IV. *Comparative Photographic Spectra of Stars to the $3\frac{1}{2}$ Magnitude.*

By Frank McClean, *F.R.S.*

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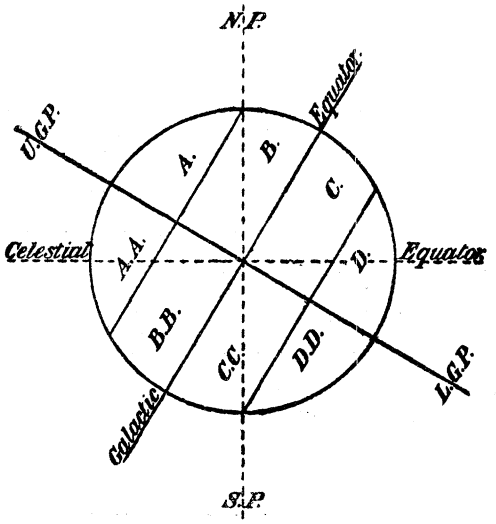
[Plates 1–17.]

The 160 photographs which accompany the paper include, with insignificant exceptions, all stars equal to and brighter than the $3\frac{1}{2}$ magnitude, contained in five out of eight equal areas, into which the celestial sphere has been divided.

The diagram shows the position of the eight areas consisting of—

Two upper galactic polar regions, viz.,				A	and AA.
,, ,, ,,	zones	,,	B	,,	BB.
Two lower galactic	zones	,,	C	,,	CC.
,, ,, ,,	polar regions	,,	D	,,	DD.

The galactic zones extend to 30° from the galactic plane.



The object of the division into equal areas is to bring out roughly any differences of distribution of the different types of spectra in relation to the galactic plane.

25.5.98

The areas A, B, C, D, and AA are included in the present series of photographs. Of these the first four constitute a complete hemisphere, symmetrically divided by the galactic plane, and the deductions as to distribution have been made from them.

The stellar spectra have been arranged in series, and classed separately for the respective areas to which they belong. It appears at once that SECCHI'S Type I. requires further subdivision into distinct classes. To effect this, a series of divisions in parallel to SECCHI'S types have been adopted, in which Divisions I., II., and III. correspond to Type I., and Divisions IV., V., and VI. to Types II., III., and IV. respectively.

The classified tables of the stellar spectra are given at the end of the paper, and previous classifications by SECCHI in 1866–1868, by VOGEL in 1883, by PICKERING in 1890, and by LOCKYER in 1892 are indicated in separate columns.

Division I. includes all stars whose spectra are characterised by the lines of hydrogen and of cleveite gas.

Subdivision I. (a) shows other special lines in addition. I have made a close comparison with the spectra of nearly all the elements, for the purpose of identifying these extra lines, but without definite result. The only suggestion that presents itself to me is the possibility of their being due to oxygen.

I have placed below the scale attached to these spectra RUNGE and PASCHEN'S spectrum of cleveite gas, which forms the characteristic spectrum of the division. Also THALÈN'S spark spectrum of oxygen. Although there is not a perfect agreement between the spectrum of oxygen and the special lines referred to, there is a very remarkable correspondence.

I have further placed below the scale CAMPBELL'S bright-line spectrum of the nebula in Orion. The general coincidence with the stellar line leaves little doubt as to the close connexion between this class of stars and the gaseous nebulæ.

Evidence to the same effect is afforded by the wonderful photographs taken in recent years, showing the physical connexion of many of these stars with the nebulæ. Such are Dr. ROBERTS'S photographs of the Pleiades and of the great nebula in Orion. Alongside copies of these I have shown the corresponding groups of the spectra of the involved stars; the respective stars and their spectra are easily identified on inspection. All six stars of the Pleiades show the cleveite gas spectrum, but the presence of the special extra lines is doubtful. The Orion stars, which include ι and θ Orionis, all show the cleveite spectrum, but in these the special lines are also recognised.

We have thus evidence of both physical and chemical connexion between these stars and the nebulæ.

[Note added 8th April, 1897.—There are two other instances of the connexion of stars of Subdivision I. (a) with nebulæ.

BARNARD, in 1895, photographed an extended nebula in the vicinity of α Scorpii (Antares). He mentions σ Scorpii as connected with the nebulosity. The photo-

graphic spectra of the four stars, β, δ, π, and σ Scorpii, all near Antares, belong to Division I. (a). They are in the area BB, and do not appear in the present series.

BARNARD also photographed, with a six-hour exposure, an extended nebula contiguous to ξ Persei, a star of the 4th magnitude. The spectra of ϵ and ζ Persei, on either side of it, appear in the photographs, and belong to Subdivision I. (a). A photograph of the spectra of ξ Persei was recently obtained, and it also belongs to the same division.

Both these instances point to the same conclusion, that stars of this type are in the first stage of stellar development from nebulæ.

The star ξ Persei and also ι Orionis give in their spectra three lines of the second hydrogen series, recently identified by PICKERING in ζ Puppis. One of the three lines at wave-length 4027 corresponds to the characteristic helium line. The other two at wave-length 4201 and wave-length 4544 do not appear in any other spectra of Subivision I. (a) in the present photographs. These lines appear to belong to the earliest stage of stellar development.]

There is further evidence to the same effect in the similarity of the distribution of this type of star, and of the gaseous and planetary nebulæ.

The gaseous nebulæ, given in the Table in FROST's edition of SCHEINER's 'Spectroscopy,' have been distributed into the same equal areas as the stars.

The following shows the relative distribution for the nebulæ and for the stars:—

	A.	B.	C.	D.
Gaseous nebulæ	3	7	16	6
Stars of Division I. . . .	3	6	17	3.

Thus it appears that the helium stars of Division I. and the gaseous nebulæ are subject to a similar law of distribution in relation to the galactic plane.

All these facts afford grounds for accepting the conclusion that the helium stars of Subdivision I. (a) are in the first stage of stellar development from the gaseous nebulæ.

Division I. has a second subdivision, viz., I. (b), which is also characterised by a few special lines. These lines have been attributed to calcium, barium, and magnesium. Since these special lines persist through the subsequent divisions, it may be concluded with tolerable certainty, that in order of development Subdivision I. (b) follows after Subdivision I. (a). The K line of calcium, which first appears in this subdivision, gradually increases in strength to such a marked extent in the subsequent divisions, that it may be practically taken (as suggested by Dr. HUGGINS), as a criterion of the type to which a spectrum belongs. Two bright line spectra have been treated as belonging respectively to the divisions to which their absorption spectra belong.

The spectrum given of γ Cassiopeiæ, clearly places it in Subdivision I. (a). It is a helium star. The bright hydrogen lines are weak, and are placed centrally in the diffuse absorption lines.

β Lyræ is also a helium star. Its spectrum belongs to Subdivision I. (*b*). Both the hydrogen and the helium lines appear bright. The peculiarities of this star are well known.

A third bright line star, of another division, may be mentioned here. The spectrum of Mira Ceti belongs to Type III. or Division V. The bright hydrogen lines appear periodically, for a brief time, with great brilliancy. The banded absorption spectrum brightens up simultaneously, a peculiarity which it is difficult to explain. The exceptionally good photograph of this spectrum was taken on the 1st January last.

Division II. is especially the hydrogen type. In it the hydrogen spectrum attains its full development both in the strength of the lines and in the extent of the spectrum. This is shown in the ultra violet series of lines, discovered by Dr. HUGGINS. The narrower and more sharply defined calcium line K, in itself distinguishes the division from those which precede and follow it. The delicate absorption lines, which also distinguish the type, are difficult to photograph, but they are well shown in the spectra of Sirius and Vega. The spectrum of α Cygni has been sometimes classed differently, but a comparison with the spectrum of Sirius, which is placed next it, clearly shows their identity, and that they only differ in strength. The fine lines appear to be due to calcium and titanium rather than to iron, although that spectrum is also present in an incipient form. The distribution of this division is irregular, viz. :

A.	B.	C.	D.	AA.
10	7	0	3	3

Division III., or the hydrogen-iron type, is the last of the separate divisions into which Type I. has been divided. In its more advanced examples the iron spectrum is fully developed. That spectrum has been plotted on the scale for comparison. This type is more closely allied to the subsequent solar type, Division IV., than to the preceding hydrogen and helium types. The brightness of the violet end, and the obscurity of the red end of the spectrum, remain the same as in the preceding divisions. The hydrogen lines remain very strong, and the calcium lines K and H are generally subordinate to them.

This division completes the requisite subdivision of SECCHI's Type I., which has not hitherto been fully established. The subsequent divisions remain as defined by SECCHI in 1868. It must also be remembered that SECCHI fully recognised the special character of the spectra of the Orion stars.

Division IV. is equivalent to Type II., or the solar type. The characteristics of this type are well defined. They are also elucidated by our more intimate knowledge of the solar spectrum, which forms the basis of our knowledge of astronomical physics.

Division V. is equivalent to Type III., and is the first of the banded types investigated by Dunèr. The photographs of this type of spectra are difficult to take. These stars are not numerous within the range of magnitude under con-

sideration. The spectra are closely allied to those of Division IV., and have been placed consecutively with them. The coincidences with the spectra of calcium and manganese have been marked on the scale.

Division VI. is equivalent to Type IV. There are no stars in this division brighter than the $5\frac{1}{2}$ magnitude, but to complete the series, photographs of the spectra of SECCHI'S Superba, and of 19 Piscium have been included. The photographs are poor owing to the faintness of the stars, but their interest lies in the hydrocarbon absorption bands, and further in the line spectrum, also recognizable, and similar to that of α Tauri (Aldebaran).

There remains the question of how far the distribution of the stars into the eight equal areas discloses any information as to the distribution of their respective types of spectra in space.

The dimensions of the sphere enclosing stars to the $3\frac{1}{2}$ magnitude is obtained from the light ratio. The decrease of light for each magnitude beyond the 1st is inversely as the light ratio 2·51. The corresponding increase of distance is as the square root of this ratio, or as 1 to 1·58. Taking the distances of the $3\frac{3}{4}$ magnitude stars arrived at in this way as the radius of the sphere containing the stars of the $3\frac{1}{2}$ magnitude, its radius will be, in terms of the mean distance of 1st magnitude stars from the sun,

$$= 1 \times (1{\cdot}58)^{\frac{11}{4}} = 3{\cdot}5 \text{ approximately.}$$

The mean distance of 1st magnitude stars from the sun has been determined from parallax observations to be approximately $36\frac{1}{2}$ light years. Thus the diameter of the enclosing sphere for stars of the $3\frac{1}{2}$ magnitude is approximately 255 light years.

This gauge block of space, although large, might be so small, compared with the dimensions of the galaxy, as to disclose nothing with regard to its structure. The following table of distribution, however, shows that within this block there are indications of differences in the distribution of the different stellar types, relatively to the plane of the galaxy. The table shows the distribution of the gaseous nebulæ, both planetary and extended, for the same areas.

TABLE of Distribution of Gaseous Nebluæ and of Stellar Types.
Stars to the $3\frac{1}{2}$ Magnitude.

	A.	B.	C.	D.	Total.	AA.	BB.	CC.	DD.	Total.
Planetary nebulæ . .	2	3	8	2	(15)	2	7	3	0	(12)
Extended „ . .	1	4	8	4	(17)	1	4	3	1	(9)
Total gaseous nebulæ	3	7	16	6	(32)	3	11	6	1	(21)
Stellar Types.										
Division I.	3	6	17	3	(29)	6				
„ II.	10	7	0	3	(20)	3				
„ III. . . .	7	8	8	4	(27)	9				
„ IV. . . .	14	8	9	13	(44)	9				
„ V.	1	2	4	3	(10)	3				
Total stellar spectra .	35	31	38	26	(130)	30				

NOTE.—The gaseous nebulæ are those given in the table in FROST'S edition of SCHEINER'S 'Astronomical Spectroscopy.'

We gather from this table that as the stellar types of spectra become more advanced they are found to be more evenly distributed in space. It suggests the idea that stars of the solar type—Division IV.—started on their career as helium stars of Division I., before the condensation of the galaxy.

The Procyon stars of Division III. possibly followed in the same course after the galaxy was formed. The paucity of stars of this type in the lower polar region, coupled with their even distribution in the other areas, suggests the idea that the sun itself is situated near the lower boundary of the galaxy.

The distribution of the Sirian stars—Division II.—is irregular, and further information is required as to their distribution in the southern areas.

The Orion stars—Division I.—are mostly confined to the galactic zones. It has been already conjectured that they are still in the first stage of stellar development from the gaseous nebulæ.

It has been throughout assumed that the successive types or divisions are merely the manifestations of the successive physical states, through which every star naturally passes in the course of its career.

Index to the Tables.

PHOTOGRAPHIC Stellar Spectra. Stars to Magnitude 3·5.

Upper Galactic Polar Region, N.

A (Plates 1 to 3).

SECCHI's Types.	Present classification.	No. of photograph.	List of Stars.	Magnitude. Uranometria Oxoniensis.	LOCKYER's "Tables," Nov. 1892, 'Phil. Trans.,' A, 1893.	PICKERING, 1890, 'DRAPER Catalogue.'	VOGEL, 1883, 'Catalogue of Stellar Spectra Zone − 1° to + 20°.'	SECCHI, 'Stellar Types,' 1866–1868.
Type I.	Division I.	1	η Ursæ Majoris .	1·8	A (α)	A	..	1
		2	κ Draconis . . .	3·7	..	A	..	2
		3	ζ ,, . . .	3·3	..	A	..	1
	Division II.	4	α Can. Venat . .	3·3	A (δ)	..	..	..
		5	ϵ Ursæ Majoris .	1·8	*	A	..	1
		6	α Coronæ . . .	2·2	A (δ)	A	..	1
		7	γ Ursæ Majoris .	2·3	A (δ)	A	..	1
		8	ϵ Herculis . . .	3·8	*	A	..	1
		9	α Draconis . . .	3·6	..	A	..	1
		10	δ Ursæ Majoris .	3·4	..	A	..	1
		11	λ ,, .	3·5	..	A	..	..
		12	β ,, .	2·2	A (γ)	A	..	1
		13	ζ ,, .	2·1	*	A	..	1
	Division III.	14	δ Herculis . . .	3·2	*	A	..	1
		15	γ Ursæ Minoris .	3·0	..	A	..	..
		16	γ Herculis . . .	3·6	A (β)	A	Ia !	1
		17	ι Ursæ Majoris .	3·2	..	A	..	..
		18	θ ,, .	3·1	..	F	..	..
		19	γ Bootis	3·2	*	A	..	1
		20	ζ Leonis	3·4	..	F	..	1
Type II.	Division IV.	21	β Draconis . . .	3·0	..	K	..	2
		22	ζ Herculis . . .	2·6	B (β)	G	..	2
		23	δ Bootis	3·4	..	K	..	2
		24	β Herculis . . .	2·7	B (β)	K	..	2
		25	ϵ Leonis	3·4	B (β)	K	..	2
		26	η Herculis . . .	3·6	B (β)	K ?	..	2
		27	ϵ Bootis	2·5	B (β)	G ?	..	2
		28	β ,, ...	3·6	B (β)	K ?	..	2
		29	α Ursæ Majoris .	1·9	B (β)	K	..	2
		30	η Draconis . . .	2·8	..	K	..	2
		31	ψ Ursæ Majoris .	3·2	C (β)	K	..	..
		32	ι Draconis . . .	3·3	..	K	..	2
		33	π Herculis . . .	3·6	B (β)	K ?	..	2
		34	β Ursæ Minoris .	2·3	C (β)	L ?	..	2
Type III.	Division V.	35	μ Ursæ Majoris .	3·1	..	M	..	..

NOTE.—For LOCKYER's Notation, see 'Phil. Trans.,' A, 1893.

For PICKERING's Notation, see 'Introduction to DRAPER Catalogue,' 1890.

For VOGEL's Notation, see 'Potsdam Observatory Publications,' No. 11, 1883.

For SECCHI's Types, see 'Mem. Soc. Italiana,' 1867. For present order of Types 2 and 3, see Preliminary Notice in 'Catalogo delle Stelle,' Paris, 1867.

Photographic Stellar Spectra. Stars to Magnitude 3·5.

Upper Galactic Zone, N.

B (Plates 4 to 7).

Secchi's Types.	Present classification.	No. of photograph.	List of Stars.	Magnitude, Uranometria Oxoniensis.	Lockyer's "Tables," Nov., 1892, 'Phil. Trans.,' A, 1893.	Pickering, 1890, 'Draper Catalogue.'	Vogel, 1883, 'Catalogue of Stellar Spectra Zone −1° to +20°.'	Secchi, 'Stellar Types,' 1866–1868.
Type I.	Division I.	1	β Lyræ	3·4 / 4·4 Var.	D	G	..	..
		2	β Cephei	3·4	..	A	..	2
		3	ε Cassiopeiæ	3·5	..	A	..	1
		4	β Canis Minoris . . .	3·1	A (γ)	A	Ia!	1
		5	γ Lyræ	3·2	A (γ)	A	..	1
		6	δ Cygni	2·8	A (α)	A	..	1
	Division II.	7	ζ Aquilæ	3·1	*	A	Ia	1
		8	θ Aurigæ	3·0	A (δ)	A	..	1
		9	β „	1·9	A (γ)	A	..	1
		10	γ Geminorum	2·1	A (δ)	A	Ia!!	1
		11	α Lyræ (Vega) . . .	(+0·9)	A (δ)	A	..	1
		12	α Geminorum (Castor)	1·5	A (δ)	A	..	1
		Compn.	α Canis Majoris (Sirius)	(+1·9)	A (δ)	A?	..	1
		13	α Cygni.	1·3	A (α)	A	..	2
	Division III.	Compn.	α Geminorum (Castor)	1·5	A (δ)	A	..	1
		14	α Ophiuchi	2·2	A (β)	A	Ia!!	1
		15	α Cephei	2·6	A (β)	A	..	1
		16	δ Geminorum	3·5	..	A	..	1
		17	α Canis Min. (Procyon)	(+0·5)	A (β)	F	Ia!	1
		18	δ Cephei	3·7 / 4·9 Var.	..	F?	..	2
		19	α Ursæ Min. (Polaris)	2·0	B (β)	..	..	2
		20	ε Aurigæ	3·0 / 4·5 Var.	..	F	..	2
		21	γ Cygni	2·3	B (α)	Q	..	2
Type II.	Division IV.	22	μ Herculis	3·5	..	I?	..	1
		23	α Aurigæ (Capella) .	(+0·9)	B (β)	F	..	2
		24	β Geminorum (Pollux)	1·4	B (β)	A	..	2
		25	γ Cephei	3·5	..	K?	..	2
		26	δ Draconis.	3·0	..	L?	..	..
		27	ε Geminorum	3·3	..	K	..	..
		28	β Cygni	3·0	..	Q?	..	2
		29	γ Draconis	2·4	C (β)	K	..	2
Type III.	Division V.	30	μ Geminorum	3·4	C (α)	M	..	..
		31	α Herculis	3·0 / 3·9 Var.	C (α)	M	IIIa!!!	3
		Compn.	ο Ceti (Miræ)					
		„	α Orionis (Betelgeuse)					

PHOTOGRAPHIC Stellar Spectra. Stars to Magnitude 3·5.

Lower Galactic Zone, N.

C (Plates 8 to 11).

SECCHI'S Types.	Present classification.	No. of photograph.	List of Stars.	Magnitude. Uranometria Oxoniensis.	LOCKYER'S "Tables," Nov. 1892, 'Phil. Trans.,' A, 1893.	PICKERING, 1890. 'DRAPER Catalogue.'	VOGEL, 1883, 'Catalogue of Stellar Spectra Zone −1° to +20°.'	SECCHI, 'Stellar Types,' 1866-1868.
Type I.	Division I.	1	γ Cassiopeiæ . . .	2·2	D	Q	..	..
		2	δ Orionis	2·2 / 2·7 Var.	A (α)	B	Ib !	1*
		3	ε „	1·8	A (α)	A	Ib ?	1*
		4	κ „	2·4	A (α)	A	..	1*
		5	ζ „	1·8	A (α)	A	..	1*
		6	ι „	3·2	A (α)	B	..	..
		7	ε Persei	3·1	A (α)	A	..	2
		8	ζ „	3·1	A (α)	A ?	..	2
		9	γ Orionis (Bellatrix)	1·8	A (α)	B	Ia	1*
		10	ζ Tauri	3·0	A (α)	A	..	..
		11	λ „	3·4 / 4·2 Var.	..	B	Ia !	..
		12	β „	1·8	A (α)	A	..	1
		13	β Persei (Algol) . .	2·3 / 3·5 Var.	A (γ)	A	..	1
		14	δ „ . .	3·1	..	A	..	1
		15	θ Aquilæ	3·3	..	A	Ia !	..
		16	η Tauri (Alcyone)	3·1	A (γ)	A	..	1
		17	β Orionis (Rigel) .	(+1·0)	A (α)	F	..	1*
	Division II.	..	None					
	Division III.	18	δ Aquilæ	3·4	..	A	Ia !	1
		19	β Eridani	2·8	..	A	..	..
		20	β Trianguli . . .	3·1	..	A	..	1
		21	α Aquilæ (Altair) .	1·0	A (β)	A	Ia !!	1
		22	δ Cassiopeiæ . . .	2·9	A (β)	A	..	1
		23	β „ . . .	2·3	A (β)	F	..	1
		24	β Delphini	3·5	*	F	Ia !	2
		25	α Persei	1·9	A (β)	F	..	1
		Compn.	γ „	3·1	..	G	..	1
Type II.	Division IV.	26	γ Persei	3·1	..	G	..	1
		27	β Aquilæ	3·7	..	I ?	IIa	2
		28	η Pegasi	2·9	B (β)	G	..	2
		29	ε Cygni	2·4	C (β)	K	..	2
		30	ζ „	3·1	B (β)	K ?	..	2
		31	α Cassiopeiæ . . .	2·2 / 2·8 Var.	B (β)	K	..	2
		32	γ Andromedæ . . .	2·1	C (β)	K	..	2
		33	γ Aquilæ	2·8	B (β)	K	IIa !!	2
		34	ι Aurigæ	2·9	..	K	..	..
Type III.	Division V.	35	β Andromedæ . . .	2·2	C (α)	K ?	..	2
		36	α Tauri (Aldebaran)	1·1	C (β)	K ?	IIa !!!	2
		37	β Pegasi	2·5	C (α)	M ?	..	3
		38	α Orionis	1·0 / 1·4 Var.	C (α)	M ?	IIIa !!!	3

PHOTOGRAPHIC Stellar Spectra. Stars to Magnitude 3·5.

Lower Galactic Polar Region, N.

D (Plates 12 to 14).

SECCHI's Types.	Present classification.	No. of photograph.	List of Stars.	Magnitude. Uranometria Oxoniensis.	LOCKYER'S "Tables," Nov. 1892, 'Phil. Trans.,' A, 1893.	PICKERING, 1890, 'DRAPER Catalogue.'	VOGEL, 1883, 'Catalogue of Stellar Spectra Zone −1° to +20°.'	SECCHI, 'Stellar Types,' 1866-1868.
Type I.	Division I.	1	γ Pegasi (Algenib) .	2·5	A (α)	A	Ia	1°
		2	ζ „ .	3·3	*	A	Ia !	1
		3	α Andromedæ. . .	2·0	A (γ)	A	..	1
	Division II.	4	α Pegasi (Markab) .	2·3	A (γ)	A	Ia !!	1
		5	θ „ „ .	3·5	..	A	Ia !!	..
		6	δ Aquarii	3·0	..	A	..	..
	Division III.	7	γ Ceti	3·4	*	A	Ia !	1
		8	α Piscium	3·7	..	A	..	1
		9	β Arietis	2·7	A (β)	A	..	1
		10	δ Capricorni . . .	3·0	A (γ)	A	..	1
Type II.	Division IV.	11	β Aquarii	3·1	..	K?	..	2
		12	α „	3·0	..	K?	IIa	2
		13	β Ceti	2·4	B (β)	K	..	2
		14	τ „	3·1	..	G?	..	2
		15	θ „	3·4	..	I	..	2
		16	δ Andromedæ. . .	3·2	..	K	..	2
		17	ι Ceti	3·7	..	K	..	2
		18	ζ „	3·5	..	K?	..	2
		19	δ Eridani	3·0	..	I	..	2
		20	ϵ „	3·4	..	K	..	2
		21	η Ceti	3·5	C (β)	K?	..	2
		22	α Arietis	2·1	B (β)	K	..	2
		23	ϵ Pegasi	2·4	C (β)	K	IIa !!!	2
Type III.	Division V.	24	γ Eridani	3·0	..	M?	..	2
		25	α Ceti	2·2	C (α)	M	IIIa !!!	3
		Compn.	α Orionis	1·0 / 1·4 Var.	C (α)	M?	IIIa !!!	3
		„	α Herculis	3·0 / 3·9 Var.	C (α)	M	IIIa !!!	3
		26	o Ceti (Mira) . . .	3·3 / 8·7 Var.	..	M	..	3
		Compn.	α Aurigæ (Capella)					

Photographic Stellar Spectrum. Stars to Magnitude 3·5.

Upper Galactic Polar Region, S.

AA (Plates 15 to 17).

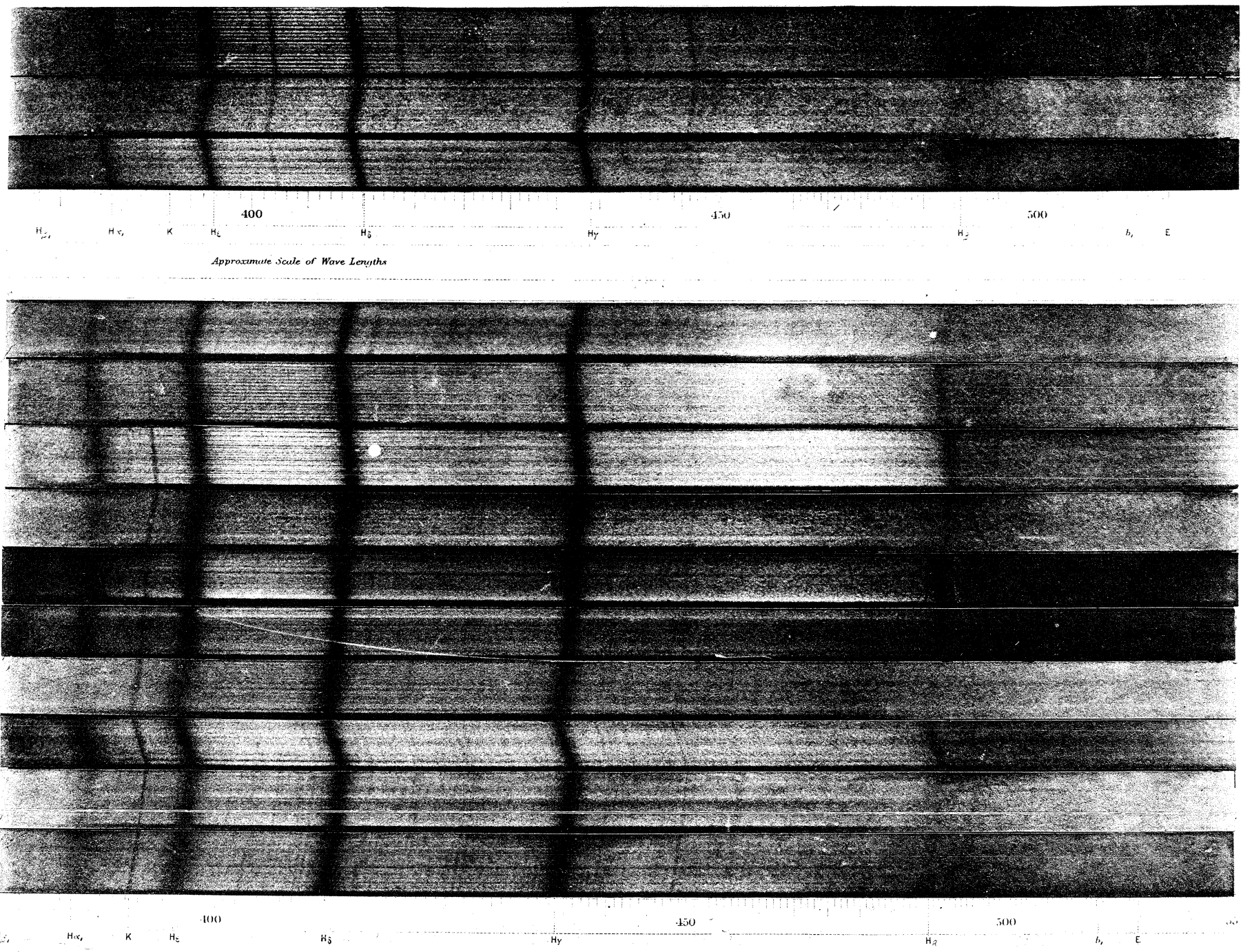
Secchi's Types.	Present classification.	No. of photograph.	List of Stars.	Magnitude, Uranometria Oxoniensis.	Lockyer's "Tables," Nov., 1892, 'Phil. Trans.,' A, 1893.	Pickering, 1890, 'Draper Catalogue.'	Vogel, 1883, 'Catalogue of Stellar Spectra Zone −1° to +20°.'	Secchi, 'Stellar Types,' 1866–68.
Type I.	Division I.	1	α Virginis (Spica) .	1·0	A (α)	A	..	1
		2	α Leonis (Regulus))	1·2	A (γ)	A	Ia !!!	1
		3	δ Corvi	3·1	*	A	..	1
		4	β Libræ	2·7	*	A	..	1
		5	γ Corvi	2·8	..	A	..	1
		6	η Leonis	3·5	A (γ)	A	Ia	1
	Division II.	7	μ Serpentis . . .	3·3	..	A	..	1
		8	η Virginis	3·8	..	A	Ia !	..
		9	θ Leonis	3·4	..	A	Ia !!!	1
	Division III.	10	ζ Virginis	3·4	*	A	Ia !!	..
		11	β Serpentis	3·5	..	A	Ia !	..
		12	α Libræ	3·0	*	A	..	1
		13	ϵ Serpentis	3·6	..	A	Ia	1
		14	β Leonis	2·1	*	A	Ia !!!	1
		15	δ „	2·5	A (β)	A	..	1
		16	θ Geminorum . . .	3·6	..	A	..	1
		17	δ Serpentis	3·8	..	A	I ! ?	2
		18	γ Virginis	2·7	A (β)	F	Ia !	1
		Compn.	η Bootis	2·7	B (β)	G	Ia !	2
Type II.	Division IV.	19	η Bootis	2·7	B (β)	G	Ia !	2
		20	β Virginis	3·6	..	G	Ia	2
		21	ζ Hydræ	3·4	B (β)	K	IIa	2
		22	ϵ Virginis	3·0	B (β)	K	IIa	2
		23	ϵ Ophiuchi	3·3	B (β)	K ?	..	2
		24	γ Leonis	2·1	B (β)	K	..	2
		25	α Bootis (Arcturus)	(+0·7)	B (β)	K	IIa !!	2
		26	α Serpentis	2·7	C (β)	K ?	IIa !!!	2
		27	α Hydræ	2·2	C (β)	K	..	2
Type III.	Division V.	28	δ Ophiuchi	2·6	C (α)	M	..	..
		29	δ Virginis	3·5	C (α)	M	IIIa !!!	3
		Compn.	α Orionis					

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC POLAR REGION S.

A



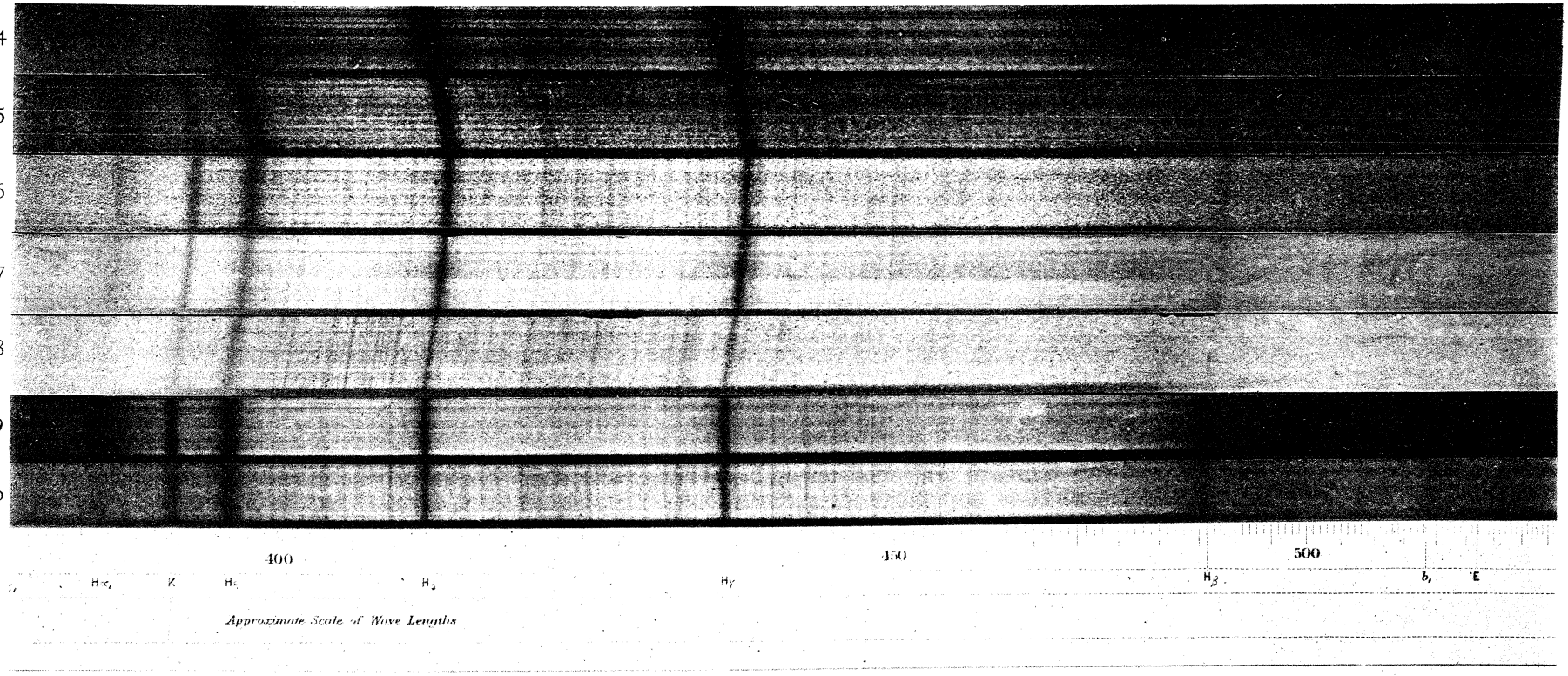
	Mag.
η Ursæ Majoris	1.8
κ Draconis	3.7
ζ ,,	3.3
α Canum	3.3
ε Ursa Majoris	1.8
α Coronæ	2.2
γ Ursa Majoris	2.3
ε Herculis	3.8
α Draconis	3.6
δ Ursa Majoris	3.4
λ ,,	3.5
β ,,	2.2
ζ ,,	2.1

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC POLAR REGION, N.

A



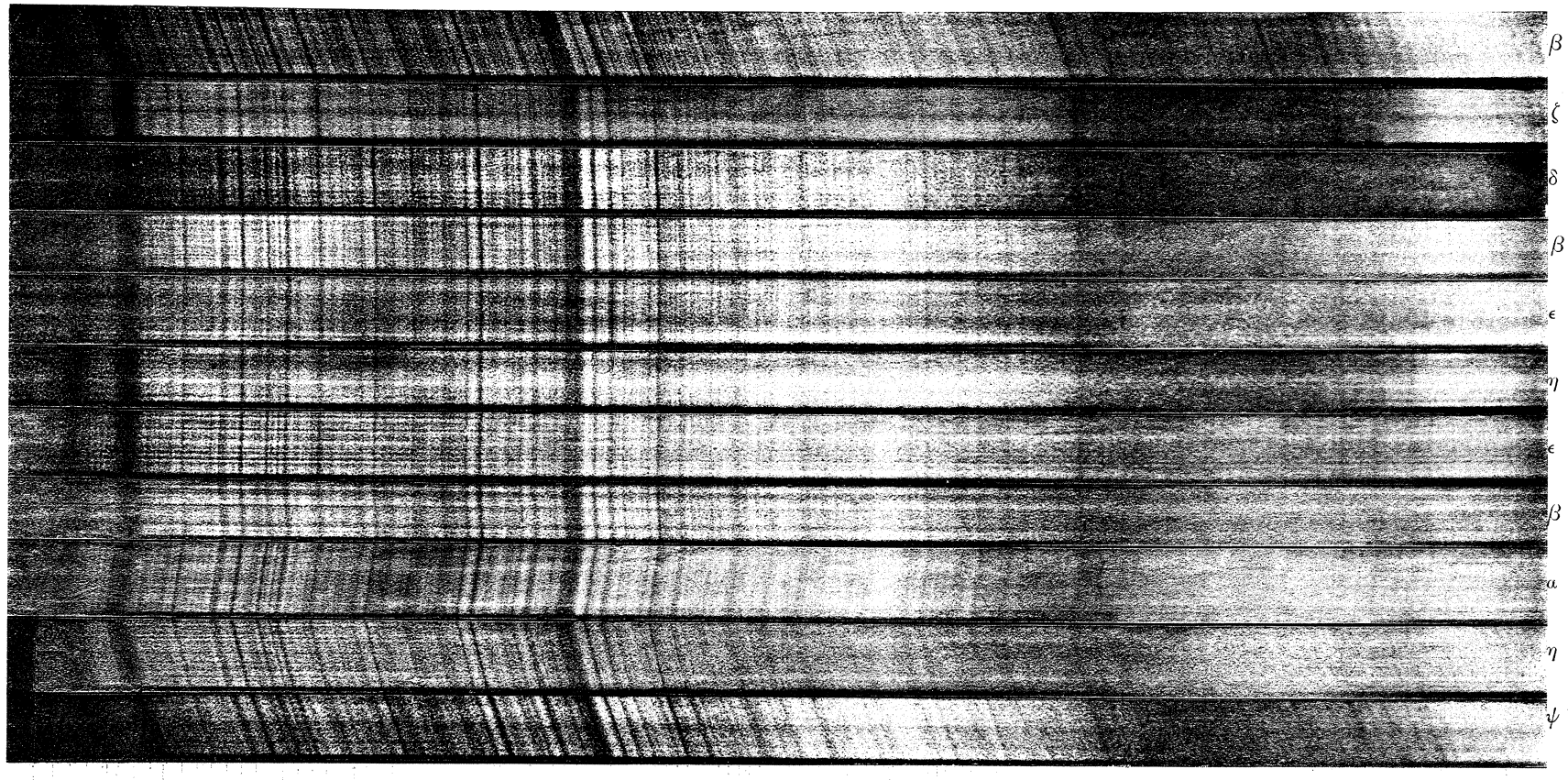
Type I. Div. III. 14	δ Herculis Mag.	3.2
15	γ Ursæ Minoris	3.0
16	γ Herculis	3.6
17	ι Ursæ Majoris	3.2
18	θ ,,	3.1
19	γ Bootis	3.2
20	ζ Leonis	3.4

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

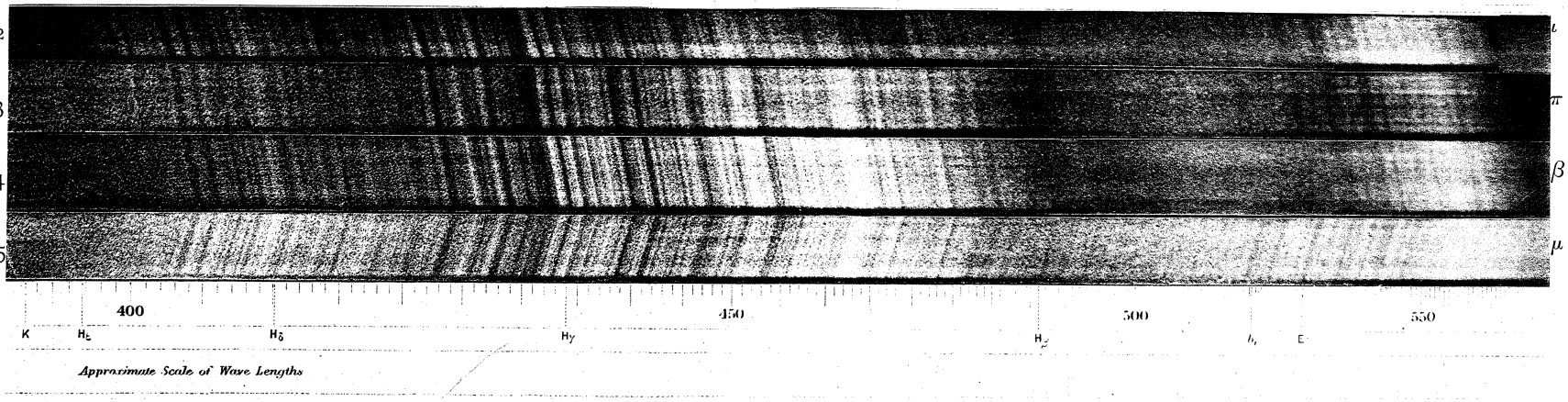
UPPER GALACTIC POLAR REGION, N.

A



Approximate Scale of Wave Lengths

Type II. Div. IV.	21	β Draconis, Mag.	3.0
	22	ζ Herculis	2.6
	23	δ Bootis	3.4
	24	β Herculis	2.7
	25	ϵ Leonis	3 4
	26	η Herculis	3.6
	27	ϵ Bootis	2.5
	28	β Bootis	3.6
	29	α Ursæ Majoris	1.9
	30	η Draconis	2.8
	31	ψ Ursæ Majoris	3.2



Approximate Scale of Wave Lengths

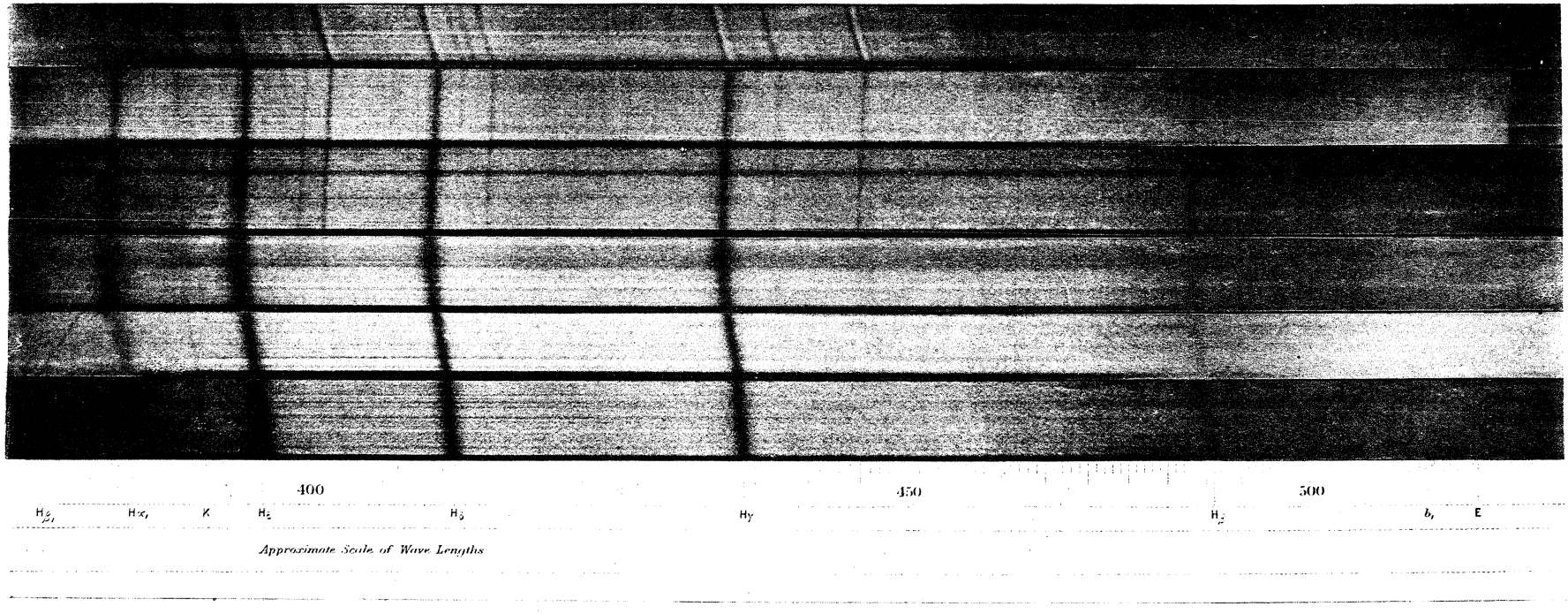
	32	ι Draconis	3.3
	33	π Herculis	3.6
	34	β Ursæ Minoris	2.3
Type III. Div. V.	35	μ Ursæ Majoris	3.1

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC ZONE N.

B



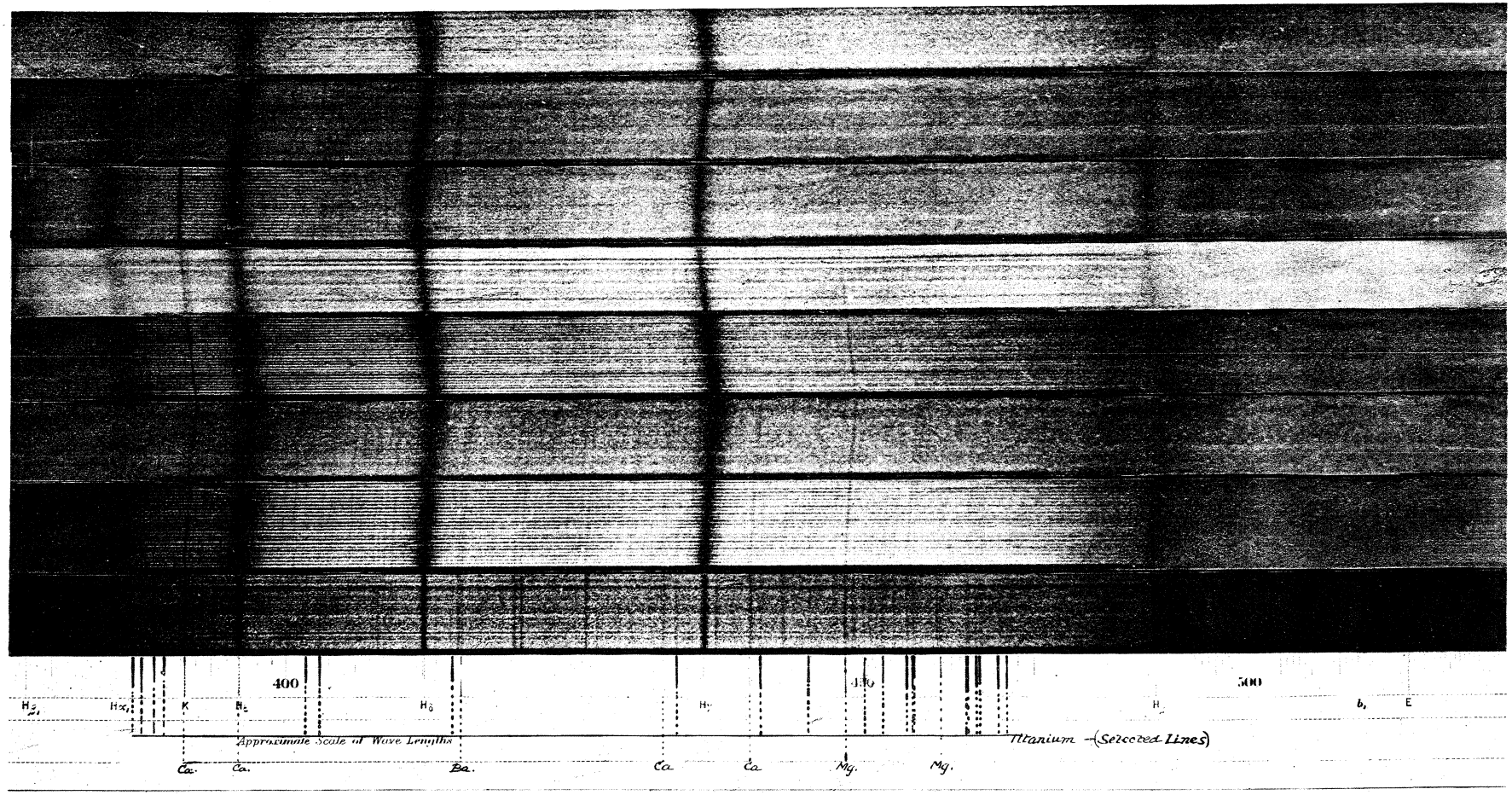
	Mag.	
β Lyræ	3.4 4.4	Var
β Cephei	3.4	
ϵ Cassiopeiæ	3.5	
β Canis Minoris	3.1	
γ Lyræ	3.2	
δ Cygni	2.8	

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3 5.

UPPER GALACTIC ZONE, N.

B



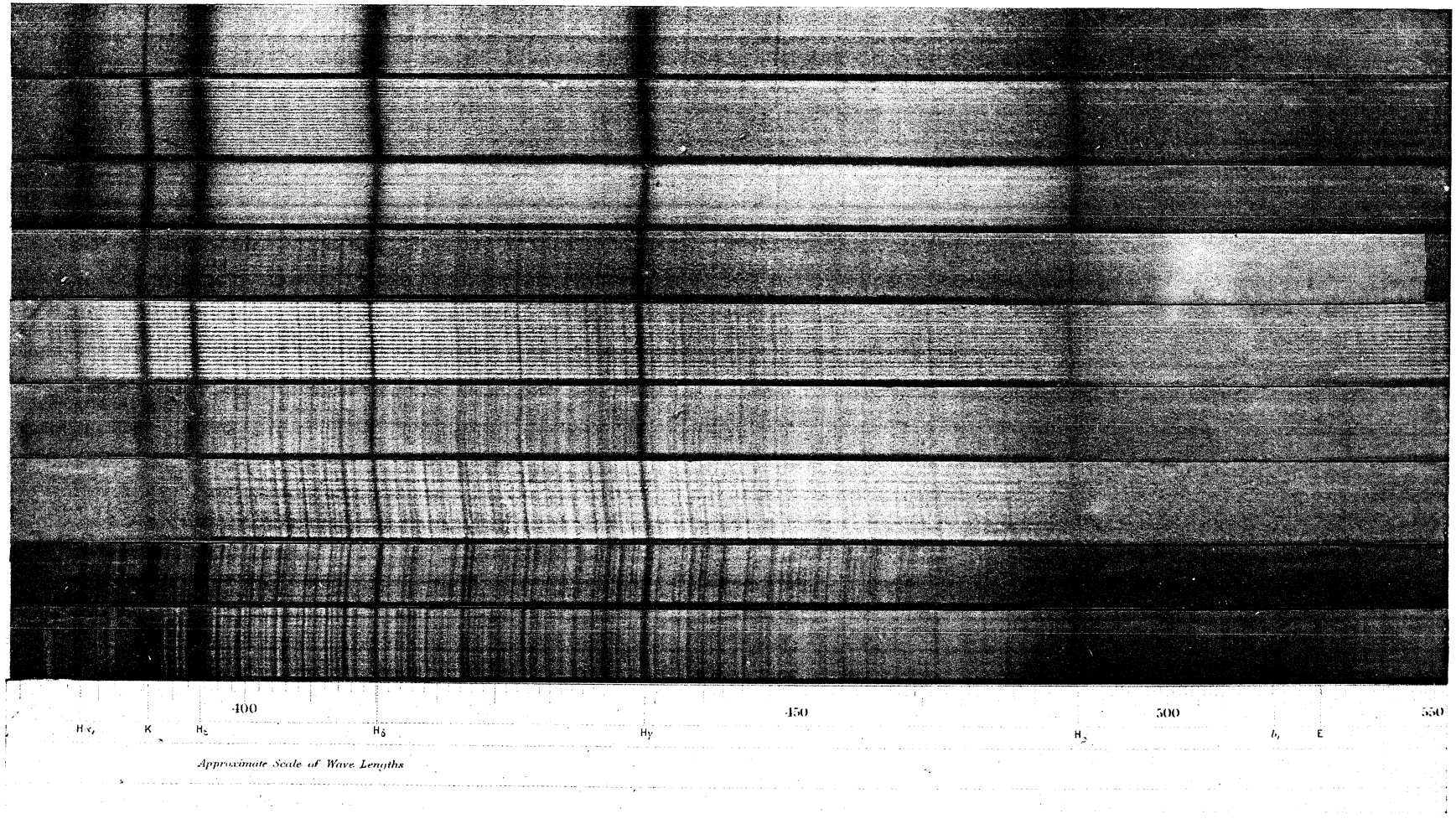
Type I, Div. II.	7	ζ Aquilæ Mag. 3.1
	8	θ Aurigæ 3.0
	9	β ,, 1 9
	10	γ Geminorum 2 1
	11	α Lyræ (+0.9) *Vega*
	12	α Geminorum 1.5 *Castor*
Compn.		α Canis Maj. (+1.9) *Sirius*
	13	α Cygni 1.3

PHOTOGRAPHIC STELLAR SPECTRA,

Stars to Magnitude 3.5.

UPPER GALACTIC ZONE, N.

B



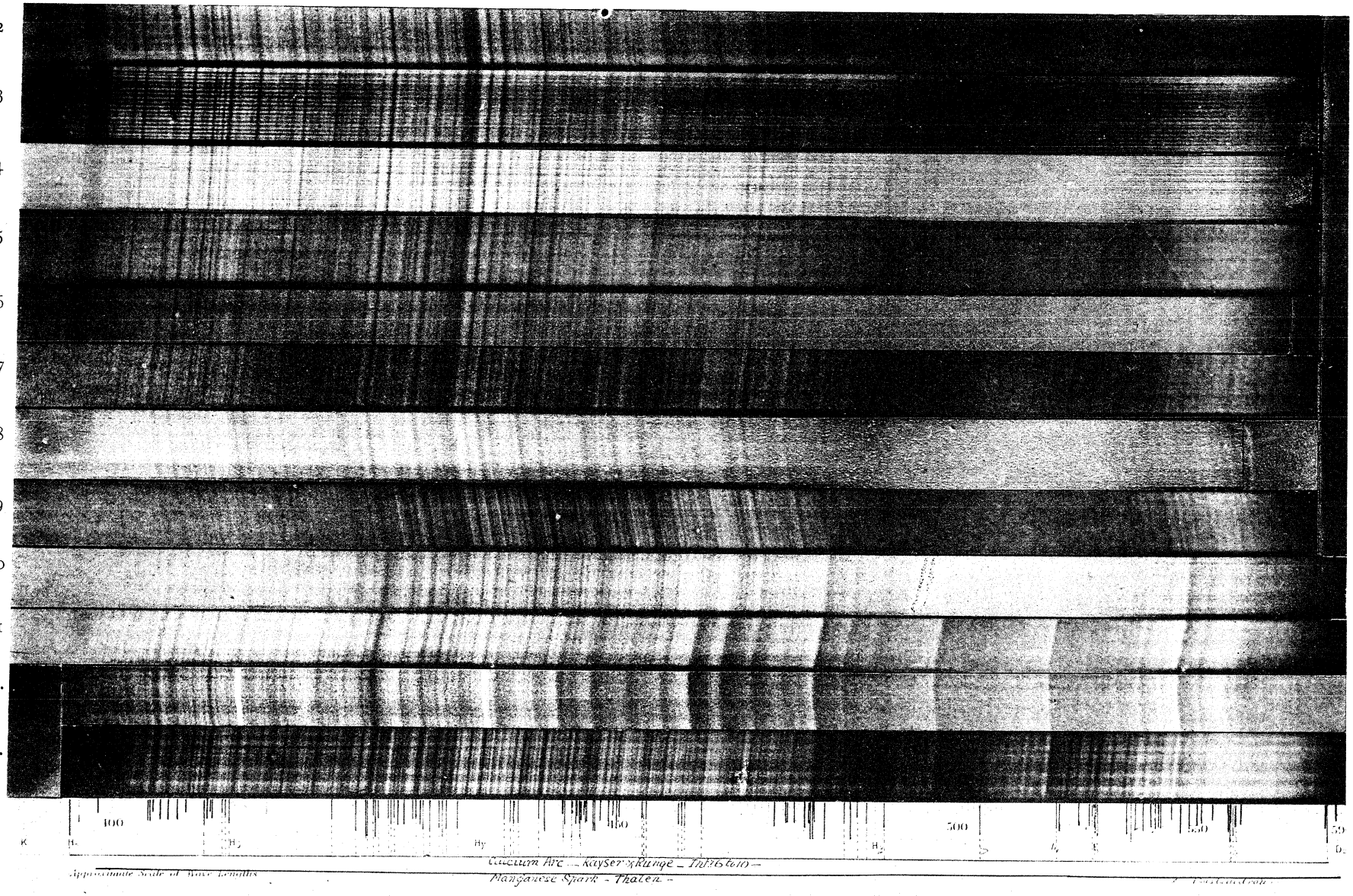
	Mag.
α Geminorum *Castor*	1.5
α Ophiuchi	2.2
α Cephei	2.6
δ Geminorum	3.5
α Canis Minoris *Procyon* (+0.5)	
δ Cephei	3.7 / 4.9 Var.
α Ursæ Minoris *Polaris*	2.0
ϵ Aurigæ	3.0 / 4.5 Var.
γ Cygni	2.3

PHOTOGRAPHIC STELLAR SPECTRA,

Stars to Magnitude 3.5.

UPPER GALACTIC ZONE, N.

B

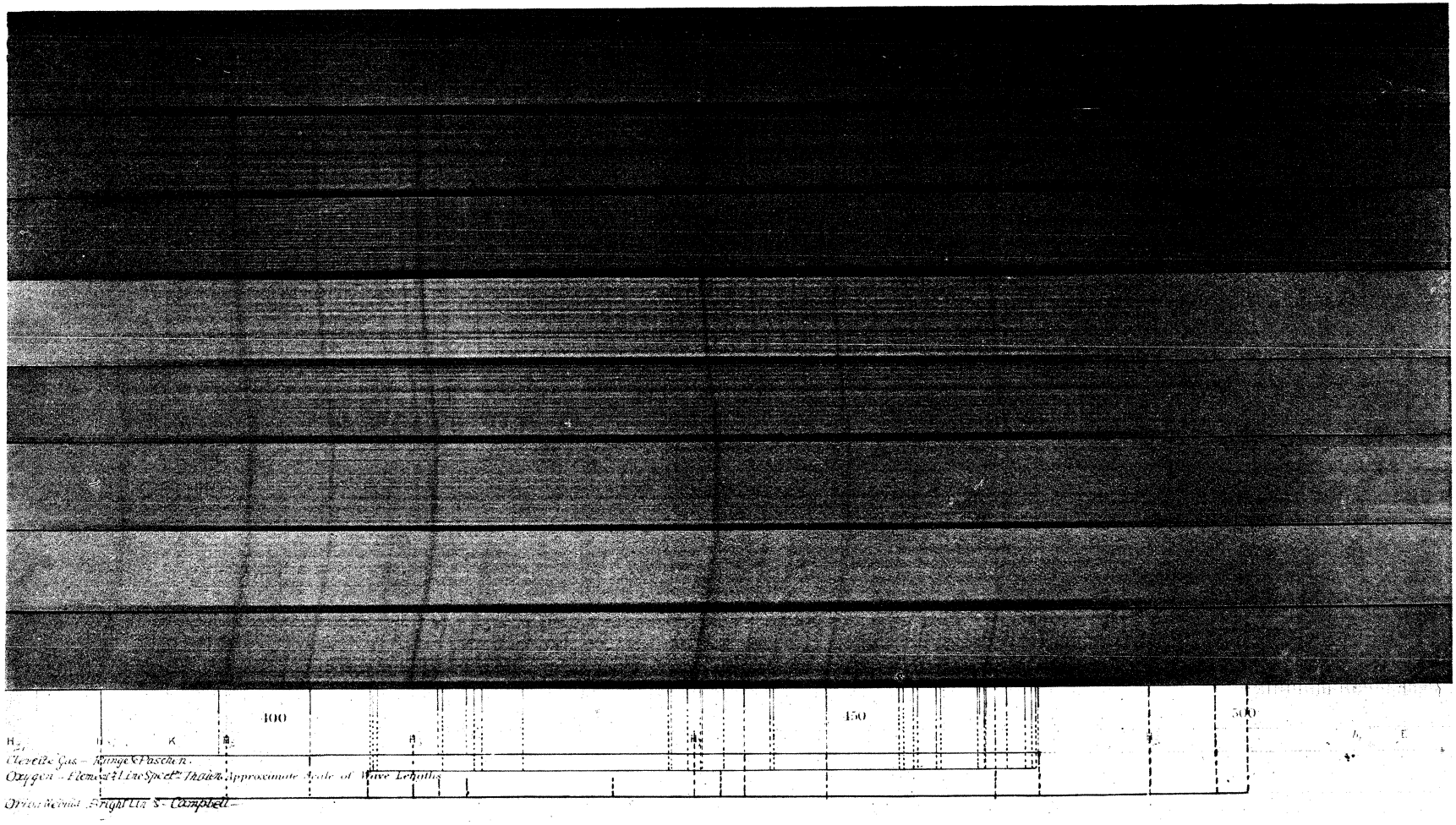


PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3 5.

LOWER GALACTIC ZONE, N.

C



Type I, Div. I. (a)		Mag.
1	γ Cassiopeiæ	2.2
2	δ Orionis	2.2 / 2.7 Var
3	ε ,,	1.8
4	κ ,,	2.4
5	ζ ,,	1.8
6	ι ,,	3.2
7	ε Persei	3.1
8	ζ ,,	3.1

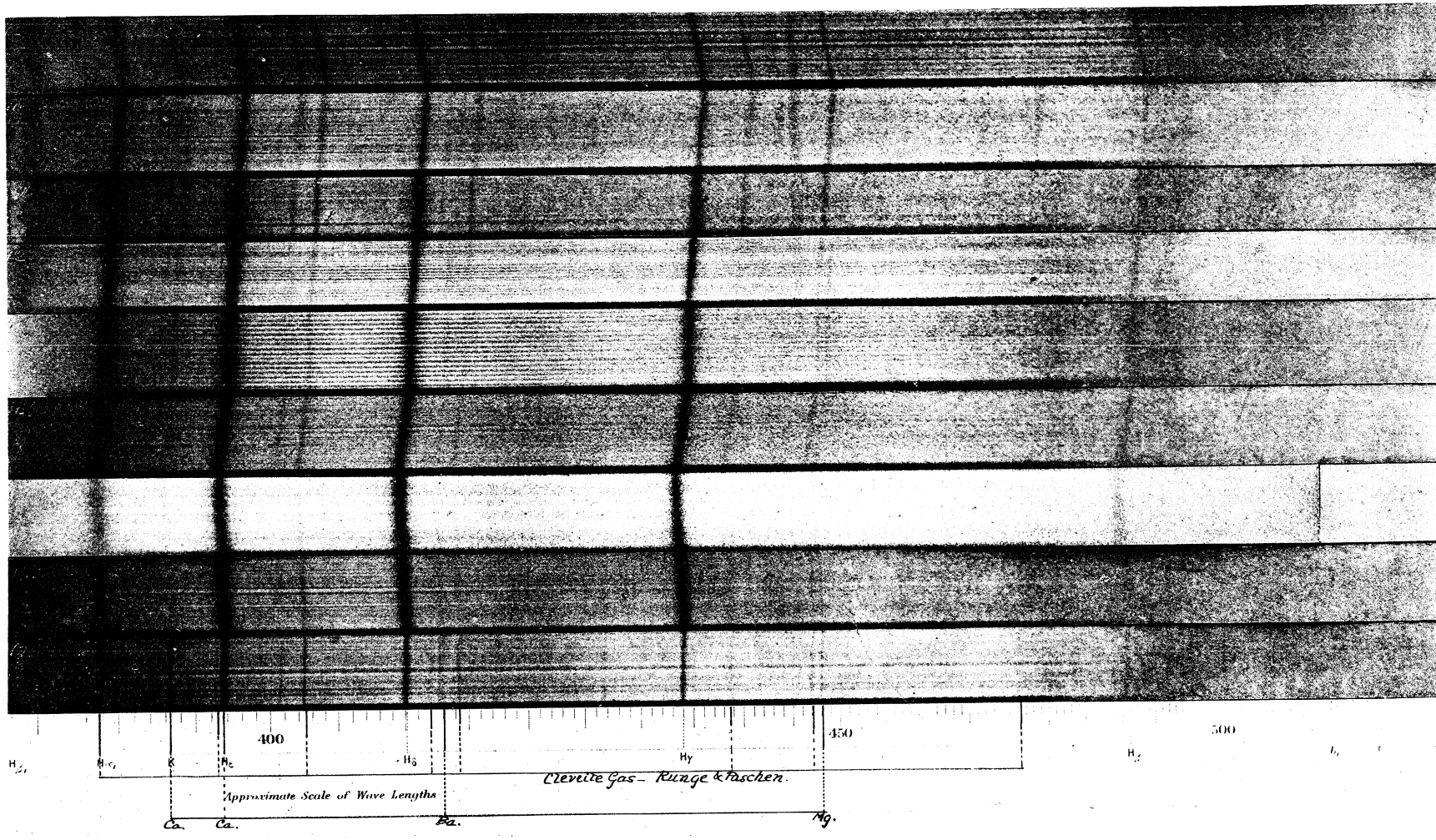
Phil. Trans. A. 191, Plate 8.

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3·5.

LOWER GALACTIC ZONE N.

C



Type I, Div. I. (3) 9 — γ Orionis Mag. 1.8 *Bellatrix*.

10 — ζ Tauri 3.0

11 — λ ,, 3.4 4.2 Var.

12 — β ,, 1.8

13 — β Persei 2.3 3.5 Var. *Algol*.

14 — δ ,, 3.1

15 — θ Aquilæ 3.3

16 — η Tauri 3.1

17 — β Orionis + 1.0 *Rigel*.

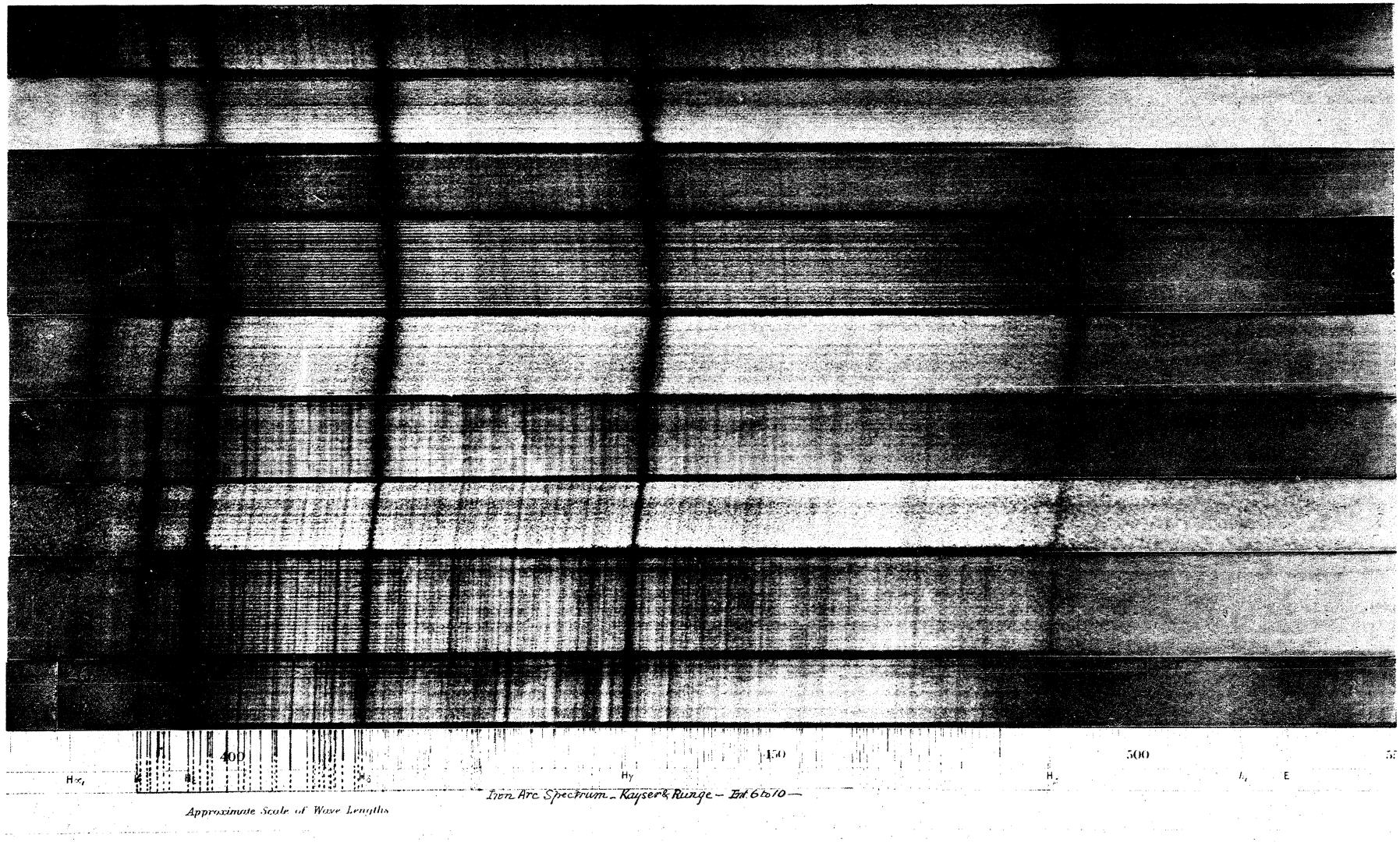
Type I, Div. II. none

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

LOWER GALACTIC ZONE, N.

C



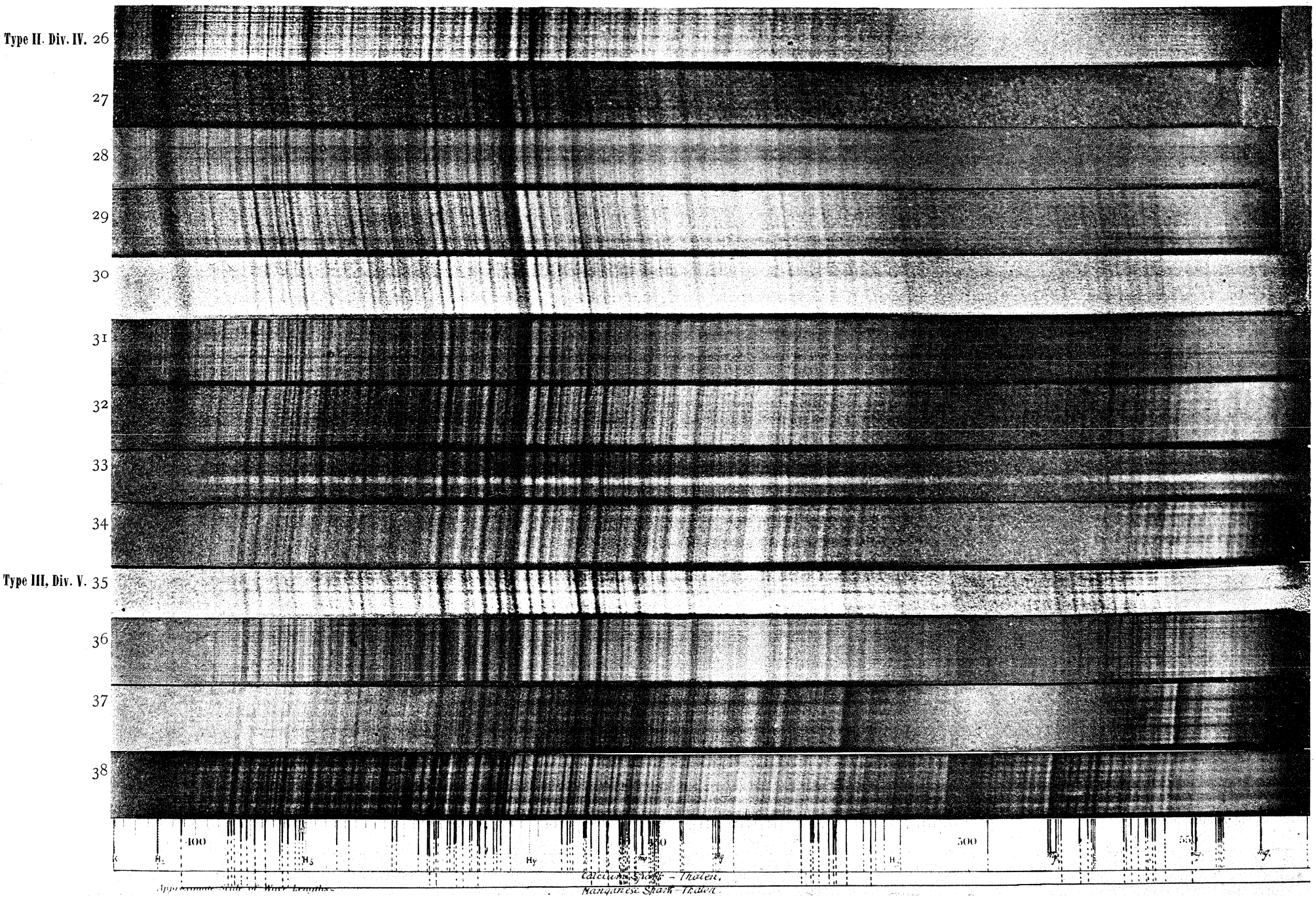
Type I. Div. III.	18	δ Aquilæ Mag.	3.4
	19	β Eridani	2.8
	20	β Trianguli	3.1
	21	α Aquilæ *Altair*	1.0
	22	δ Cassiopeiæ	2.8
	23	β ,,	2.3
	24	β Delphini	3.5
	25	α Persei	1.9
Comp.		γ ,,	3.1

PHOTOGRAPHIC STELLAR SPECTRA,

Stars to Magnitude 3.5.

UPPER GALACTIC ZONE, N.

C

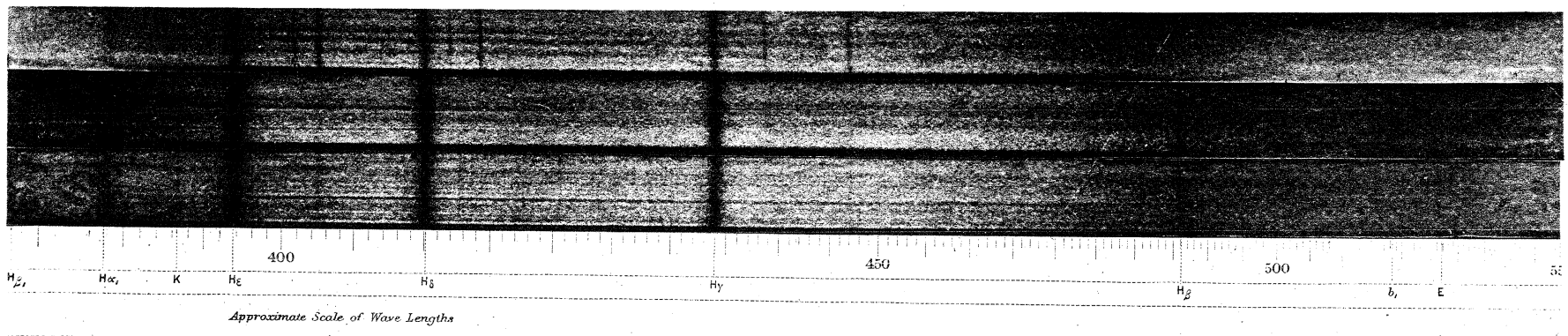


PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

LOWER GALACTIC POLAR REGION, N.

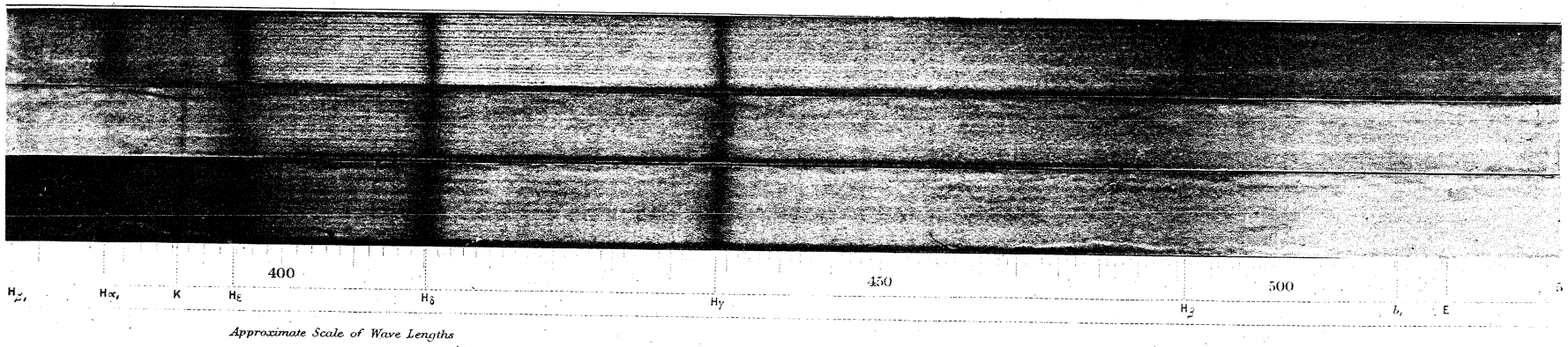
D



Type I, Div. I (b). 1 — γ Pegasi Mag. 2.5 *Algenib*

2 — ,, 3.3

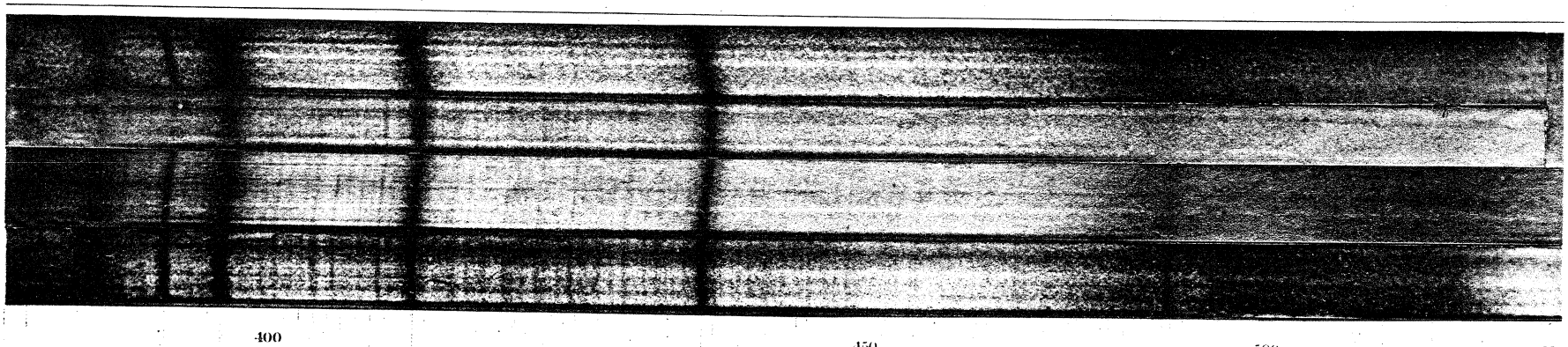
3 — α Andromedæ 2.0



Type I, Div. II 4 — α Pegasi Mag. 2.3 *Markab*

5 — θ ,, 3.5

6 — δ Aquarii 3.0



Type I, Div. III. 7 — γ Ceti Mag. 3.4

8 — α Piscium 3.7

9 — β Arietis 2.7

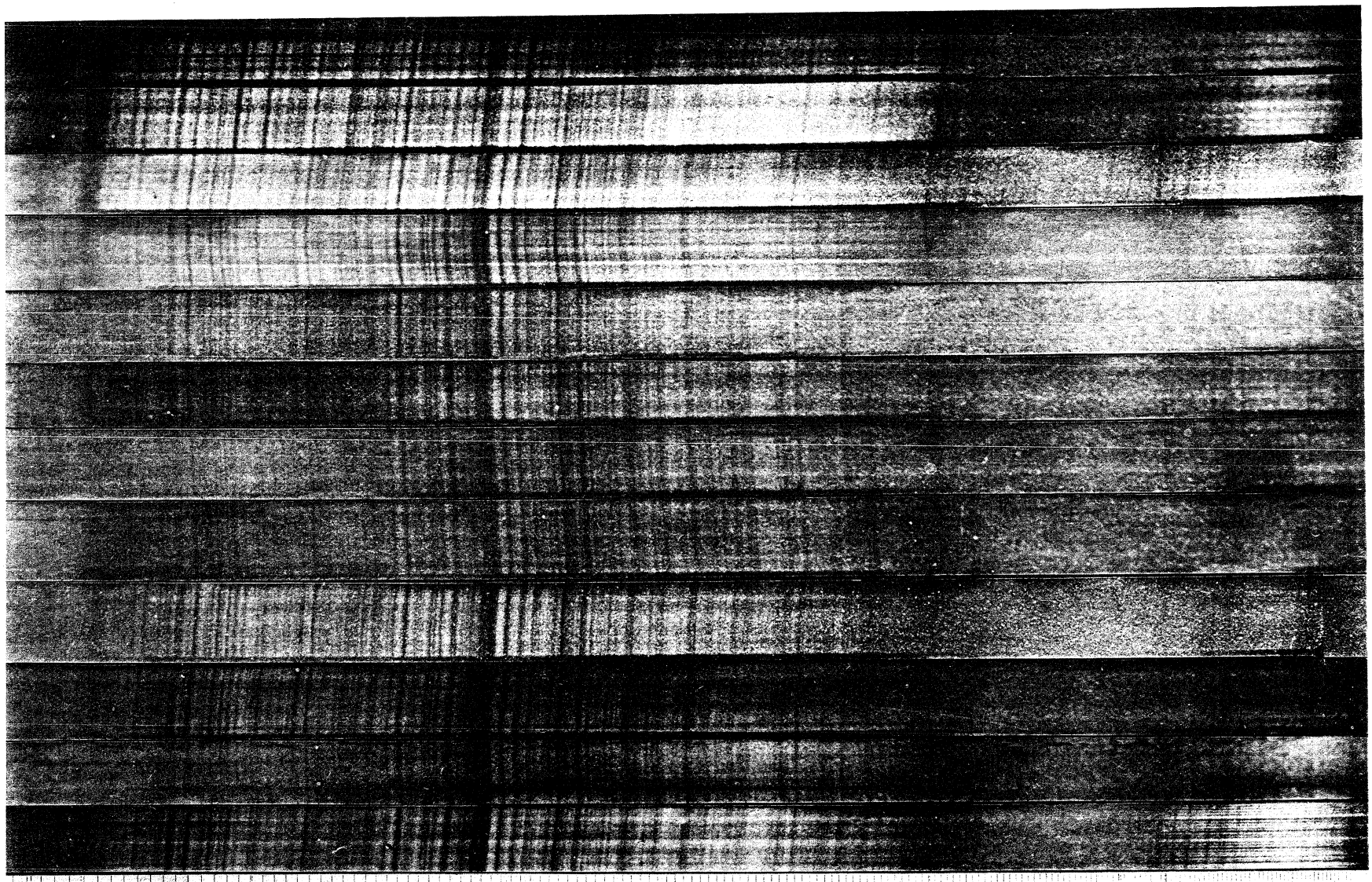
10 — δ Capricorni 3.0

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

LOWER GALACTIC POLAR REGION, N.

D



Approximate Scale of Wave Lengths

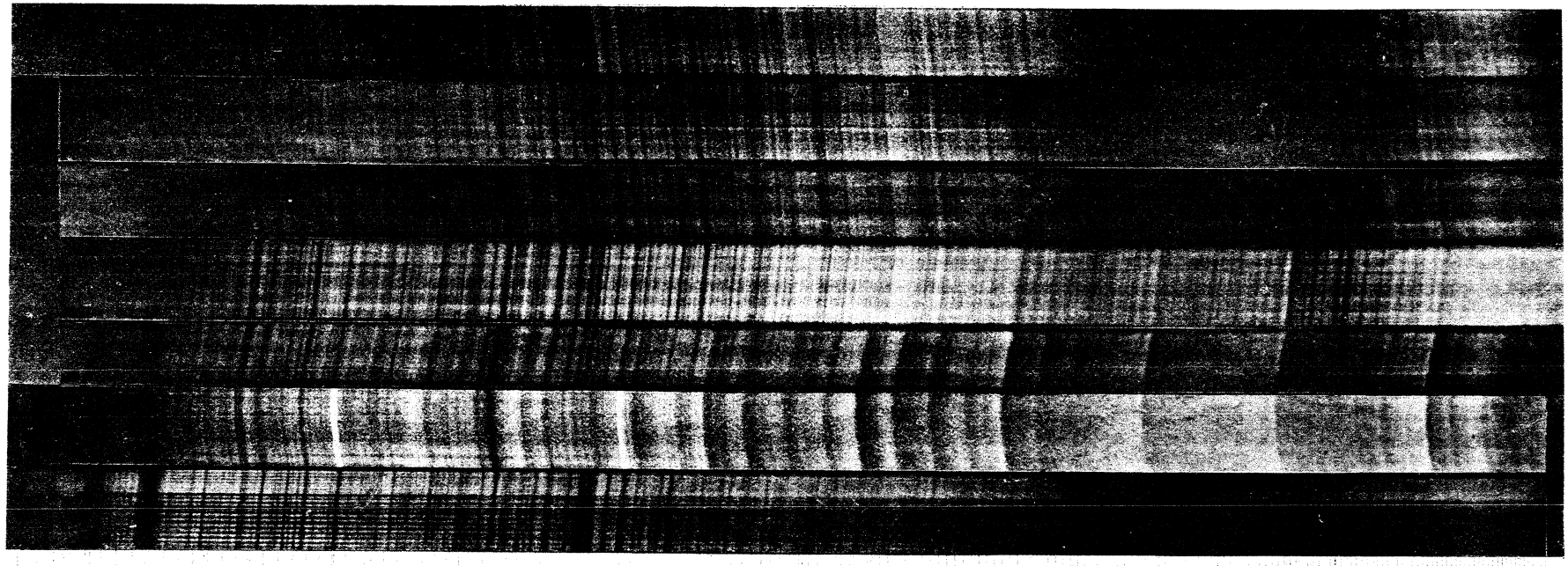
Type II, Div. IV.	11	β Aquarii	Mag. 3.1
	12	α ,,	3.0
	13	β Ceti	2.4
	14	τ ,,	3.1
	15	θ ,,	3.4
	16	δ Andromedæ	3.2
	17	ι Ceti	3.7
	18	ζ ,,	3.5
	19	δ Eridani	3.0
	20	ϵ ,,	3.4
	21	η Ceti	3.5
	22	α Arietis	2.1

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

LOWER GALACTIC POLAR REGION, N.

D



Type II. Div. IV, 23 *contd.*

Type III Div. V. 24

25

Comp.

Comp.

26

Comp.

ϵ Pegasi Mag. 2.4

γ Eridani 3.0

α Ceti 2.2

α Orionis 1.0 / 1.4 Var.

α Herculis 3.0 / 3.9 Var.

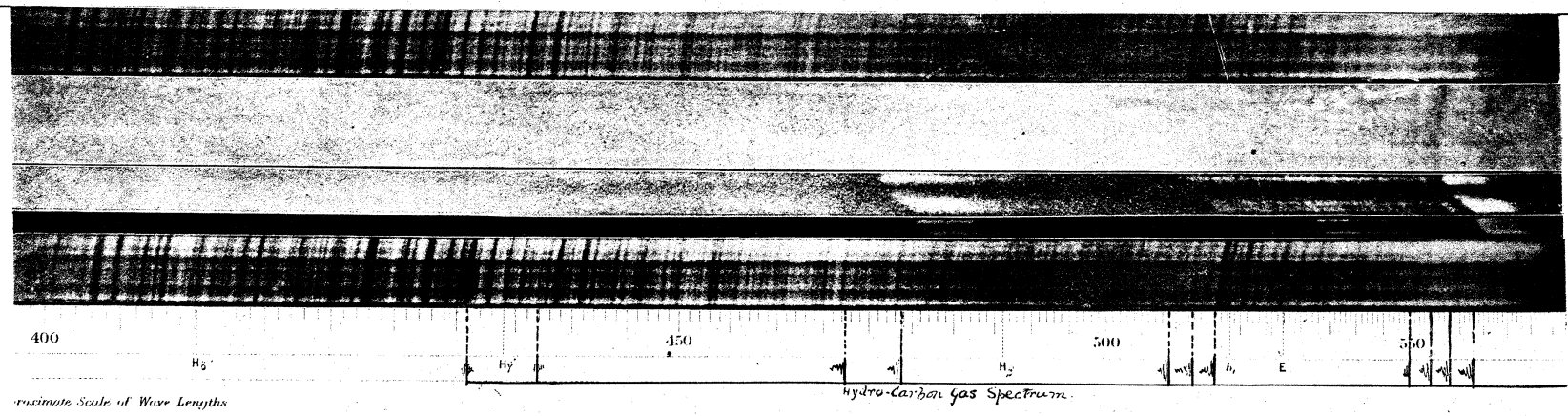
ο Ceti 3.3 / 8.7 Var. *Mira.*

α Aurigæ (+0.9) *Capella.*

400 450 500 550

Hx, K, Hε, Hδ, Hγ, Hβ, b, E

Approximate Scale of Wave Lengths



Comp.

Type IV. iv. VI.

Comp.

α Tauri.

19 Piscium Mag. 5½

Superba 5½

α Tauri

400 450 500 550

Hδ, Hγ, Hβ, b, E

Approximate Scale of Wave Lengths

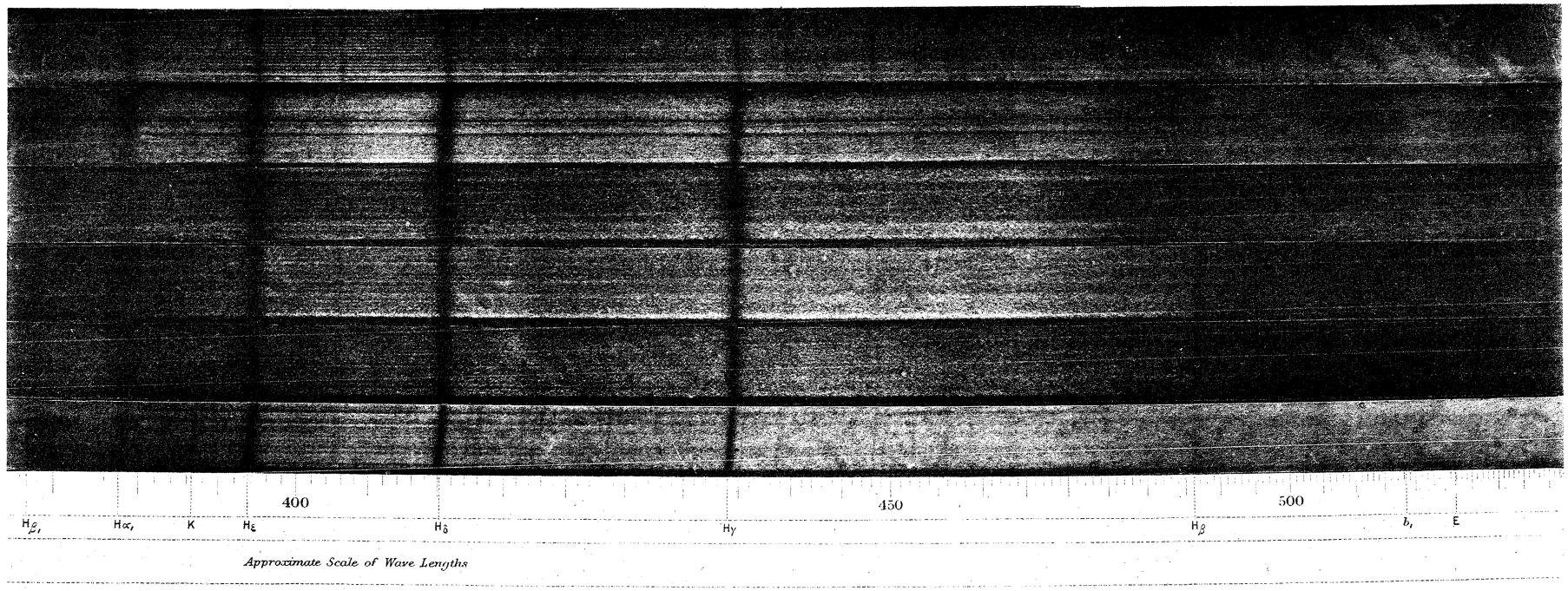
Hydro-Carbon gas Spectrum.

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC POLAR REGION S.

AA



Type I, Div. 1 (b). 1 — α Virginis Mag. 1.0 *Spica*

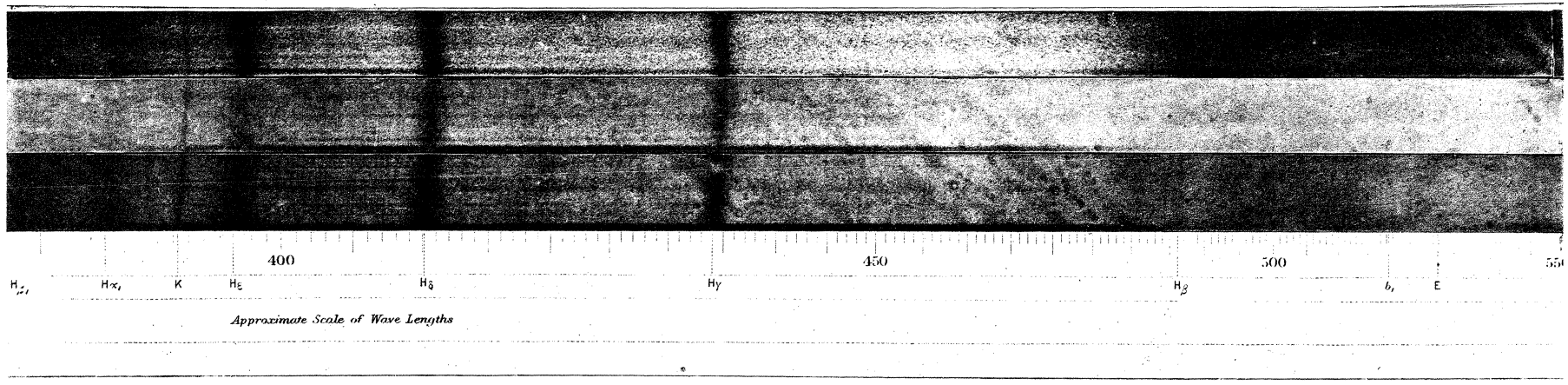
2 — α Leonis 1.2

3 — δ Corvi 3.1

4 — β Libræ 2.7

5 — γ Corvi 2.8

6 — η Leonis 3.5



Type I. Div. II. 7 — μ Serpentis 3.3

8 — η Virginis 3.8

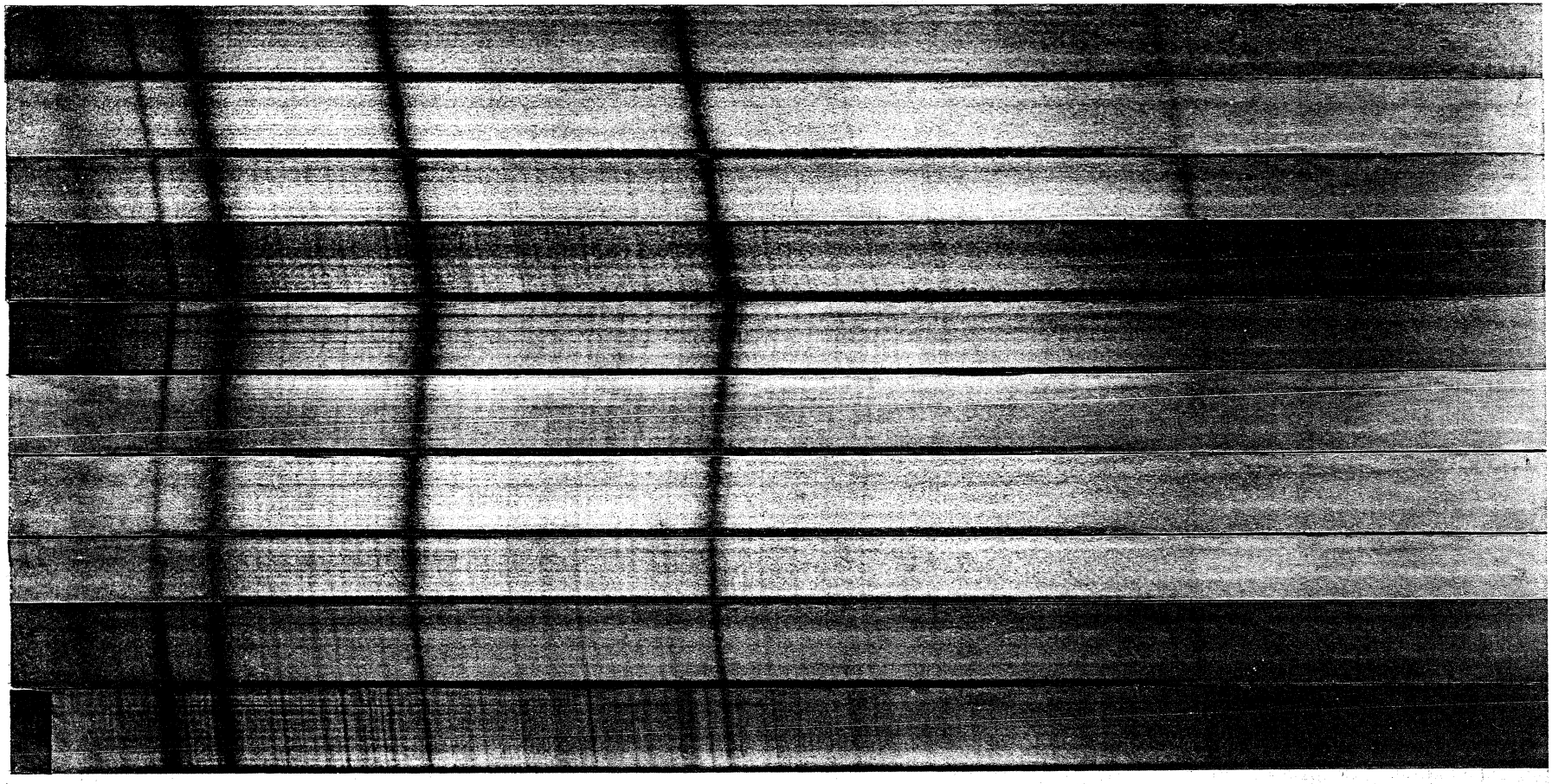
9 — θ Leonis 3.4

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC POLAR REGION, S.

AA



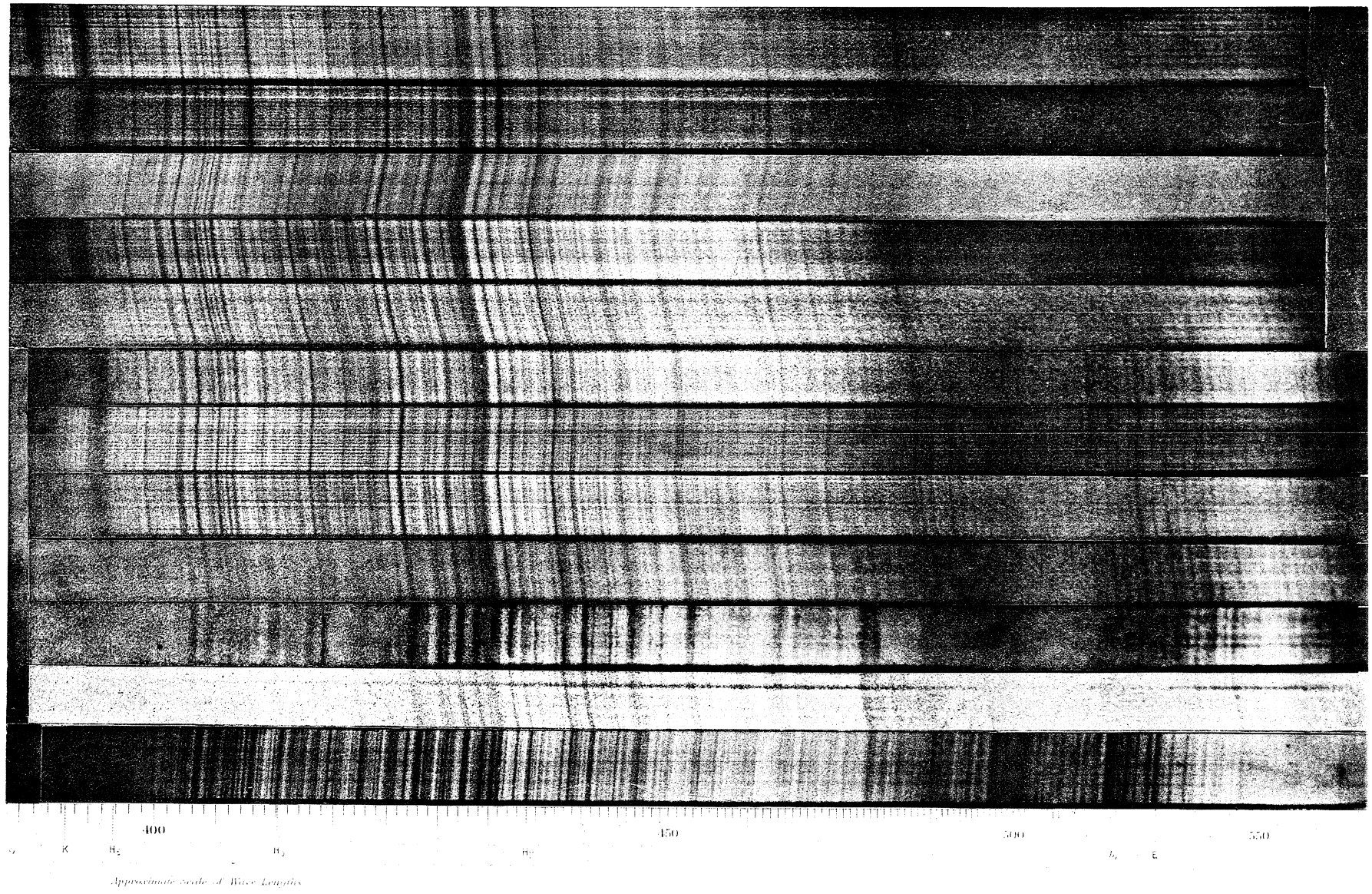
Type I, Div. III.	10	ζ Virginis	**Mag. 3.4**
	11	β Serpentis	**3.5**
	12	α Librœ	**3.0**
	13	ε Serpentis	**3.6**
	14	β Leonis	**2.1**
	15	δ ,,	**2.5**
	16	θ Geminorum	**3.6**
	17	δ Serpentis	**3.8**
	18	γ Virginis	**2.7**
Compn.		η Bootis	**2.7**

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC POLAR REGION, S.

AA



Approximate Scale of Wave Lengths

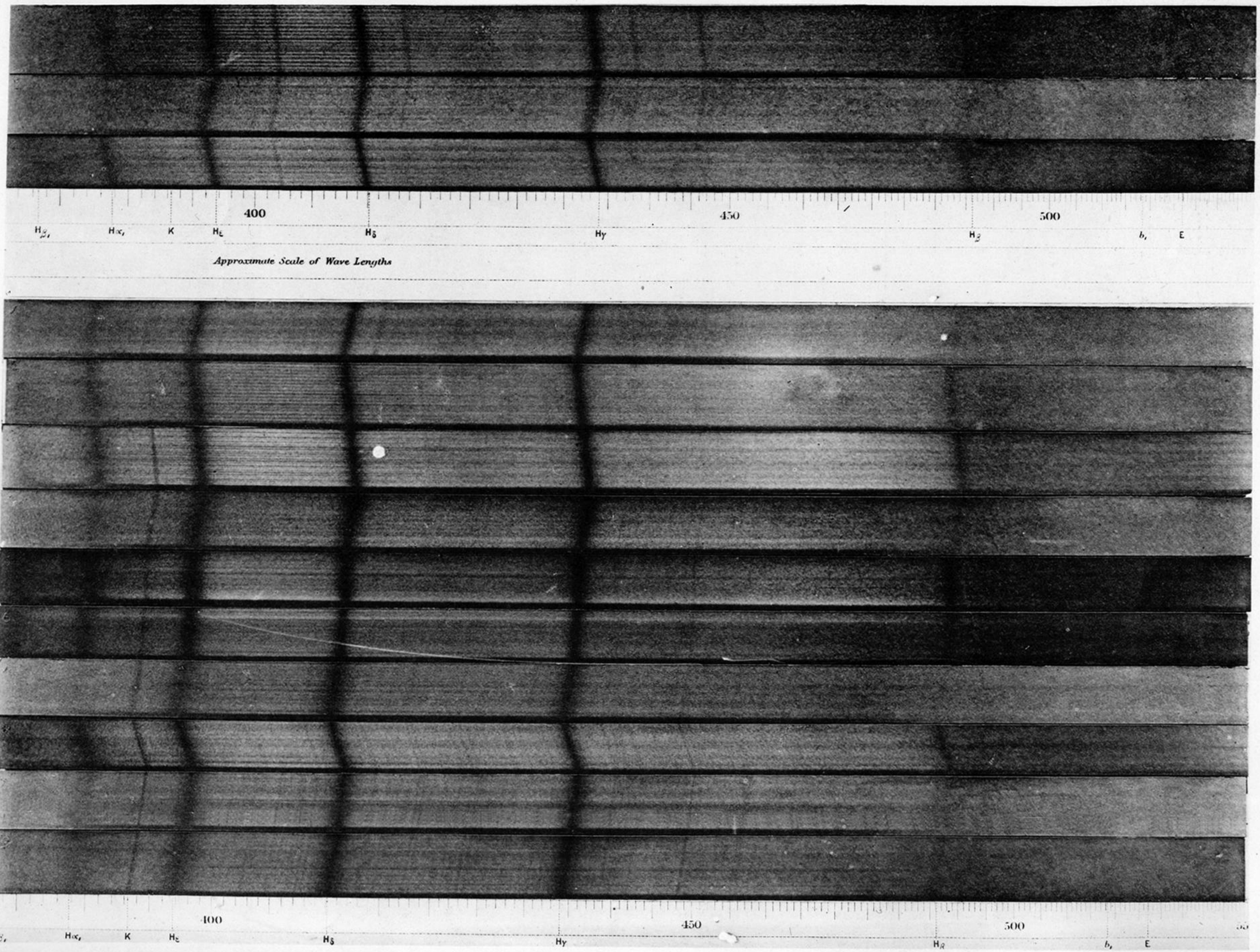
Type II, Div. IV.	19	η Bootis	Mag. 2.7
	20	β Virginis	3.6
	21	ζ Hydræ	3.4
	22	ϵ Virginis	3.0
	23	ϵ Ophiuchi	3.3
	24	γ Leonis	2.1
	25	α Bootis (+0.7) *Arcturus*	
	26	α Serpentis	2.7
	27	α Hydræ	2.2
Type III, Div. V.	28	δ Opiuchi	2.6
	29	δ Virginis	3.5
Compn.		α Orionis	1.0 1.4 Var

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC POLAR REGION S.

A



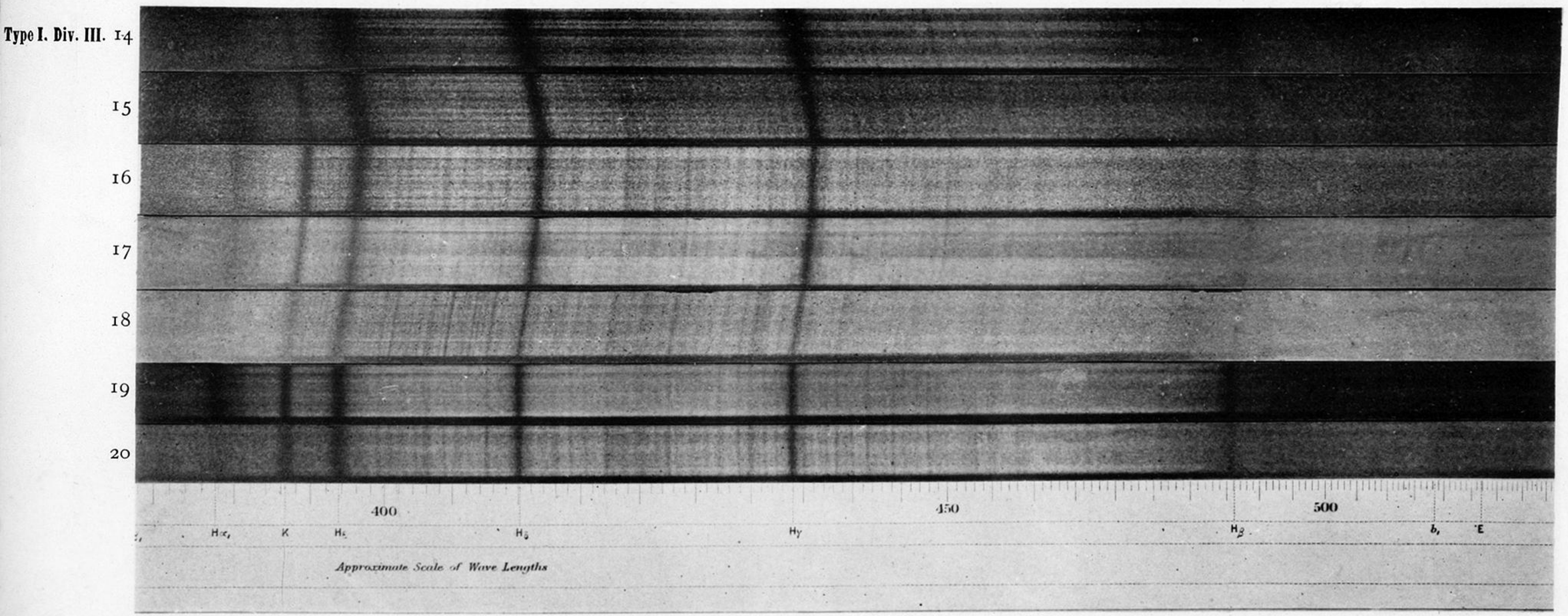
		Mag.
Div. I. (*b*) 1	η Ursæ Majoris	1.8
2	κ Draconis	3.7
3	ζ ,,	3.3
Div. II. 4	α Canum	3.3
5	ϵ Ursa Majoris	1.8
6	α Coronæ	2.2
7	γ Ursa Majoris	2.3
8	ϵ Herculis	3.8
9	α Draconis	3.6
10	δ Ursa Majoris	3.4
11	λ ,,	3.5
12	β ,,	2.2
13	ζ ,,	2.1

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC POLAR REGION, N.

A



Type I. Div. III.	14	δ Herculis Mag.	3.2
	15	γ Ursæ Minoris	3.0
	16	γ Herculis	3.6
	17	ι Ursæ Majoris	3.2
	18	θ ,,	3.1
	19	γ Bootis	3.2
	20	ζ Leonis	3.4

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC POLAR REGION, N.

A

Type II. Div. IV.	21	β Draconis, Mag.	3.0
	22	ζ Herculis	2.6
	23	δ Bootis	3.4
	24	β Herculis	2.7
	25	ϵ Leonis	3 4
	26	η Herculis	3.6
	27	ϵ Bootis	2.5
	28	β Bootis	3.6
	29	α Ursæ Majoris	1.9
	30	η Draconis	2.8
	31	ψ Ursæ Majoris	3.2

Approximate Scale of Wave Lengths

	32	ι Draconis	3.3
	33	π Herculis	3.6
	34	β Ursæ Minoris	2.3
Type III. Div. V.	35	μ Ursæ Majoris	3.1

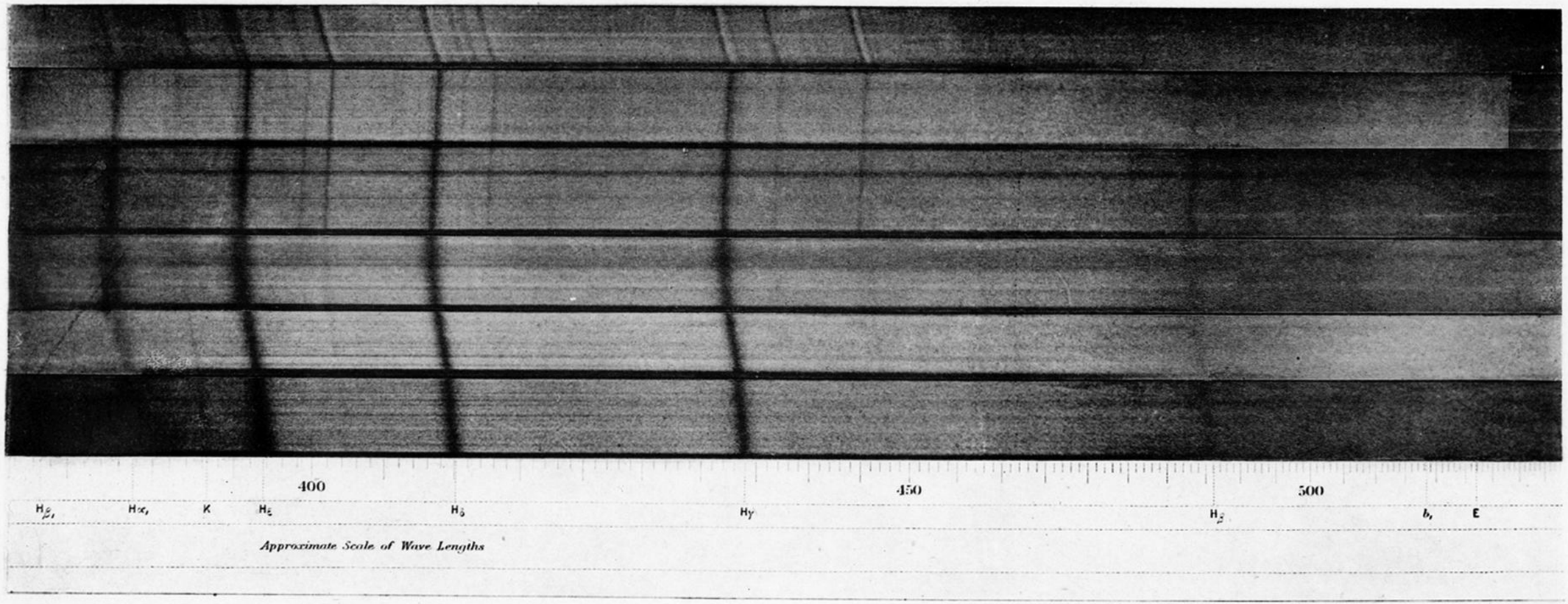
Approximate Scale of Wave Lengths

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC ZONE N.

B



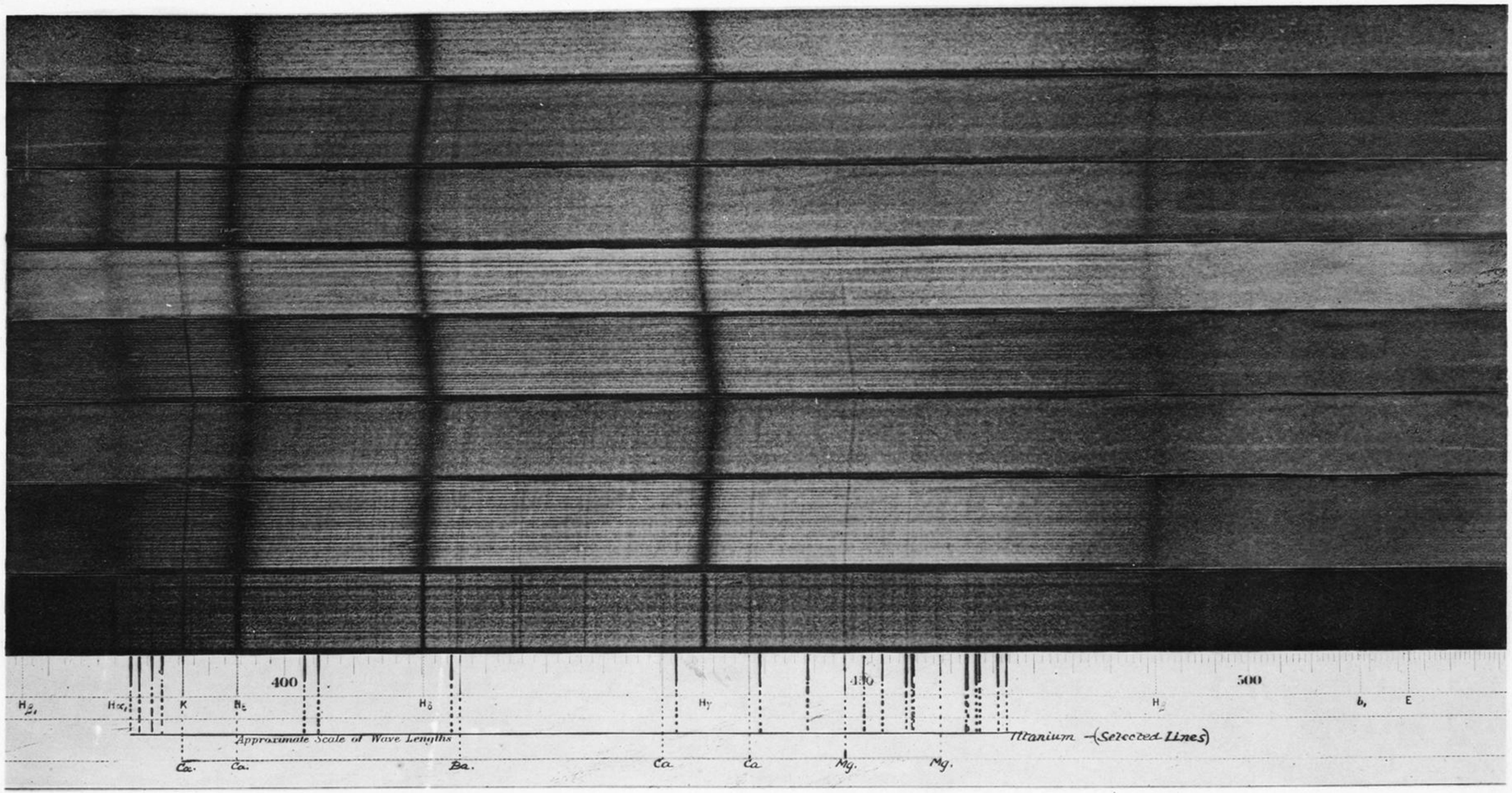
			Mag.	
Type I, Div. I. (*b*)	1	β Lyræ	3.4 4.4	Var
(*a*)	2	β Cephei	3.4	
(*b*)	3	ϵ Cassiopeiæ	3.5	
	4	β Canis Minoris	3.1	
	5	γ Lyræ	3.2	
	6	δ Cygni	2.8	

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3 5.

UPPER GALACTIC ZONE, N.

B



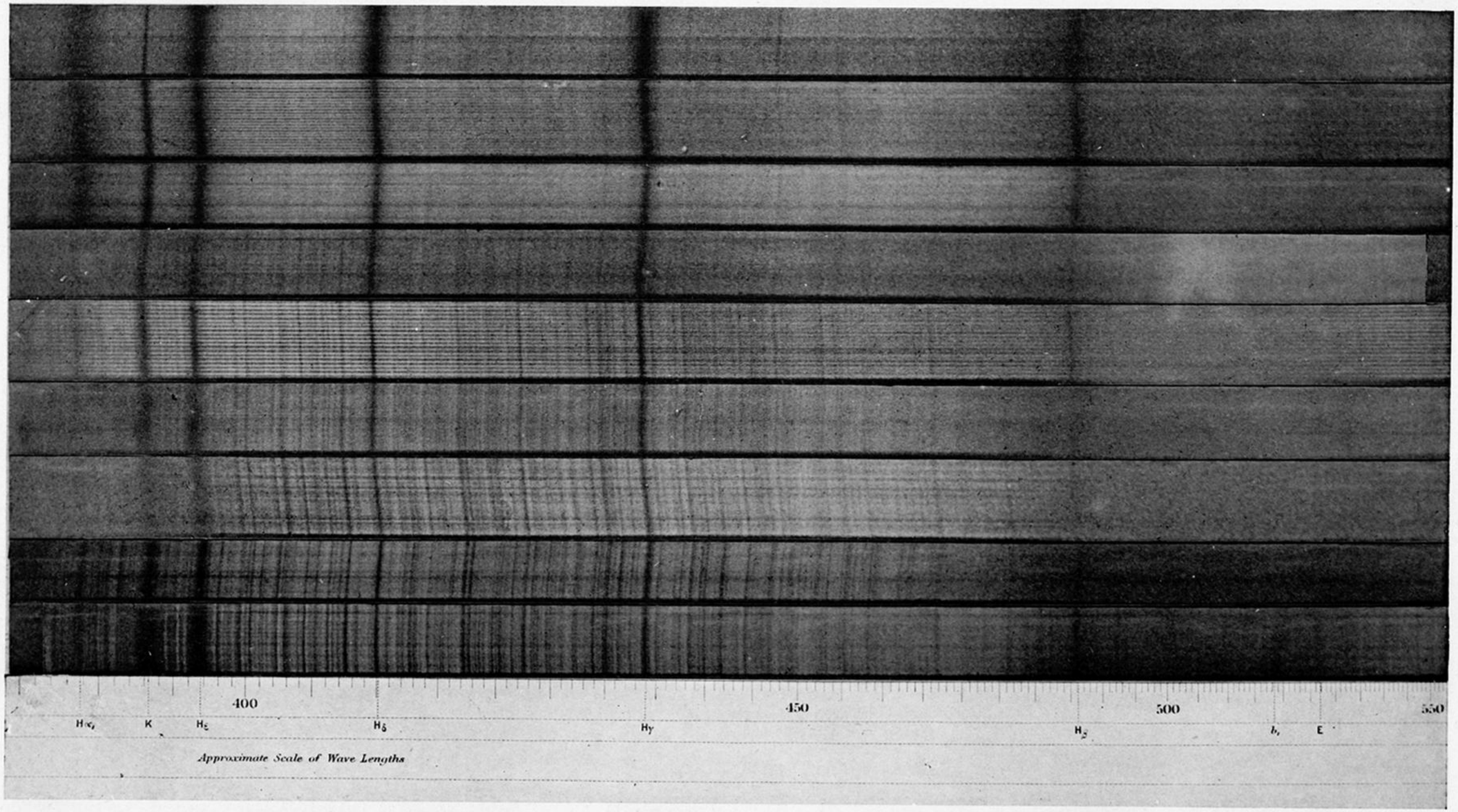
Type I, Div. II.	7	ζ Aquilæ	Mag. 3.1
	8	θ Aurigæ	3.0
	9	β ,,	1.9
	10	γ Geminorum	2.1
	11	α Lyræ (+0.9) *Vega*	
	12	α Geminorum *Castor*	1.5
Compn.		α Canis Maj. (+1.9) *Sirius*	
	13	α Cygni	1.3

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC ZONE, N.

B



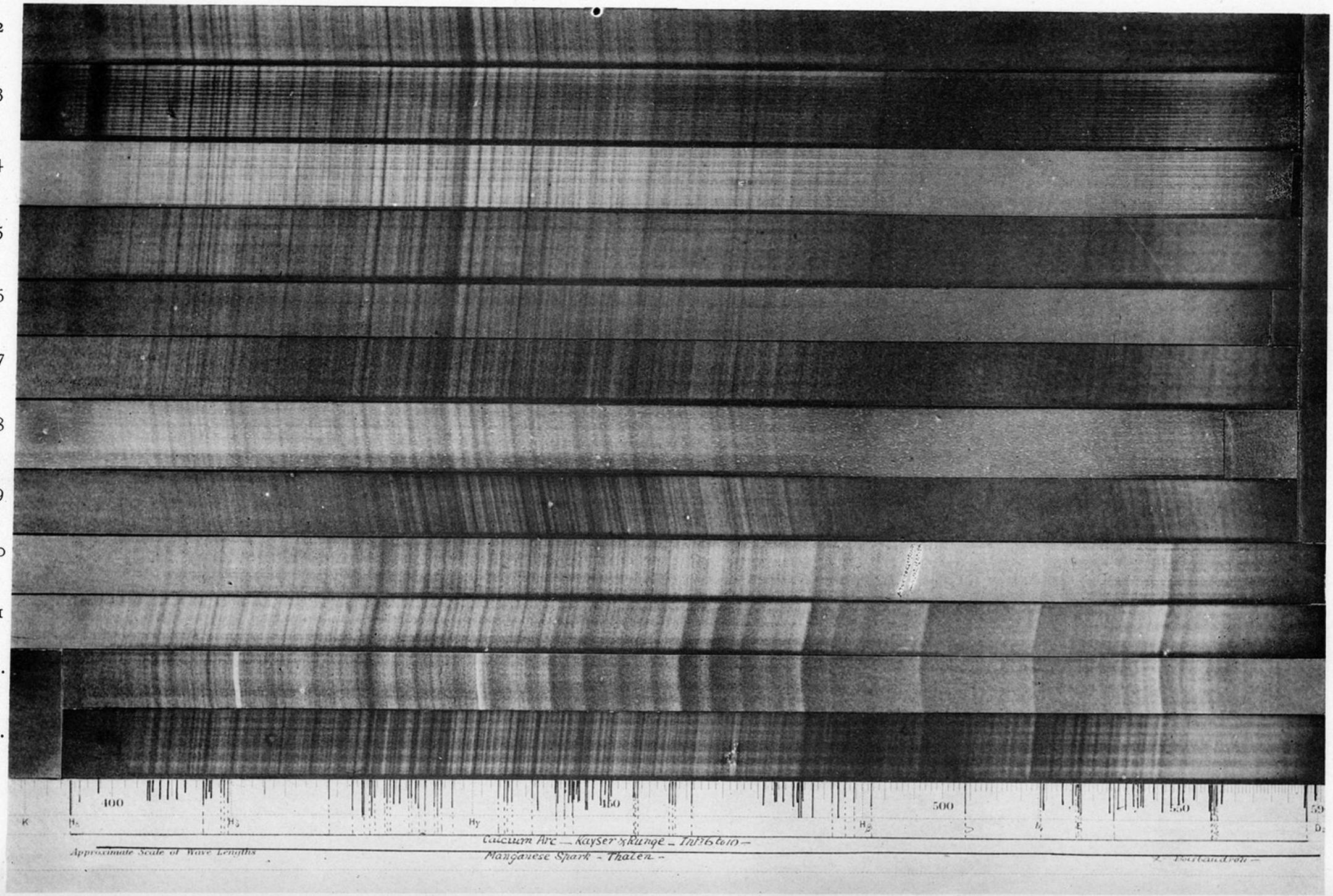
		Mag.
	α Geminorum *Castor*	1.5
	α Ophiuchi	2.2
	α Cephei	2.6
	δ Geminorum	3.5
	α Canis Minoris *Procyon* (+0.5)	
	δ Cephei	3.7 4.9 Var.
	α Ursæ Minoris *Polaris*	2.0
	ϵ Aurigæ	3.0 4.5 Var.
	γ Cygni	2.3

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC ZONE, N.

B



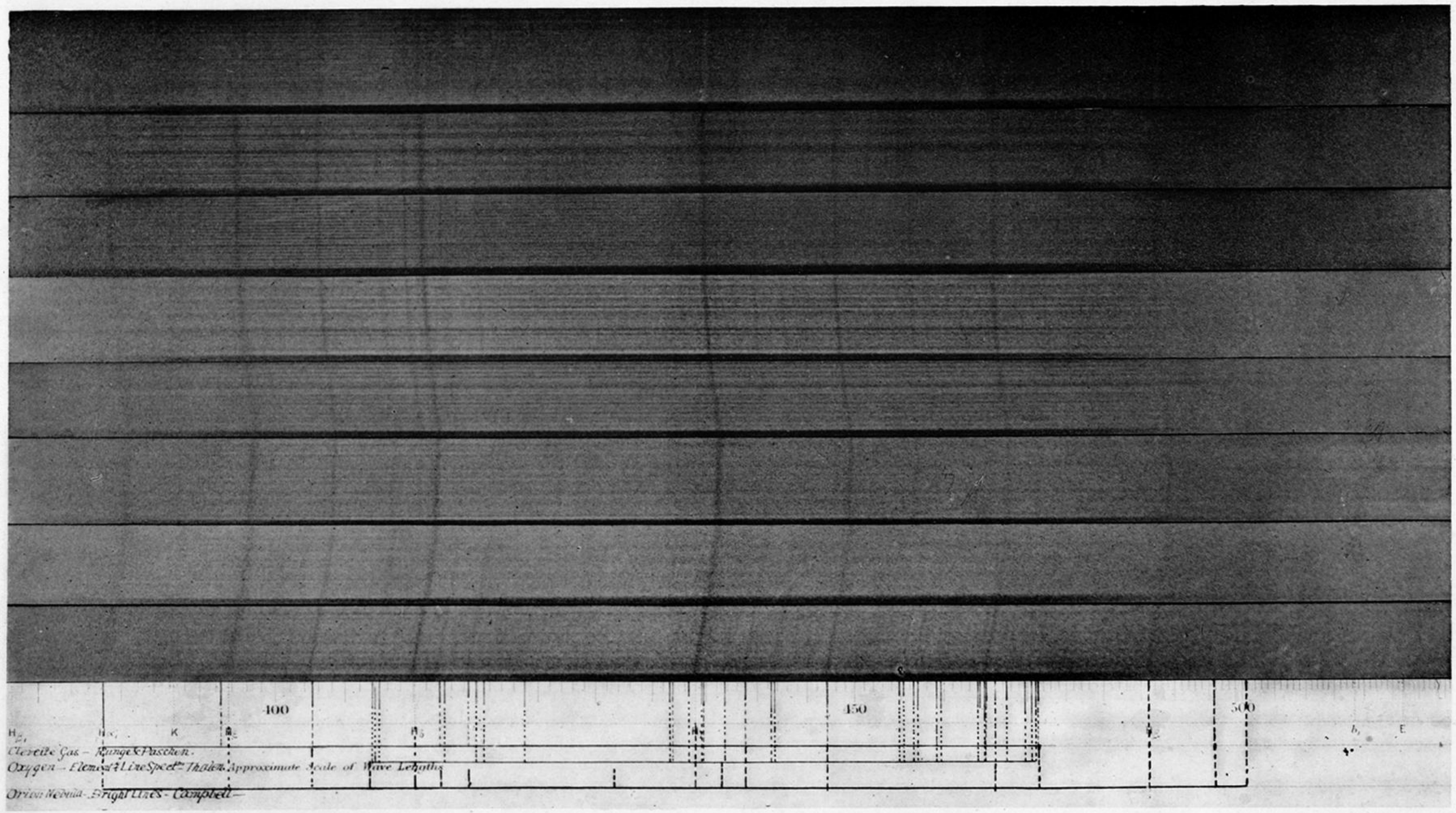
Type II. Div. IV.	22	μ Herculis Mag.3.5	
	23	α Aurigæ (+0.9) *Capella.*	
	24	β Geminorum 1.4 *Pollux*	
	25	γ Cephei 3.5	
	26	δ Draconis 3.0	
	27	ϵ Geminorum 3.3	
	28	β Cygni 3.0	
	29	γ Draconis 2.4	
Type III. Div. V.	30	μ Geminorum 3.4	
	31	α Herculis 3.0 / 3.9 Var.	
	Comp.	o Ceti 3.3 / 8.7 Var. *Mira*	
	Comp.	α Orionis 1.0 / 1.4 Var. *Betelgeuze*	

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3 5.

LOWER GALACTIC ZONE, N.

C



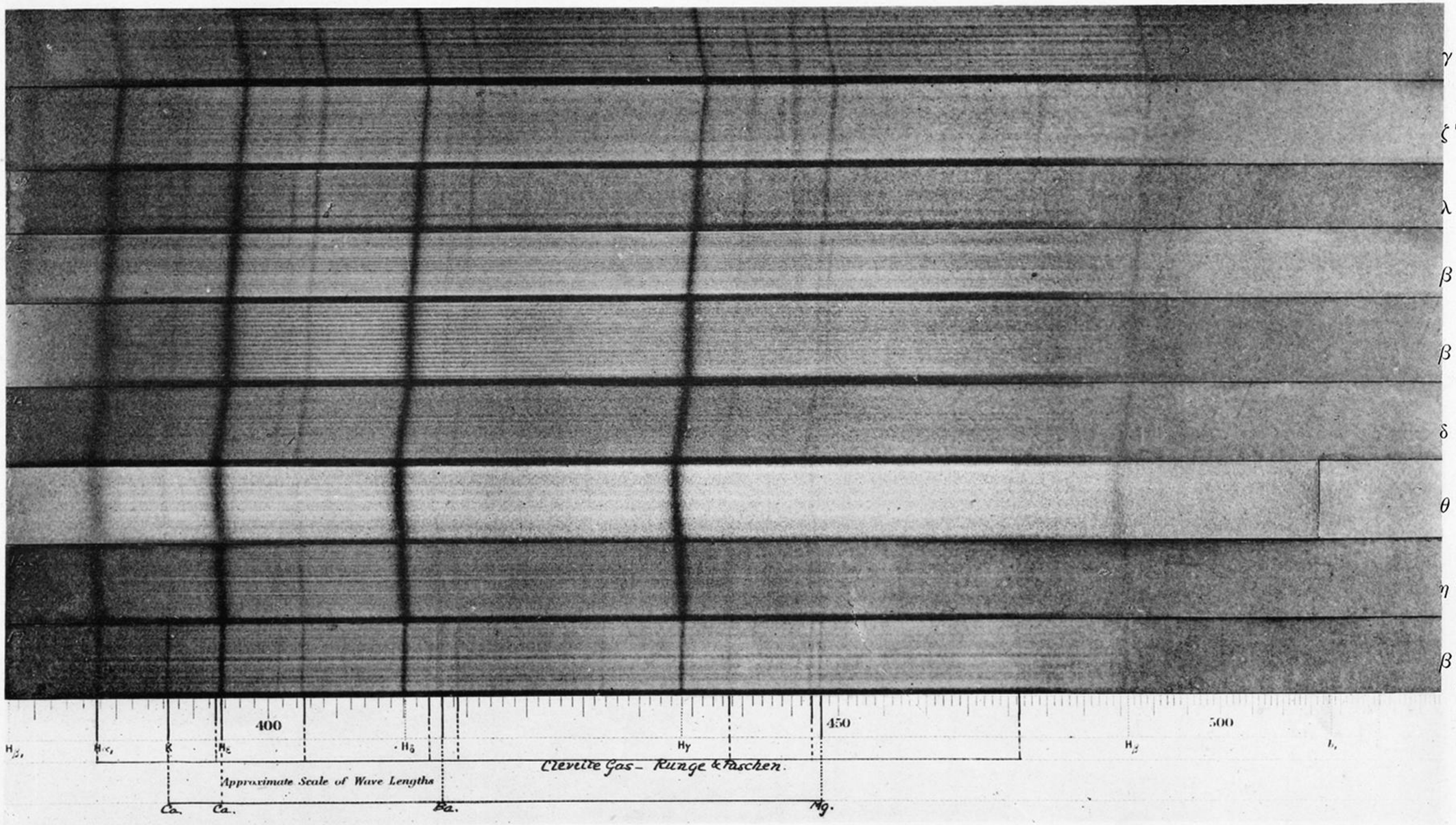
			Mag.
Type I, Div. I. (a)	1	γ Cassiopeiæ	2.2
	2	δ Orionis	2.2 / 2.7 Var
	3	ε ,,	1.8
	4	κ ,,	2.4
	5	ζ ,,	1.8
	6	ι ,,	3.2
	7	ε Persei	3.1
	8	ζ ,,	3.1

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

LOWER GALACTIC ZONE N.

C



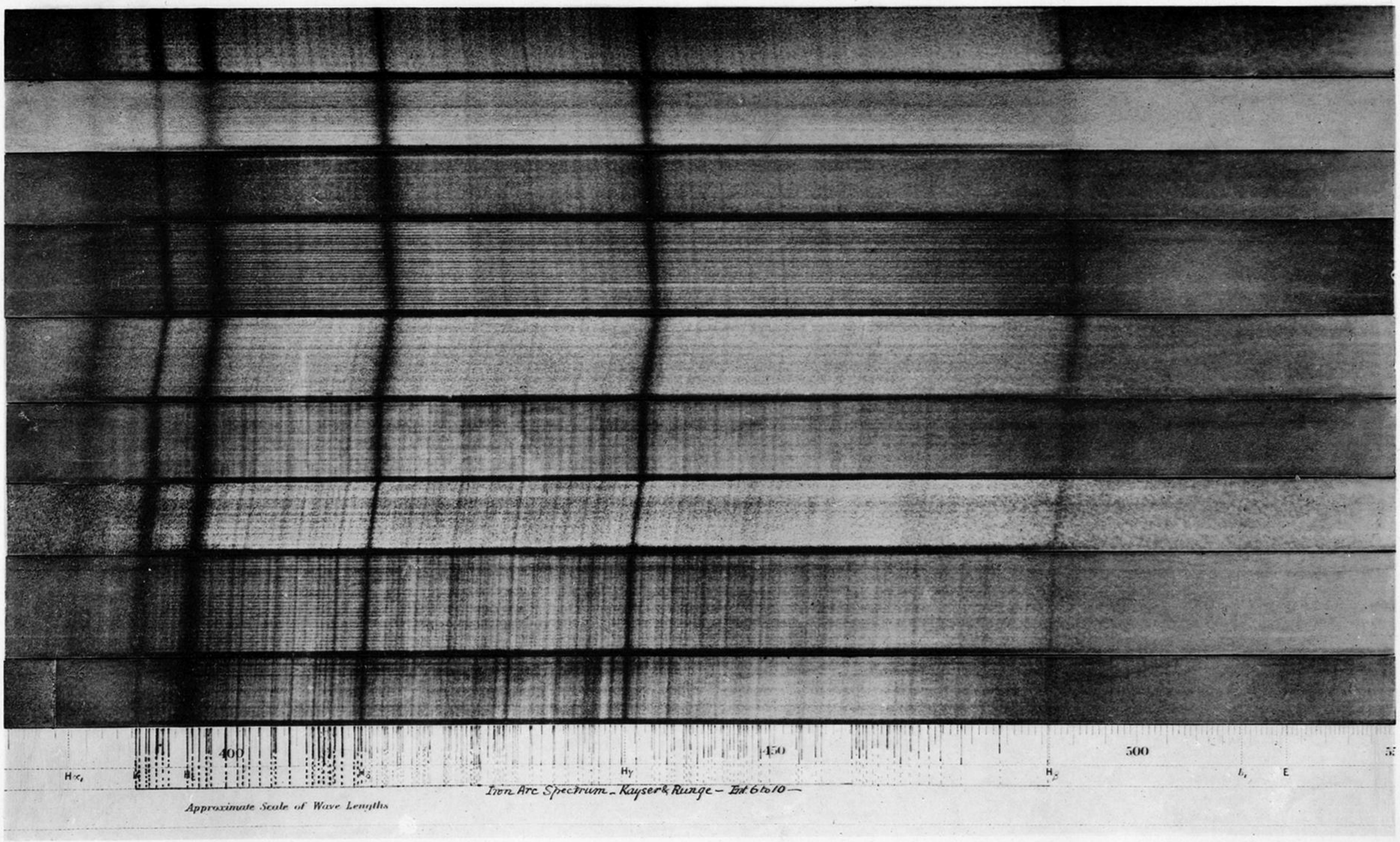
Type I, Div. 1. (3)	9	γ Orionis *Beliatrix.*	Mag. 1.8	
	10	ζ Tauri	3.0	
	11	λ ,,	3.4 4.2	Var.
	12	β ,,	1.8	
	13	β Persei *Algol.*	2.3 3.5	Var.
	14	δ ,,	3.1	
	15	θ Aquilæ	3.3	
	16	η Tauri	3.1	
	17	β Orionis *Rigel.*	+ 1.0	
Type I, Div. II. none				

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

LOWER GALACTIC ZONE, N.

C



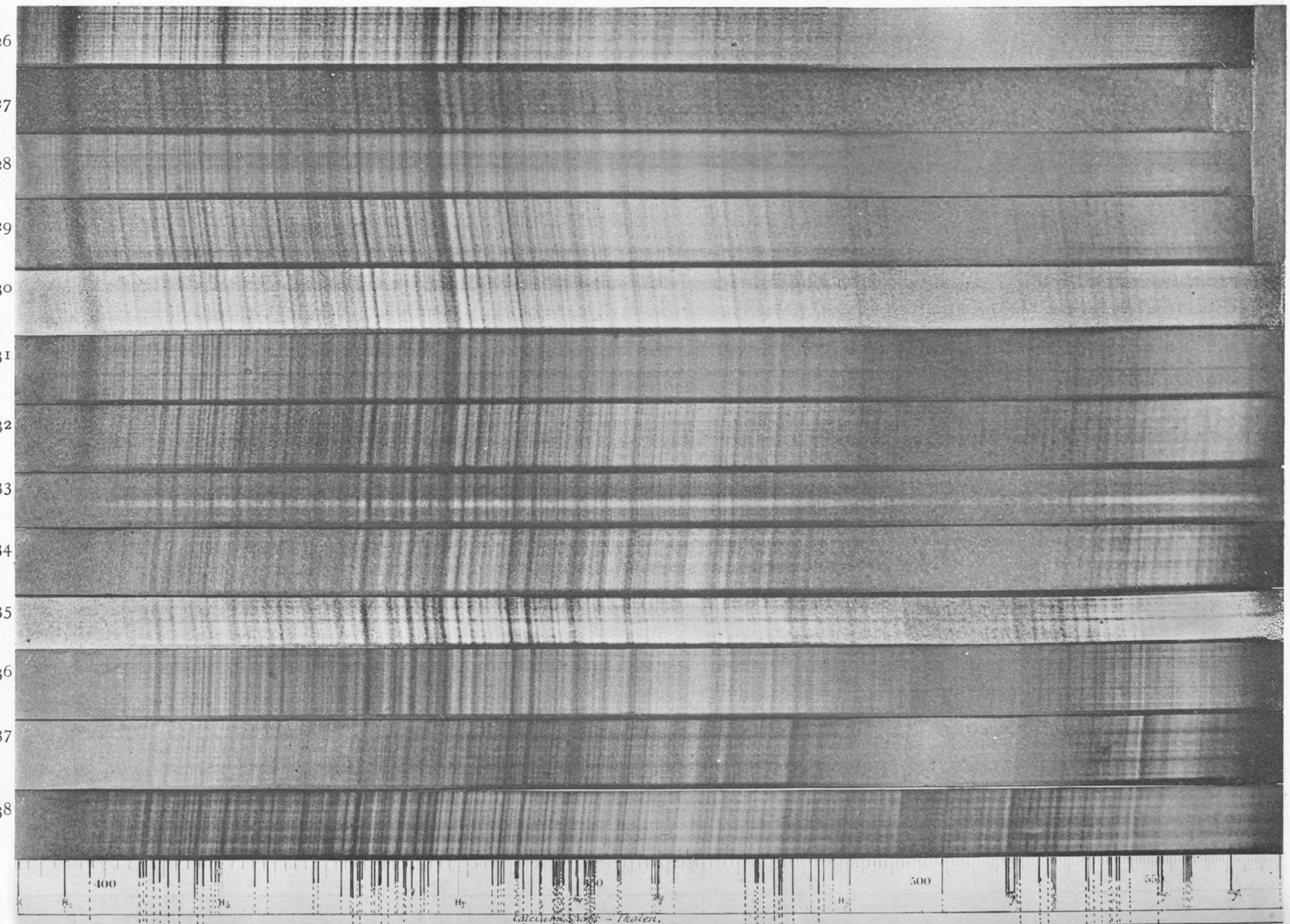
Type I. Div. III.	18	δ Aquilæ	Mag. 3.4
	19	β Eridani	2.8
	20	β Trianguli	3.1
	21	α Aquilæ *Altair*	1.0
	22	δ Cassiopeiæ	2.8
	23	β ,,	2.3
	24	β Delphini	3.5
	25	α Persei	1.9
Comp.		γ ,,	3.1

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC ZONE, N.

C



Type II. Div. IV.	26	γ Persei	Mag. 3
	27	β Aquilæ	3
	28	η Pegasi	2
	29	ε Cygni	2
	30	ζ „	3
	31	α Cassiopeiæ	$\frac{2.2}{2.8}$ V
	32	γ Andromedæ	2
	33	γ Aquilæ	2
	34	ι Aurigæ	2
Type III, Div. V.	35	β Andromedæ	2
	36	α Tauri *Aldebaran.*	1
	37	β Pegasi	2
	38	α Orionis	$\frac{1.0}{1.4}$ Va

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

LOWER GALACTIC POLAR REGION, N.

D

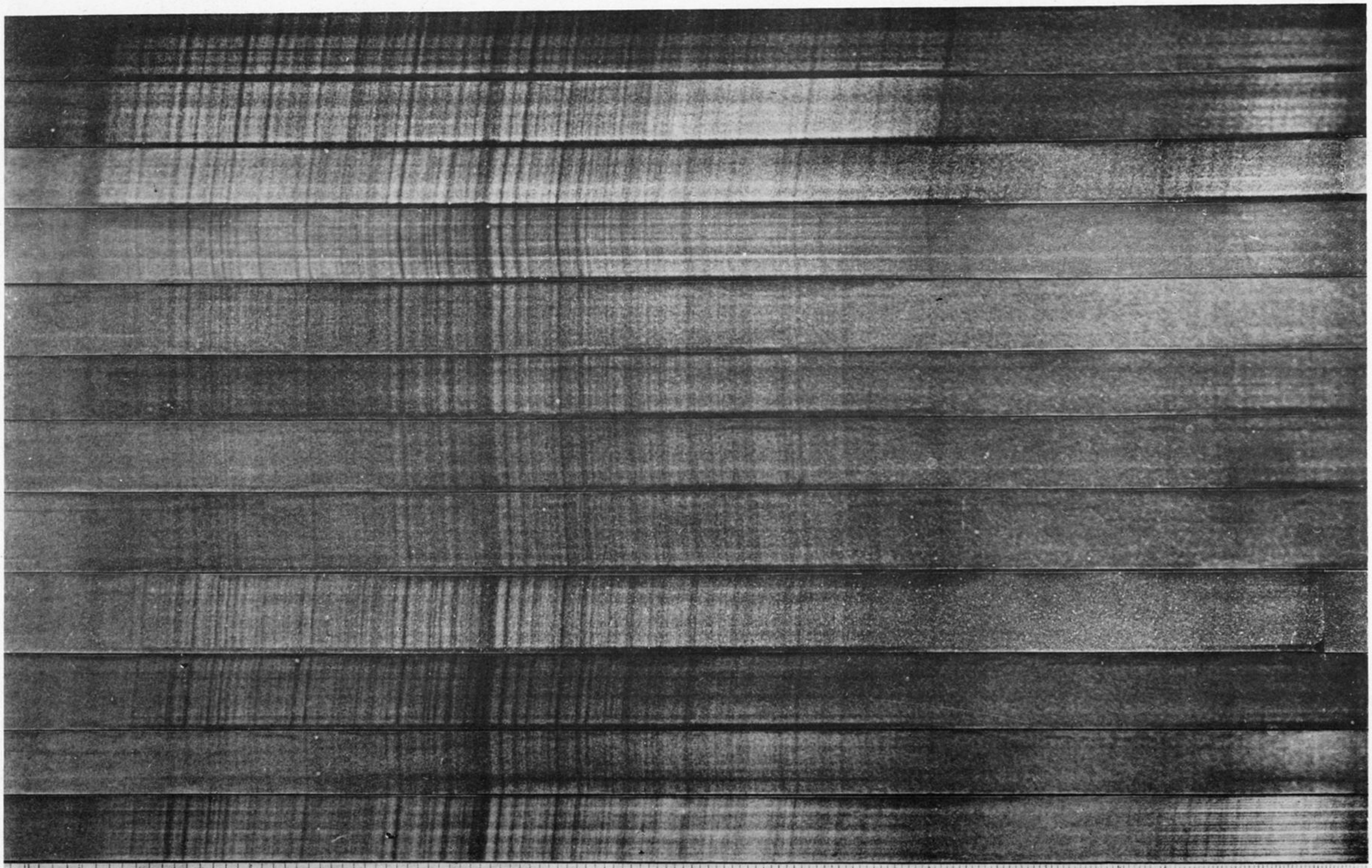
Type I, Div. 1 (b).	1	γ Pegasi	Mag. 2.5
		Algenib	
	2	,,	3.8
	3	α Andromedæ	2.0
Type I, Div. II	4	α Pegasi	Mag. 2.3
		Markab	
	5	θ ,,	3.5
	6	δ Aquarii	3.0
Type I, Div. III.	7	γ Ceti	Mag. 3.4
	8	α Piscium	3.7
	9	β Arietis	2.7
	10	δ Capricorni	3.0

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

LOWER GALACTIC POLAR REGION, N.

D



Approximate Scale of Wave Lengths

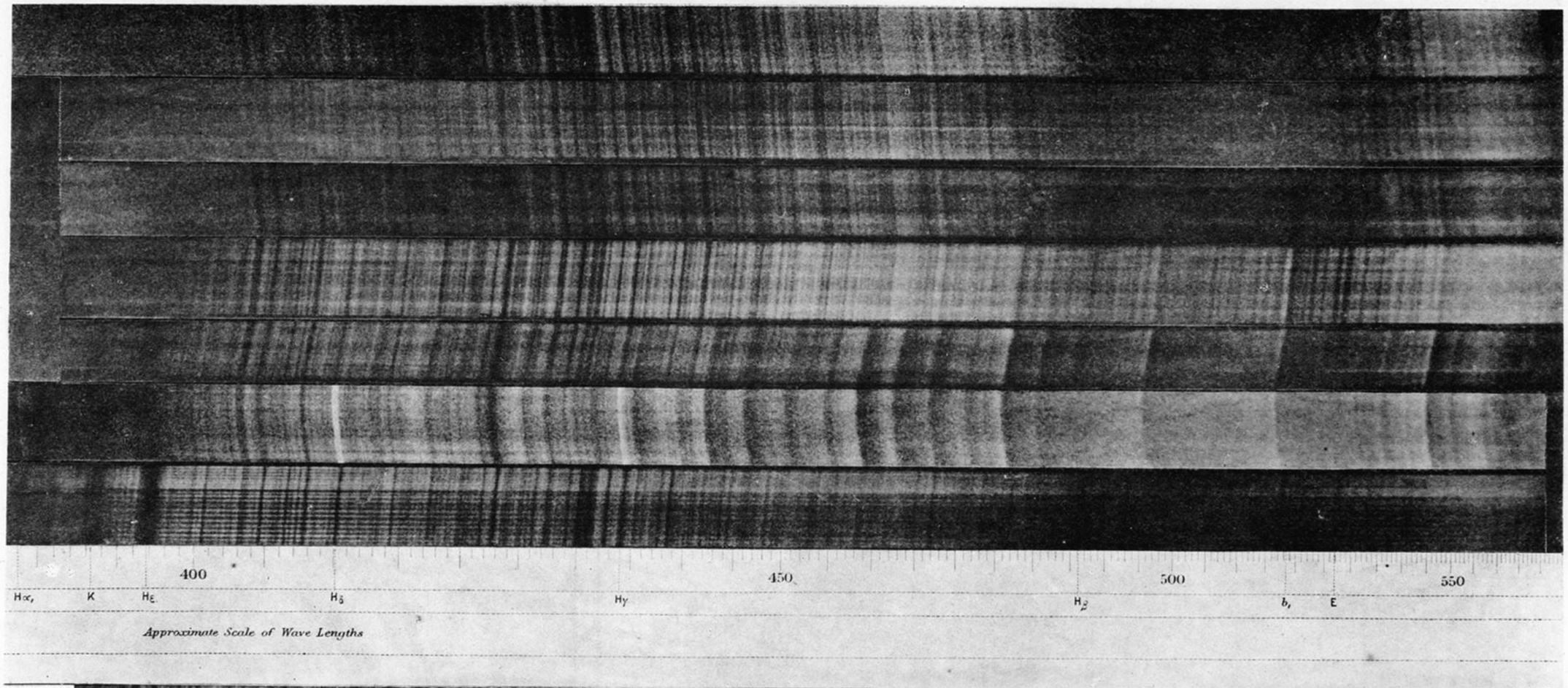
Type II, Div. IV.	11	β Aquarii	Mag. 3.1
	12	α ,,	3.0
	13	β Ceti	2.4
	14	τ ,,	3.1
	15	θ ,,	3.4
	16	δ Andromedæ	3.2
	17	ι Ceti	3.7
	18	ζ ,,	3.5
	19	δ Eridani	3.0
	20	ε ,,	3.4
	21	η Ceti	3.5
	22	α Arietis	2.1

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

LOWER GALACTIC POLAR REGION, N.

D



Type II. Div. IV. 23 *contd.* — ε Pegasi Mag. 2.4

Type III Div. V. 24 — γ Eridani 3.0

25 — α Ceti 2.2

Comp. — α Orionis 1.0 / 1.4 Var.

Comp. — α Herculis 3.0 / 3.9 Var.

26 — ο Ceti 3.3 / 8.7 Var. *Mira.*

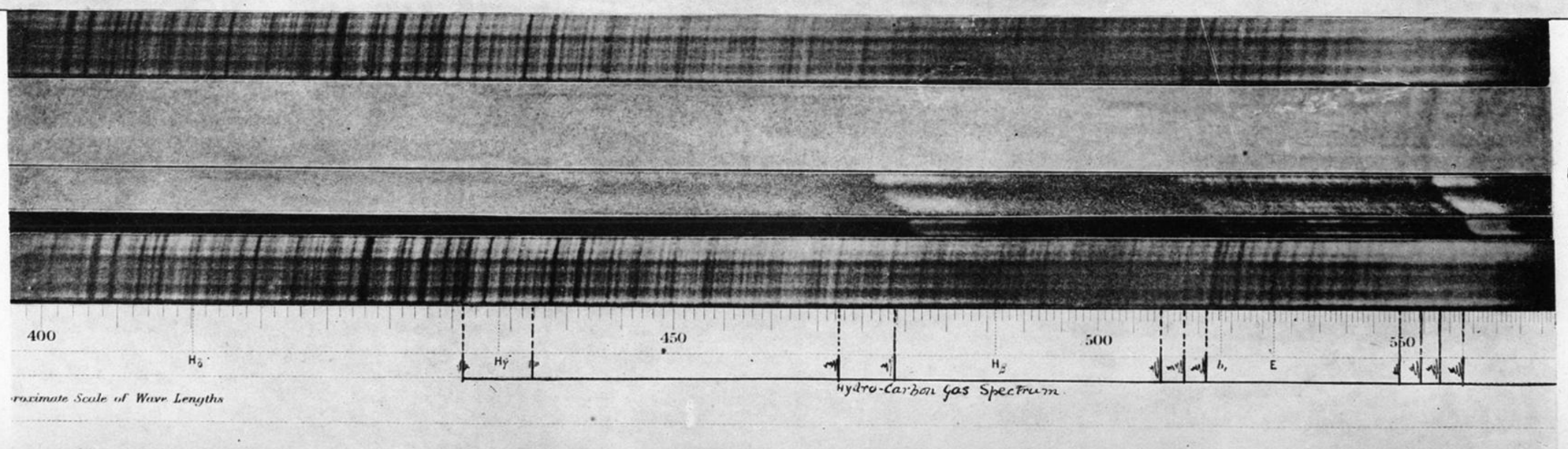
Comp. — α Aurigæ (+0.9) *Capella.*

Comp. — α Tauri.

Type IV. iv. VI. — 19 Piscium Mag. 5½

Superba 5½

Comp. — α Tauri

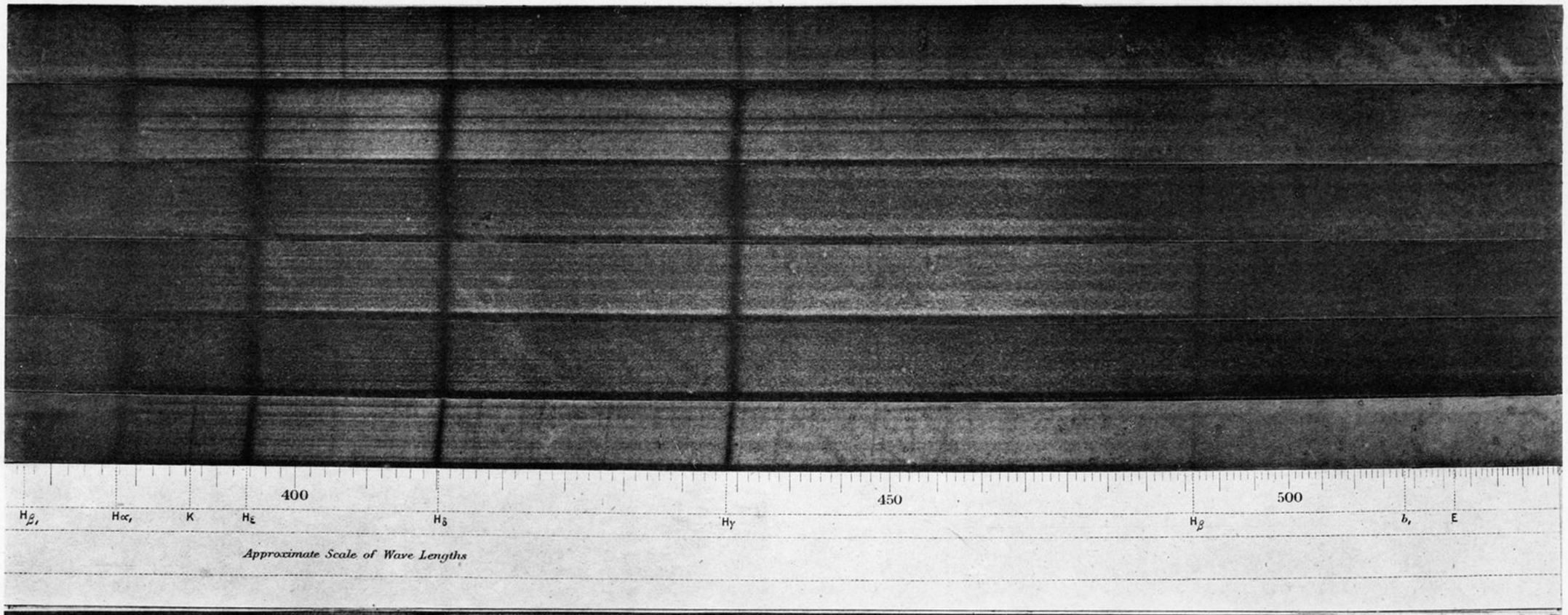


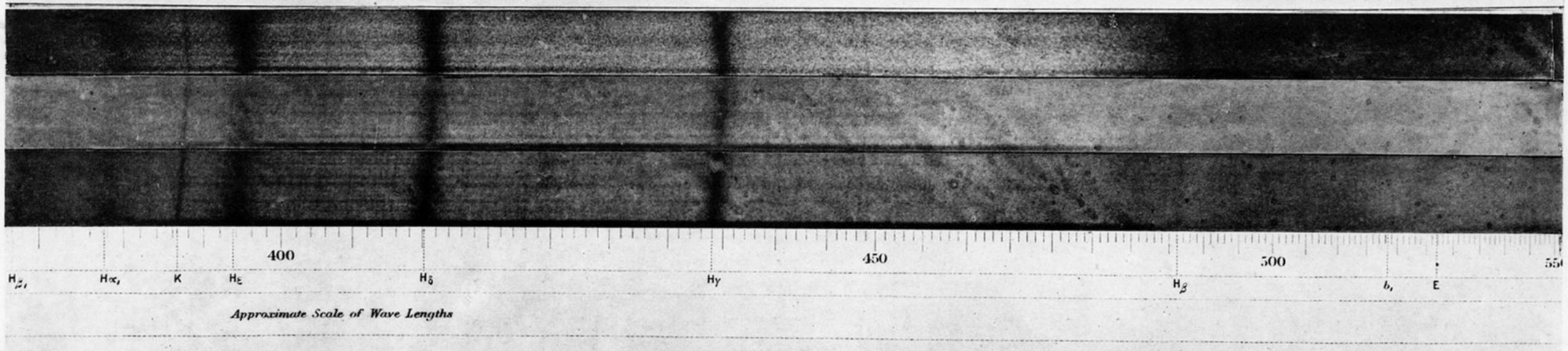
PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC POLAR REGION S.

AA





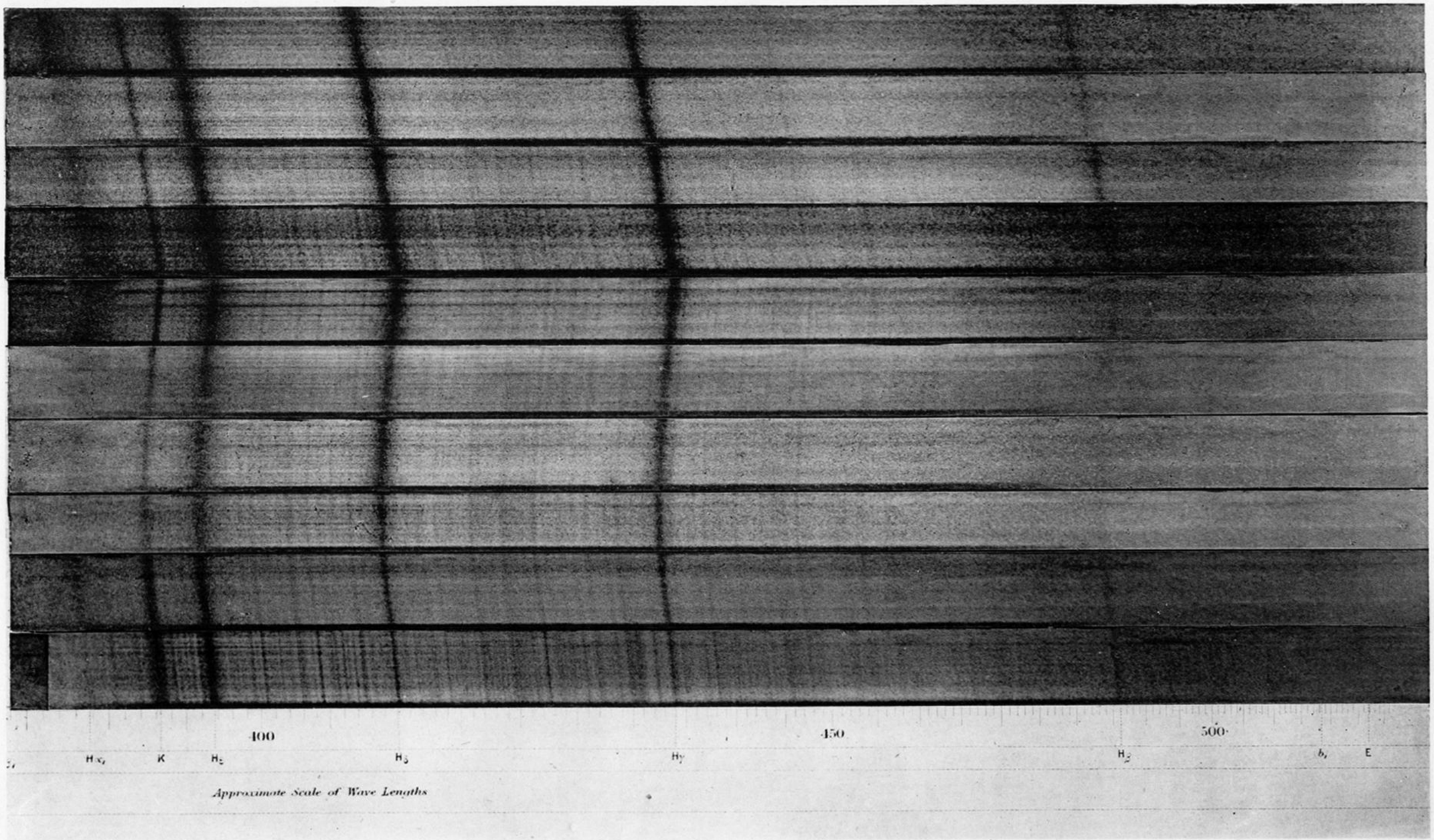
Type I, Div. 1 (b).	1	α Virginis *Spica*	Mag. 1.0
	2	α Leonis	1.2
	3	δ Corvi	3.1
	4	β Libræ	2.7
	5	γ Corvi	2.8
	6	η Leonis	3.5
Type I. Div. II.	7	μ Serpentis	3.3
	8	η Virginis	3.8
	9	θ Leonis	3.4

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC POLAR REGION, S.

AA



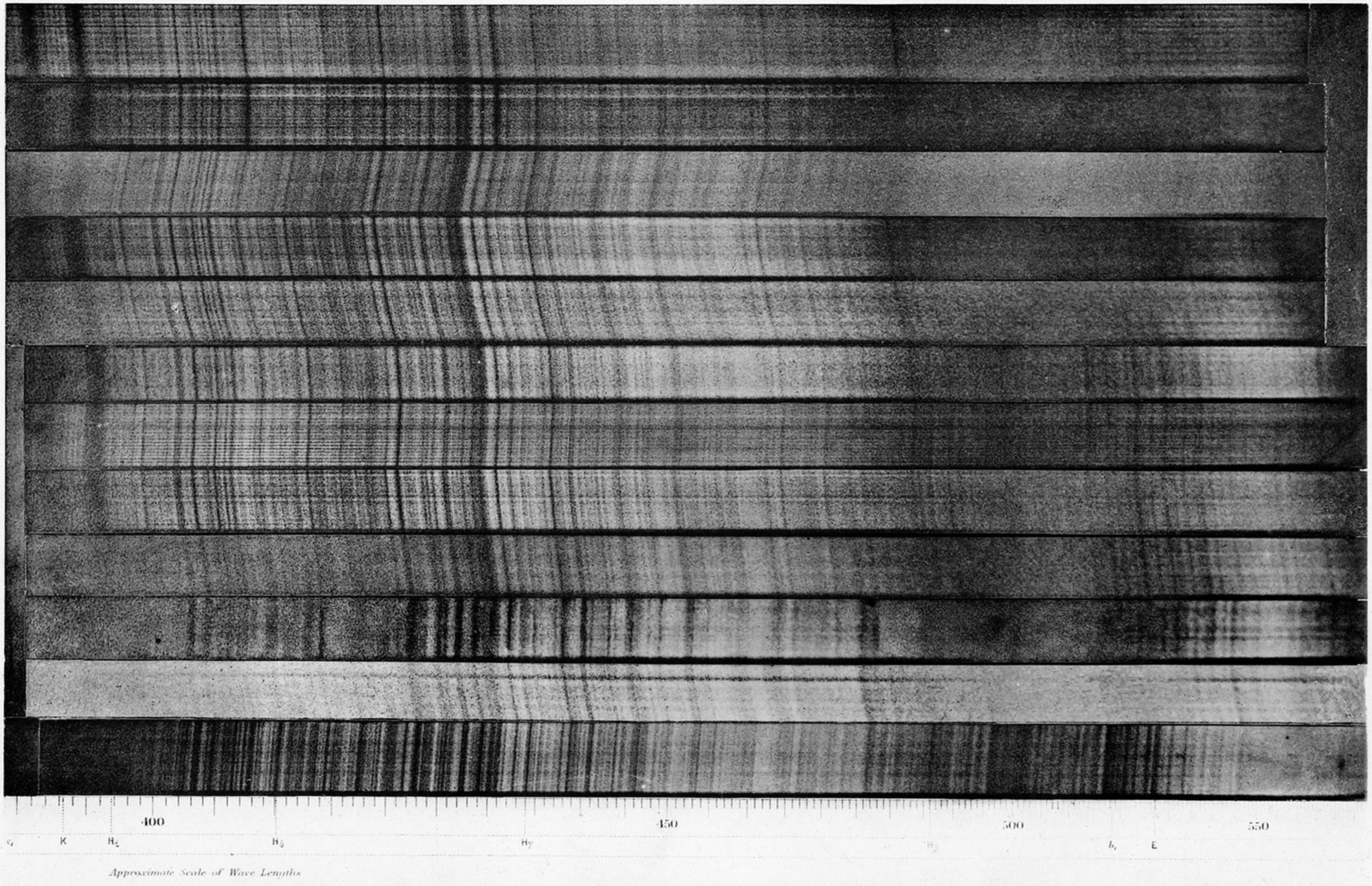
Type I, Div. III.	10	ζ Virginis	Mag. 3.4
	11	β Serpentis	3.5
	12	α Librœ	3.0
	13	ε Serpentis	3.6
	14	β Leonis	2.1
	15	δ ,,	2.5
	16	θ Geminorum	3.6
	17	δ Serpentis	3.8
	18	γ Virginis	2.7
Compn.		η Bootis	2.7

PHOTOGRAPHIC STELLAR SPECTRA.

Stars to Magnitude 3.5.

UPPER GALACTIC POLAR REGION, S.

AA



Type II, Div. IV.	19	η Bootis	Mag. 2.7
	20	β Virginis	3.6
	21	ζ Hydræ	3.4
	22	ϵ Virginis	3.0
	23	ϵ Ophiuchi	3.3
	24	γ Leonis	2.1
	25	α Bootis (+0.7) *Arcturus*	
	26	α Serpentis	2.7
	27	α Hydræ	2.2
Type III, Div. V.	28	δ Opiuchi	2.6
	29	δ Virginis	3.5
Compn.		α Orionis	1.0 1.4 Var