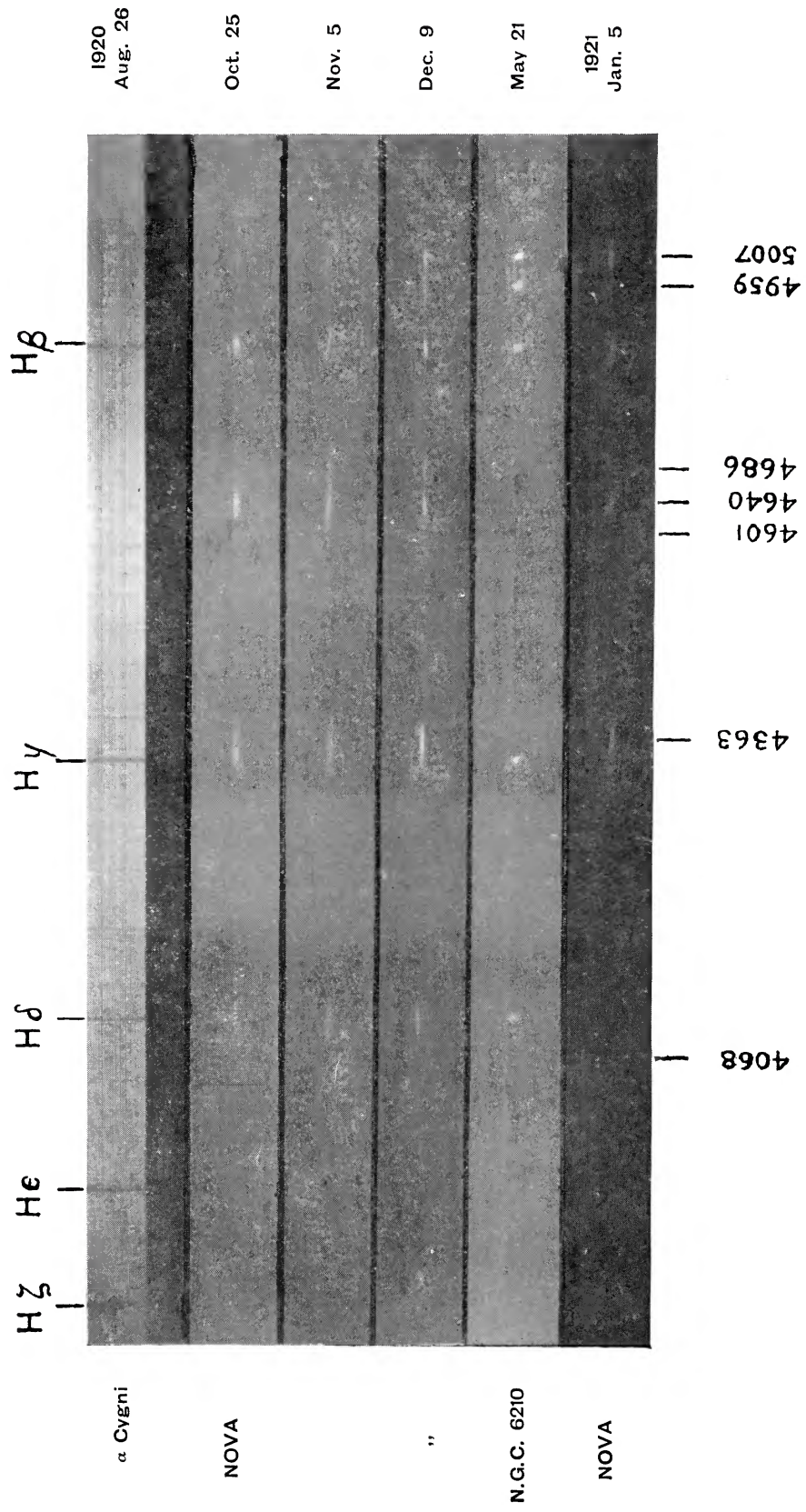
Comparison of the Nova with Planetary Nebulæ.

The more recent photographs which have been obtained of the nova show that the latter is now apparently assuming the character of a planetary nebula. The most characteristic lines in the spectrum of a typical planetary nebula are the Balmer series of hydrogen, the "Pickering" series (which is much fainter), λ4686, and the nebulium lines. It will be noticed that in our photographs the Balmer series and λ4686 are very strong indeed. The Pickering series is present, though faint (as in the nebulæ); and the nebulium lines are very prominent. The general resemblance to planetary nebulæ is thus very striking. At first sight the presence of nitrogen might appear to constitute an important difference; but it must be remarked that the nitrogen lines are rather faint, and are possibly dying out—as shown by the fading of the "λ4640" band. Also, in referring to Wright's list of nebular lines,* it is found that there are several lines given which might be attributed to nitrogen. The chief of these are at λ4097 (identified as N by Wright), λ4634 (attributed to "H II"), and λ4641 (no origin given), all of which are enhanced lines of intensity 10, 8, and 10 respectively, according to Fowler. The two last lines, together with one at λ4649 (C) in the same list, are in the positions indicated by Lunt as the maxima of the "λ4640" band in Nova Aquilæ (3). It appears therefore that the fading away of this band might result in the lines given by Wright.

Description of the Plate.

Four spectra of the nova are shown in this plate, and they were taken on October 25, November 5, December 9, and January 5 (1921). They are enlarged 3·7 times from the original negatives. At the top is reproduced the spectrum of α Cygni, the star the nova resembled at its earlier stage, and the last but one is the spectrum of the planetary nebula *N.G.C.* 6210; both of these

* *Publications of the Lick Observatory*, 1918, 13, opp. p. 242.



Progressive Spectra of Nova Cygni III. (1920).

photographs were taken with the same instrument and adjustments as the nova negatives. On October 25 it will be noticed that the "λ4640" band is relatively strong, and the nebular lines weak. On November 5 the nebular lines N_1, N_2 and λ4363 have strengthened considerably, also λ4686, while λ4640 has slightly weakened. By December 9 all three nebular lines are very pronounced, also λ4686, but λ4640 has diminished in brightness. In the last-mentioned photograph several other bands are seen in the original negative, but are too faint to be reproduced in the illustration. On the photograph taken on January 5 of the present year, λ4363 is the most prominent line, followed in intensity by H_β and the nebular lines. λ4640 is considerably reduced in relative intensity, and also λ4686, but to a less degree.

The approximate wave-lengths of some of the stronger lines are indicated at the bottom of the plate.

Photographic Magnitudes and Effective Wave-Lengths of Nova Cygni (1920), *from Photographs taken at the Cambridge Observatory.* By W. M. Smart, M.A., and H. E. Green.

(*Communicated by Professor A. S. Eddington, F.R.S.*)

The photographic magnitudes of Nova Cygni were obtained by comparing the images of the Nova with those of γ Cygni and Boss 5026. The values of the magnitudes of the comparison stars adopted were those of *Harvard Annals*, **50**, namely, 2·32 and 5·86 respectively. As the Zenith distances at which the Nova and comparison stars were observed were very small, no corrections for differences in atmospherical absorption were applied.

The photographs were taken with the Sheepshanks (Coudé) Equatorial. Over the object-glass was placed a parallel-strip diffraction grating for which the widths of strips and spaces are the same (0·37 cm.). The dispersion is such that the separation between the central image and the first-order image is 0·035 cm. For the grating, the theoretical difference of magnitude between the central and first-order images is 0·98. (Chapman and Melotte, *M.N.*, **74**, 53.)

From a plate of five minutes' exposure on the Pleiades, the measures of the central and first-order images of 12 stars, ranging in magnitude from 2·84 to 6·66 (*H.A.*, **91**), were combined to determine the constants in a linear relation connecting the magnitudes and the measured diameters, the theoretical magnitude interval being applied in the case of the first-order images. For purposes of magnitude determination, exposures of 20^s, in groups of 10, were made on the Nova and γ Cygni, and from September 26 of 1^m and 2^m on the Nova and Boss 5026. By means of the relation derived from the Pleiades plate, the differences of mag-