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## The Solar Surface During the Past Twelve Years - A Review of Sun-Spot Observations Made at Alta, Iowa, from 1890 to 1902

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men this supposed growth is really taking place, and at each end the bone for a short distance is imbedded in cartilage.

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THE SOLAR SURFACE DURING THE PAST TWELVE  
YEARS--A REVIEW OF SUN-SPOT OBSERVA-  
TIONS MADE AT ALTA, IOWA, FROM  
1890 TO 1902.

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BY DAVID E. HADDEN.

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The following paper is a resume of a series of sun-spot observations commenced by the writer in 1890, August 1st, and continued without interruption, except by cloudy weather and other unavoidable causes—such as sickness or absence from the city—until the present time.

Embracing, as it does, the most interesting period of a sun-spot cycle—that of a maximum of solar activity, included between two minima—it is hoped that a study of the results may be of interest and value to students, and a contribution to the literature of solar physics.

The principal instrument used was a 3-inch telescope until 1897, February, after which time a 4-inch telescope,

equatorially mounted, by Brashear, was employed, using a Herschelian diagonal eye-piece with various powers, usually one magnifying about 78. The method of projection of the solar image to a diameter of 8 or 10 inches was sometimes used, and the positions of the spots and faculae determined by means of Thomsen's discs; but generally the relative heliographic positions were noted by means of cross wires in the eye-piece, and afterwards reduced by reference to the usual "tables for physical observations of the sun."

A spectroscope with a 2-inch Rowland diffraction grating of 14,438 lines per inch, was employed in viewing the prominences and examining spot spectra.

Daily observations were taken, usually about noon in the autumn and winter months, and in the morning between 7 and 8 o'clock during the warmer seasons, when better definition was secured than during the hotter portion of the day; the visual observations consisted of noting the number of groups of spots—each disturbance of one or more spots being considered as a group—the total number of individual spots in each group, and the number of groups of faculae. The relative positions of each of these were plotted on paper, and a sketch made of the appearance of each group, with more detailed drawings of the greater disturbances; in addition, the condition of the definition was noted with reference to the visibility of the granulation of the solar surface and lastly the time of the observation was inserted. The daily results thus obtained have been published from time to time in various journals, and for reference a list is appended to this paper.

During the period under review, about 1,750 groups have been observed on the visible disc, the greatest number, 285 being registered in the year 1893, and least number, eighteen, in 1901.

As the purpose of this paper is but a review of the recent solar cycle of sun-spots, a detailed account of the observations is not attempted, reference for these being made to daily results as contributed to journals and societies given in the list appended, as before mentioned: hence only the

greater or more important disturbances will be briefly alluded to, in the following descriptions, which are given for each year.

1890, (AUGUST TO DECEMBER).

Some large sun-spots appeared on the disc towards the end of August, which practically marked the beginning of the new cycle of solar activity, and which reached a maximum about three years later; the minimum probably occurred towards the middle of the year 1899, and as is usual in sun-spot periodicity, the interval from a minimum to maximum is much shorter than the decline from maximum to the next following minimum.

Large spots were also present during the months of September, October, November and December, some especially fine spots being present in the third decade of October.

1891.

This year was one of rapid increase in sun-spot activity; there were ten or twelve spotless days in January, a few in February and March, but after that time the disc was not free from spots for a period of about five years.

Several large and fine groups and spots were observed during the year, notably those on February 17-26th, April 21-30th, May 19-25th, June 25-30th, July 10-25th and August 29th to September 10th; this last disturbance was especially interesting, being large and easily visible to the naked eye. Unusual activity was present in the group during its transit, and its ingress on the disc was marked by brilliant auroras which continued for three nights; the return of this disturbed area at the east limb on September 25th was again attended by brilliant auroras for several evenings.

Another large disturbance made the transit from November 15th to 27th, and is of interest as marking the beginning of the giant outburst of 1892, February.

1892.

The year 1892, like that of 1891, was one of great increase and activity in all solar disturbances. It would be almost impossible to give a detailed account of the many groups of interest which appeared during the year in a paper of this kind, without the use of drawings or photographs to illustrate the appearance of the intricate markings in the large groups. Among the numerous outbursts, however, those of February 5-18th, May 23d-31st, June 18-28th, July 3d-15th, July 24th to August 7th, August 13-25th, September 7-18th, and October 29th to November 6th, were especially fine. The great spot of February was probably the largest visible on the sun's disc in many decades, and was the largest ever photographed on the sun; its length exceeded 100,000 miles and the area 2,000,000,000 square miles.

Several beautiful groups were present in June, accompanied by great activity and numerous spots, exceeding 100 on some days. July and August were rich in magnificent groups, some containing enormous umbrae in large and complicated penumbrae of various forms; these remarkable disturbances were accompanied by some incomparably brilliant manifestations of terrestrial electricity in the form of Aurora Borealis. The solar surface during these months was dotted with eight to thirteen large groups of spots daily.

1893.

All solar phenomena continued to increase during this year; the average daily number of groups and spots combined, reached a maximum during the month of August, after which a marked decline set in, with, however, several fluctuations for a couple of years later. August then marked the apex of the sun-spot cycle extending from 1889.6 to 1901.5, the length of the period from minimum to maximum being about 4.1 years, and from maximum to minimum, 7.8 years.

During the year 1893 very many magnificent groups were present on the sun; especial mention of the group of February 5th to 18th in south latitude is noted as being very intricate with numerous nuclei and interlacing penumbra; several fine auroras were also visible during this period.

The next large group made the transit from March 17th to 30th, and developed into a fine train of spots. Two large and active groups were in south latitude from April 27th to May 14th, one containing curiously shaped umbrae and penumbrae, with many luminous "bridges" crossing the umbrae. The other group was still more active and interesting, undergoing continuous changes from day to day—small spots increasing to large nuclear spots, then forming a train, afterwards a stream, finally becoming single spots again. A large quadruple cluster of spots was visible in June, a fine train of large spots in July, and the disc continued to be spotted with many beautiful groups and trains,—unusual displays of the Northern lights were coincident with these. August was especially rich in fine groups, which were easily visible to the naked eye. A remarkable group appeared at the east limb on the 2d, which by the following day had developed unusual activity and increased enormously with auroral manifestations in the evening; two days later the group still consisted of two huge spots with scorpion-like nucleus in one spot, and was a superb object; aurora continued for several evenings. On the 8th fully 100 spots in fourteen groups dotted the sunspot zones and the climax of the sunspot curve was full of groups of tremendous magnitude, with immense areas of penumbrae, enclosing umbrae of all forms—helical, wing-shaped, triangular, and fimbriated, cruciform, pitcher-shaped, tassel-like, eel-shaped, etc.

Many other interesting groups continued till November and December, when large composite groups were present, fully rivaling in extent, the giant disturbance of February, 1892.

1894.

Like the preceding year, the one now under review was also noted for the persistence of large and very interesting sun-spot groups. Every month of the year witnessed some "greater sun-spot disturbance," thus while the crest of the sunspot curve was undoubtedly passed in the late summer of 1893, the decline was marked at first and then became more gradual with a slight revival until midsummer of 1894, after which time a more pronounced and steady decline set in, until the minimum epoch.

In January a large group visible to the naked eye was present. During February a spot 48,000 miles in length was an interesting object; its umbra, on the 19th, when examined by means of the spectroscope, was the location of brilliant reversals of the Ha line, and when the slit of the instrument was widely opened the reversal presented a flame or tree-like appearance. On the 25th bright reversals took place in the penumbra of the same spot.

Large double spots, with variously formed nuclei were transiting the disc during the first week in April; and in May and June splendid groups of wonderfully complicated and intricate markings were of fascinating interest.

On June 7th a remarkable eruptive prominence was observed with the spectroscope, consisting of "spikes" and "flames," which was in violent commotion; its height was estimated to be 70,000 miles; ten minutes later the entire disturbance had nearly subsided, the shifting of the Ha line towards the blue end of the spectrum indicated a rapid approach in a direction towards the earth; later the region of the photosphere further in, on the disc was violently agitated, the Ha line appeared with blow-pipe looking jets directed towards the red end of the spectrum. Single and composite groups of great size and beauty were noted in August, September, October and December, with much spectroscopic disturbance and strong reversals of Hydrogen lines in the large group of October 6th.

1895.

The steady decline in numbers of solar groups and spots mentioned as having set in during the latter half of 1894, continued during this year, but with some rather sharp fluctuations. During the year several striking disturbances were noted. A train of spots in the southern hemisphere, on January 28th, was the location of considerable spectroscopic disturbance, the Ha line being reversed and distorted in numerous portions of the group. March was noted for a fine group which made the transit from 16th to 26th, about  $10^{\circ}$  south of the equator.

Some large spots were present during April, a fine normal one on the 28th, near the west limb, contained a dense black hole or nucleus in the umbra. Some beautiful and active disturbances were witnessed in the month of June; on the 6th an active protuberance was seen near the new group on the east limb, and the region surrounding the spots near by was spectroscopically active.

On the 16th, much disturbance in and around a large group in north latitude, consisting of reversals and distortions of the Hydrogen lines directed towards the red end of the spectrum, was observed.

Several large spots were observed during the first half of August, one large spot persisting during four solar rotations; its umbra was quite interesting from day to day, at times being single, double, round, irregular and curved.

Other large groups were seen during the closing days of September, the fore part of October, and again during the third decade of the same month; also from November 1st to 9th and latter part of December.

1896.

Notwithstanding the fact that the present year is the third following the maximum, the solar surface contained some unusually large groups during the year. It is worthy of note that the descending curve of solar activity is frequently marked by sudden and enormous outbursts of the solar gases or other forms of energy which give rise to the



formation and appearance of a sunspot. One cannot study the solar surface markings day after day for years, without coming to the conclusion that the mechanism of a sunspot is analogous to our terrestrial cyclones and other storms, the stupendous forces far below the visible photosphere manifesting the violence of their eruptions by the extent, area, color and form of umbra and penumbra, and various other phenomena, including that of terrestrial magnetic and atmospherical electrical effects.

The decline in total number of groups and spots was quite marked during the year under review; several days without spots were noted in April, August and October.

A fine group consisting of from three to five centers of activity was observed from 18th to 29th of February, in north latitude.

An interesting feature of May was the development from a few dots to a group of considerable size on the visible disc from the 26th to 3d of June.

A great spot which underwent many changes passed across the disc from July 12th to 24th; on the 20th its area was nearly 400,000,000 square miles. September brought the most remarkable group of the year—a stream of spots extending over  $26^{\circ}$  of solar longitude, or about 190,000 miles—first observed as irregular spots near the east limb, on the 10th, and rapidly increased by the next day with many nuclei; the groups increased daily until the 20th, when the greatest elongation occurred; by the 22d it was passing out of view round the west limb, and must have rapidly declined on the invisible disc of the sun, as its return during the following month was marked by only a normal spot.

A brilliant solar protuberance was witnessed on October 23d, at the east limb, position angle  $110^{\circ}$ , almost directly over a large spot which was coming into view; it was in violent agitation, but was of short duration, as the disturbance entirely subsided in about an hour. My detailed account of the phenomenon was published in *Popular Astronomy* for December, 1896. Two days later a large

feather-like prominence was on the west limb; its height was fully 90,000 miles.

1897.

Like the preceding year, the one now being reviewed was remarkable for several highly interesting groups, especially those of January, May, August, September and December, which appearing about midway between the maximum and minimum of the sun-spot curve, furnished new material for speculation as to the nature of sun-spot phenomena. The gradual decline in the total number of groups and spots continued during the present year, with a decided increase in the number of spotless days. The year began with a magnificent group on the disc, from January 3d to 15th, which reached a length of about 120,000 miles, and a breadth of about 47,000 miles, and enclosing a area of nearly 2,800,000,000 square miles; this enormous group was in a very active state during its entire appearance, and its umbra was noted as having various tints of color from 7th to 11th, being reddish-brown, shading into gray and green, and finally a uniform black. A considerable group was present early in May, and another one during the closing days of the same month.

No spots were visible during several days of May and June—forerunners of the minimum yet three years away. During August a fine spot, the largest since January, made the entire transit across the disc. On September 2d a group of small spots appeared at the east limb by solar rotation, in south latitude  $12^{\circ}$ – $15^{\circ}$  which, by the following day, became very active with spots increasing, and the hydrogen lines in their spectra reversed and distorted in numerous portions of the group, activity continued every day thereafter until its disappearance, with constantly changing umbra and outlines; strong cyclonic motion was apparent in the penumbra and projecting umbral filaments on the 6th, the motion being counter-clockwise; during the following day the group was breaking up, with shattered umbra, crossed by “bridges.” The year closed with

a large group of much activity, which passed over to the invisible side of the sun on December 19th.

1898.

During the present year fully two-thirds of all the sun-spots observed were small; the number of spotless days slightly increased, and the average number of groups and spots remained fairly steady compared with the preceding year.

The year under review was also remarkable for the appearance of several fine outbursts which occurred in the months of February, March, September, October and November. The group of February 9th to 20th was at first but a few small spots at the east limb, but which in a few days rapidly increased, becoming a very fine train, fully 130,000 miles in length, on the 14th, but much diminished before reaching the west limb.

Another considerable stream appeared from March 5th to 17th, with dimensions fully as large as the February group, and showing much activity on the 10th.

By far the greatest and finest group of the year appeared in the month of September, from 2d to 15th; this group probably originated about August 11th, as a cluster of tiny spots, and finally disappeared on November 7th, hence completing four rotations to the central meridian. Appearing at a period of fast approaching minimum, this group was remarkable for its enormous size and associated spectroscopic and magnetic and electrical manifestations. The following account of it is transcribed from my observing note book: "When I first observed it, but a mere line of light separated it from the edge of the east limb, no penumbra being visible, except on the north and south edges of the long umbral line; a bright aurora was coincident with its ingress the same evening. On the following day penumbra was visible on all sides of the umbra and the spot promised to be interesting, the changes from day to day being quite marked. Owing to unsatisfactory atmospheric conditions, the spectroscope could not be used until the 6th, when but little or no disturbance could be noticed in the

vicinity of the spot. On the 7th, however, a sudden outburst occurred; when the spectroscope was adjusted at 11:40 A. M., the entire region just preceding and for some distance following, and also north and south of the spot was greatly agitated, the Ha line being reversed and distorted. small dark jets projecting from either side of the line were noted in several places, and upon opening the slit slightly, the flame and spike-like form of the disturbance could be clearly seen, extending from the umbra to the edge of the penumbra on the east edge; this phenomenon was particularly striking--the intensely bright scarlet flame nearly in the center of the dark absorption band of the spot spectrum being very interesting, the D3 line of Helium was bright, and D1 and D2 and numerous other lines widened. At 12:05 P. M. a small dark line, attached to the Ha line, extended obliquely towards the red end of the spectrum in the region just preceding the chief spot.

Observations were interrupted at 12:10 P. M. and could not be resumed again until 1:40 P. M., but the entire disturbance had then almost ceased, only a few slight reversals being noted."

The maximum length of the group was about 140,000 miles and the dimensions of the chief spot about 50,000 miles in diameter. This group returned by solar rotation again in the closing days of September, and disappeared after its third rotation at the west limb on October 12th, surrounded by extensive and brilliant faculæ.

1899.

All solar phenomena declined rapidly during this year, the average number of groups, spots and faculæ being over 50 per cent less than in the preceding year. The total number of days without spots amounted to 108 out of a possible 259 days of observation, or nearly 42 per cent, compared with 13 per cent for the year 1898.

Spotless days occurred every month of the year, the number being greatest in the month of August. The

northern hemisphere of the sun was the least disturbed, being nearly one-fourth less than the southern.

While the sun was now rapidly approaching the period of solar activity when the spots are smaller, fewer and more transitory; still a few interesting groups were observed this year. On March 15th and 26th fairly large spots entered the disc and made the transit; the latter one was unique in that the major axis of its umbra seemed to have a cyclonic motion, which nearly completed a revolution around its common center.

The next important spot, and, in fact, the largest of the year, entered at the east limb on June 23d—an oval spot, with “bridged” umbra and much spectroscopic activity on the 26th; the spot was increasing on the 27th, its umbra being a deep purple color, and having near its center an intensely black “hole” or nucleus; it still increased with branching umbra and penumbra, and later was breaking up, not to reappear at a subsequent rotation. A somewhat large normal spot passed across the disc during the first half of July, after which date a period of prolonged quiescence set in, lasting during the rest of the year, with occasional small transitory spots in September and October.

### 1900.

The average number of groups, spots and faculæ continued to diminish during the present year, and the total number of spotless days increased to 134 or 52½ per cent of the number of days of observation.

Periods of absolute tranquility occurred in every month of the year.

The principal spots observed were in March, April, May and October. The March group appeared suddenly, and during several rotations the region was active; the disturbance finally disappeared during the first week in May. The telescope was dismantled and shipped to Wadesboro, North Carolina, shortly after May 16th, where the writer successively observed the total eclipse of the sun on May 28th. Observations were not again resumed regularly until June 3d. Mainly small and sporadic spots were noted during

the balance of the year, except a large-sized group which later formed a stream of small spots in October. The closing two months of 1900 were absolutely quiet.

### 1901.

The year now under review marks the end of the eleven year cycle of solar activity, the minimum having in all probability been reached by the middle of the year.

In August some few short-lived spots broke out in high southern latitude, which would indicate that the new cycle had commenced, as it is now fully demonstrated that spots of a new curve of activity first appear in high latitudes and gradually approach the equator as the period progresses, until as the minimum is reached again, the evidences of the dying cycle are found in zones within the equatorial regions.

During the year 1901 there were 212 spotless days out of a total of 269 days of observation, or nearly seventy-nine per cent.

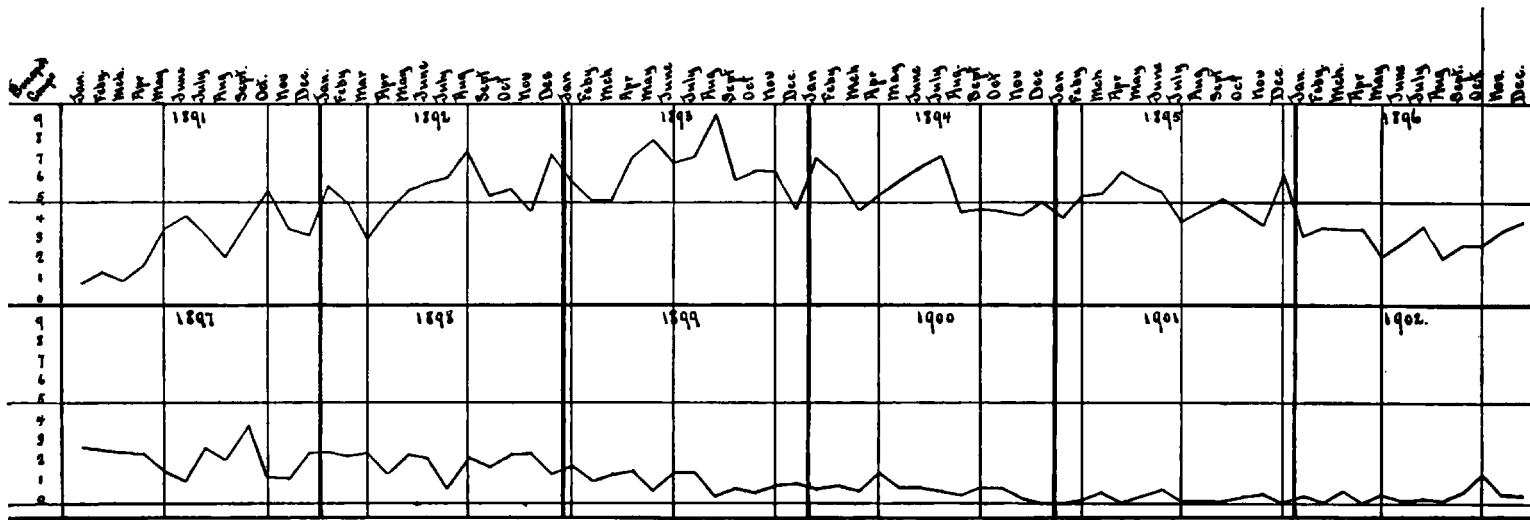
The most noticeable characteristic of the year's record was the sudden outburst of a large spot in May, which was easily visible to the naked eye; its low latitude indicated that it belonged to the expiring cycle rather than to the incoming period. Coming at a period of absolute quiescence, it was certainly a surprise to observers of solar phenomena. It was the final outburst of the pent-up forces which brought the minimum to an end.

### 1902.

During the first half of January an average sized group crossed the visible disc near the equator; this was followed by a period of perfect quiescence—an entire absence of spots and faculae—lasting until March 1st, when a fairly large group in high north latitude, belonging to the new cycle, completed the transit. Another period of prolonged tranquility followed, which lasted until May 23d, on which date a normal spot appeared, which in all probability was a return of the March group, but which was not visible in

IOWA ACADEMY OF SCIENCES.

Plate XXIII.



the interum rotations; but in its place, on March 30th, a bright faculae at the east limb was coincident with an unusual manifestation of the aurora—a full account of which I contributed to *Popular Astronomy* for May, 1902, extracts of which are given here. “About 9 o'clock in the evening of March 29th, 1902, a bright auroral beam was observed in the south-east sky, at an altitude of about 30 degrees. When first seen it was more or less obscured by light clouds, and its true nature was hard to determine. It was a perpendicular, pale, narrow streak of light, about 5 degrees in length and about  $\frac{1}{2}$  degree in width, with the star Gamma in the constellation Virgo, about exactly in the middle of the beam. About twenty minutes later the clouds cleared away and the beam was a beautiful object, resembling strongly a fine comet of a pale greenish white light. Ten minutes later it reached its maximum brightness, when it was a deep yellow to orange color, and had moved about a degree farther north. Underneath, towards the horizon, was a dark region, above which was a faint auroral glow. Five minutes later the phenomenon disappeared, and did not appear again. Its position in the south-east sky was unusual.”

After the disappearance of the May group, the sun's surface was practically spotless for a period extending over four rotations.

During the latter part of September and in October, fair sized groups in south latitude, belonging to the new cycle, were present.

No disturbance of the first magnitude was visible during the year. There were 163 spotless days out of 230 days of observation, or about seventy-one per cent, which indicates the uncertainty and sometimes difficulty of determining the precise date of the minimum epoch.

In the following tables are given the numerical summaries of all the observations from August, 1890, to December, 1902, inclusive. The columns are self-explanatory.

The results thus tabulated are shown graphically in Plate XXIII, which exhibits the progress of the average daily numbers of spot groups.



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MONTHS.	NUMBER OF OBSERVING DAYS.	AVERAGE NUMBER OF—			AVERAGE NUMBER OF GROUPS IN—		Number of spotless days.
		Groups.	Spots.	Faculae.	North latitude.	South latitude.	
1890—August . . . . .	27	0.6	2.5	.....	.....	.....	13
September . . . . .	26	1.0	2.6	.....	.....	.....	5
October . . . . .	19	0.8	4.0	.....	.....	.....	7
November . . . . .	25	1.2	3.7	.....	.....	.....	11
December . . . . .	24	0.8	2.4	.....	.....	.....	13
1891—January . . . . .	25	1.0	2.7	1.7	.....	.....	13
February . . . . .	20	1.6	7.3	1.3	.....	.....	6
March . . . . .	21	1.1	2.5	2.2	.....	.....	3
April . . . . .	23	1.9	12.2	3.1	.....	.....	0
May . . . . .	28	3.6	16.8	4.1	.....	.....	0
June . . . . .	17	4.2	16.9	5.3	.....	.....	0
July . . . . .	24	3.5	26.1	5.7	.....	.....	0
August . . . . .	18	2.2	13.0	4.4	.....	.....	2
September . . . . .	23	4.0	23.1	5.2	.....	.....	0
October . . . . .	23	4.6	19.5	3.6	.....	.....	0
November . . . . .	17	3.8	23.1	3.6	.....	.....	0
December . . . . .	18	3.4	15.6	3.1	.....	.....	0
1892—January . . . . .	24	5.8	28.0	4.1	.....	.....	0
February . . . . .	13	5.0	46.0	3.5	.....	.....	0
March . . . . .	14	3.2	14.0	3.1	.....	.....	0
April . . . . .	13	4.6	21.5	4.6	.....	.....	0
May . . . . .	5	5.6	30.0	2.6	.....	.....	0
June . . . . .	23	6.0	35.0	4.4	.....	.....	0
July . . . . .	22	6.2	56.9	4.4	.....	.....	0
August . . . . .	23	7.6	38.4	5.1	.....	.....	0
September . . . . .	18	5.3	30.2	5.7	.....	.....	0
October . . . . .	22	5.7	41.6	4.6	.....	.....	0
November . . . . .	15	4.7	35.4	3.2	.....	.....	0
December . . . . .	13	7.4	31.1	4.0	.....	.....	0
1893—January . . . . .	13	6.1	42.3	3.5	.....	.....	0
February . . . . .	15	5.1	42.4	3.4	.....	.....	0
March . . . . .	17	5.1	30.0	3.3	.....	.....	0
April . . . . .	15	7.3	31.5	3.9	.....	.....	0
May . . . . .	19	8.1	31.5	4.5	.....	.....	0
June . . . . .	8	7.0	46.7	4.6	.....	.....	0
July . . . . .	22	7.4	49.3	4.4	.....	.....	0
August . . . . .	21	9.4	53.8	4.7	.....	.....	0
September . . . . .	24	6.1	34.6	4.4	.....	.....	0
October . . . . .	10	6.7	30.7	4.7	.....	.....	0
November . . . . .	7	6.6	24.7	4.0	.....	.....	0
December . . . . .	6	4.8	21.7	3.0	.....	.....	0
1894—January . . . . .	9	7.2	40.0	3.7	.....	.....	0
February . . . . .	19	6.4	26.6	2.9	.....	.....	0
March . . . . .	8	4.6	21.0	3.8	.....	.....	0
April . . . . .	7	5.3	25.4	3.7	.....	.....	0
May . . . . .	13	6.1	33.5	3.0	.....	.....	0
June . . . . .	20	6.8	30.3	3.4	.....	.....	0
July . . . . .	20	7.3	34.6	3.8	.....	.....	0
August . . . . .	13	4.5	22.1	3.2	.....	.....	0
September . . . . .	10	4.7	17.5	3.3	.....	.....	0

MONTHS.	NUMBER OF OBSERVING DAYS.	AVERAGE NUMBER OF—			AVERAGE NUMBER OF GROUPS IN—		Number of spotless days.
		Groups.	Spots.	Faculae.	North latitude.	South latitude.	
1894—October . . . . .	12	4.6	34.5	3.6	.....	.....	0
November . . . . .	7	4.4	16.6	2.8	.....	.....	0
December . . . . .	1	5.0	28.0	4.0	.....	.....	0
1895—January . . . . .	6	4.2	.....	4.2	.....	.....	0
February . . . . .	11	5.3	23.6	3.5	.....	.....	0
March . . . . .	13	5.4	25.7	4.0	.....	.....	0
April . . . . .	5	6.6	32.8	4.8	.....	.....	0
May . . . . .	7	6.0	34.9	4.1	.....	.....	0
June . . . . .	10	5.6	43.1	3.6	.....	.....	0
July . . . . .	30 [B. A. A.] *	4.0	.....	.....	.....	.....	0
August . . . . .	22	4.7	43.9	2.9	.....	.....	0
September . . . . .	19	5.1	22.3	2.8	.....	.....	0
October . . . . .	20	4.6	35.5	3.3	.....	.....	0
November . . . . .	16	3.9	16.2	2.9	.....	.....	0
December . . . . .	17	6.3	27.1	2.9	.....	.....	0
1896—January . . . . .	9	3.2	8.5	3.2	1.1	2.1	0
February . . . . .	18	3.8	24.0	2.5	2.1	1.7	0
March . . . . .	16	3.7	14.8	2.6	1.1	2.6	0
April . . . . .	17	3.7	21.8	3.2	2.0	1.8	2
May . . . . .	18	2.3	10.7	2.6	0.6	1.7	0
June . . . . .	16	3.0	23.1	2.3	0.9	2.1	0
July . . . . .	23	3.8	15.1	2.7	0.9	2.8	0
August . . . . .	20	2.2	10.7	2.6	0.4	1.8	2
September . . . . .	17	2.9	31.2	3.3	1.0	1.9	0
October . . . . .	21	2.9	12.9	2.6	1.0	1.8	1
November . . . . .	12	3.6	16.0	3.2	0.7	2.8	0
December . . . . .	10	4.0	24.7	3.6	1.5	2.5	0
1897—January . . . . .	10	2.9	28.7	3.4	0.2	2.7	0
February . . . . .	3* [B. A. A.]	2.7	.....	.....	1.3	1.4	0
March . . . . .	14	2.6	9.9	2.5	2.4	0.2	0
April . . . . .	6	2.5	7.5	2.7	2.3	0.2	1
May . . . . .	22	1.6	7.7	2.3	0.6	1.0	6
June . . . . .	20	1.1	4.8	1.4	0.1	1.0	7
July . . . . .	26	2.8	11.3	1.8	0.5	2.3	0
August . . . . .	28	2.1	9.5	2.3	0.3	1.7	0
September . . . . .	28	3.8	22.2	2.8	2.0	1.8	0
October . . . . .	14	1.3	3.3	2.3	1.0	0.3	5
November . . . . .	16	1.2	3.8	1.3	0.4	0.8	5
December . . . . .	11	2.5	12.6	2.4	1.9	0.6	0
1898—January . . . . .	18	2.6	9.3	2.7	2.0	0.7	1
February . . . . .	20	2.4	16.5	2.0	1.0	1.4	2
March . . . . .	23	2.6	15.0	2.4	0.6	2.0	6
April . . . . .	25	1.5	6.7	2.2	0.3	1.2	3
May . . . . .	18	2.4	13.3	2.8	0.3	2.1	0
June . . . . .	24	2.2	9.5	2.5	1.1	1.2	2

\*NOTE—Owing to absence from town during the greater portion of July, 1896, and July, 1898, and insufficiency of observations in February, 1897, and July, 1898, a part of the data given is supplied from the British Astronomical Association solar section reports.

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MONTHS.	NUMBER OF OBSERVING DAYS.	AVERAGE NUMBER OF—			AVERAGE NUMBER OF GROUPS IN—		Number of spotless days.
		Groups.	Spots.	Faculae.	North lati- tude.	South lati- tude.	
1898—	30 [B. A. A.]*	0.7					
July.....	9	0.4	0.9	2.8	0.1	0.6	6
August.....	24	2.2	13.9	2.2	1.0	1.2	2
September....	25	1.9	11.6	2.3	0.7	1.2	1
October.....	16	2.4	15.0	2.3	1.2	1.2	0
November....	16	2.5	15.0	2.3	1.0	1.5	0
December.....	16	1.5	5.0	2.2	0.4	1.0	2
1899—							
January.....	22	1.9	10.0	1.9	0.2	1.7	1
February.....	18	1.1	4.8	1.8	0.0	1.1	6
March.....	17	1.5	5.5	1.4	0.3	1.2	2
April.....	22	1.7	3.2	1.5	0.3	1.5	1
May.....	24	0.7	2.6	1.0	0.0	0.7	7
June.....	25	1.6	10.0	1.6	0.7	0.9	2
July.....	29	1.5	6.7	2.0	0.4	1.1	8
August.....	27	0.3	0.6	1.8	0.2	0.1	21
September....	27	0.8	3.4	1.4	0.1	0.7	13
October.....	22	0.5	4.3	1.4	0.1	0.4	15
November....	18	0.9	3.3	0.9	0.3	0.6	7
December.....	9	1.0	2.8	1.2	0.4	0.6	3
1900—							
January.....	21	0.7	2.5	1.2	0.4	0.3	9
February....	13	0.9	5.2	0.7	0.6	0.3	7
March.....	23	0.6	2.0	1.0	0.2	0.4	12
April.....	21	1.5	7.0	1.7	0.7	0.7	1
May.....	15	0.8	5.7	1.3	0.4	0.4	8
June.....	27	0.8	4.5	0.9	0.4	0.4	13
July.....	27	0.6	2.6	1.1	0.2	0.4	16
August.....	28	0.4	1.6	0.6	0.0	0.4	20
September....	24	0.8	3.1	0.8	0.0	0.8	13
October.....	23	0.8	6.0	1.0	0.0	0.8	7
November....	17	0.3	0.6	0.6	0.0	0.3	12
December.....	16	0.0	0.0	0.8	0.0	0.0	16
1901—							
January.....	20	0.0	0.0	0.2	0.0	0.0	20
February....	20	0.15	0.15	0.4	0.15	0.0	17
March.....	17	0.6	2.1	0.4	0.5	0.1	11
April.....	23	0.0	0.0	0.3	0.0	0.0	23
May.....	26	0.4	3.7	0.5	0.4	0.0	16
June.....	24	0.8	2.1	0.6	0.6	0.2	11
July.....	30	0.1	0.1	0.4	0.00	0.10	27
August.....	28	0.1	0.2	0.2	0.07	0.03	25
September....	25	0.1	0.1	0.0	0.04	0.04	23
October.....	24	0.3	1.0	0.4	0.04	0.26	18
November....	22	0.5	0.8	0.4	0.00	0.50	11
December.....	10	0.0	0.0	0.0	0.00	0.00	10
1902—							
January.....	23	0.4	2.0	0.2	0.00	0.39	14
February....	19	0.0	0.0	0.0	0.00	0.00	19
March.....	18	0.7	5.9	0.4	0.61	0.06	9
April.....	20	0.0	0.0	0.3	0.00	0.00	20

\*NOTE—Owing to absence from town during the greater portion of July, 1898, and July, 1898, and insufficiency of observations in February, 1897, and July, 1898, a part of the data given is supplied from the British Astronomical Association solar section reports.

MONTHS.	NUMBER OF OBSERVING DAYS.	AVERAGE NUMBER OF—			AVERAGE NUMBER OF GROUPS IN—		Number of spotless days.
		Groups.	Spots.	Faculae.	North latitude.	South latitude.	
1902—May .....	20	0.4	0.8	0.4	0.49	0.00	12
June .....	20	0.1	0.3	0.3	0.15	0.00	17
July .....	24	0.2	0.3	0.5	0.17	0.00	20
August .....	24	0.1	0.2	0.2	0.12	0.00	21
September .....	22	0.5	2.6	0.6	0.27	0.27	14
October .....	17	1.3	7.6	0.7	0.30	1.00	2
November .....	13	0.4	3.5	1.1	0.38	0.08	8
December .....	10	0.3	0.9	1.4	0.30	0.00	7

The following tables exhibit the greatest and least number of sun-spot groups visible on any day during each month of the twelve years record:

MAXIMUM DAILY NUMBER OF SUN-SPOT GROUPS.

MONTHS.	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
January .....	4	11	11	10	7	6	5	6	3	2	0	1	0
February .....	3	8	9	8	8	5	5	6	3	2	2	2	2
March .....	4	7	10	7	8	7	7	4	3	4	0	0	0
April .....	5	7	11	9	10	4	4	4	1	2	1	1	1
May .....	7	9	11	9	7	5	3	5	3	2	2	1	1
June .....	8	13	10	11	8	9	5	3	4	2	1	1	1
July .....	2	5	10	14	8	8	5	4	4	3	2	1	1
August .....	2	8	9	9	9	9	6	6	4	3	2	1	3
September .....	2	5	8	12	7	8	6	5	4	2	2	2	2
October .....	4	8	9	6	6	6	3	5	2	1	1	1	2
November .....	3	7	13	9	8	11	8	5	3	2	0	0	1
December .....													

MINIMUM DAILY NUMBER OF SUN-SPOT GROUPS.

January .....	0	2	2	4	3	1	1	0	0	0	0	0	0
February .....	0	1	2	4	3	1	1	0	0	0	0	0	0
March .....	0	1	3	3	1	1	0	0	0	0	0	0	0
April .....	1	2	4	3	5	0	0	0	0	0	0	0	0
May .....	2	4	6	3	1	1	0	1	0	0	0	0	0
June .....	1	4	5	5	4	2	0	0	0	0	0	0	0
July .....	2	3	4	4	1	1	1	0	0	0	0	0	0
August .....	0	0	4	6	2	2	0	1	0	0	0	0	0
September .....	0	1	3	4	2	2	1	1	0	0	0	0	0
October .....	0	3	2	5	2	2	0	0	1	0	0	0	0
November .....	0	2	3	4	3	1	2	0	1	0	0	0	0
December .....	0	1	2	2	2	1	2	1	0	0	0	0	0

In the subjoined table is given the average annual results for each year from 1891 to 1902.

YEARS	NUMBER OF OBSERVING DAYS.	AVERAGE ANNUAL NUMBER OF			TOTAL NUMBER OF SPOTLESS DAYS.	PER CENT OF SPOTLESS DAYS.
		GROUPS.	SPOTS.	FACULAE		
1891...	257	2.9	14.9	3.6	24	9.3
1892...	205	5.6	34.0	4.1	0	0.0
1893...	177	6.6	36.6	4.1	0	0.0
1894...	139	5.6	30.0	3.4	0	0.0
1895...	149	5.2	30.5	3.5	0	0.0
1896..	197	3.2	17.8	2.9	5	2.5
1897...	198	2.2	11.0	2.3	29	14.6
1898...	234	2.1	11.0	2.4	30	12.8
1899...	259	1.1	4.8	1.5	108	41.7
1900...	255	0.7	3.4	1.0	134	52.5
1901...	269	0.25	0.9	0.3	212	78.8
1902*..	220	0.38	2.1	0.4	156	71.0

\*Not including month of December.

Plate XXIV represents graphically the summaries of the groups and spots, the former being indicated by the heavy, smooth line, and the latter by the dotted one.

In conclusion the author would state that the foregoing brief and rather unsatisfactory review of the recent sun-spot cycle was written rather hurriedly, but he trusts that the account, as given, may not be uninteresting.

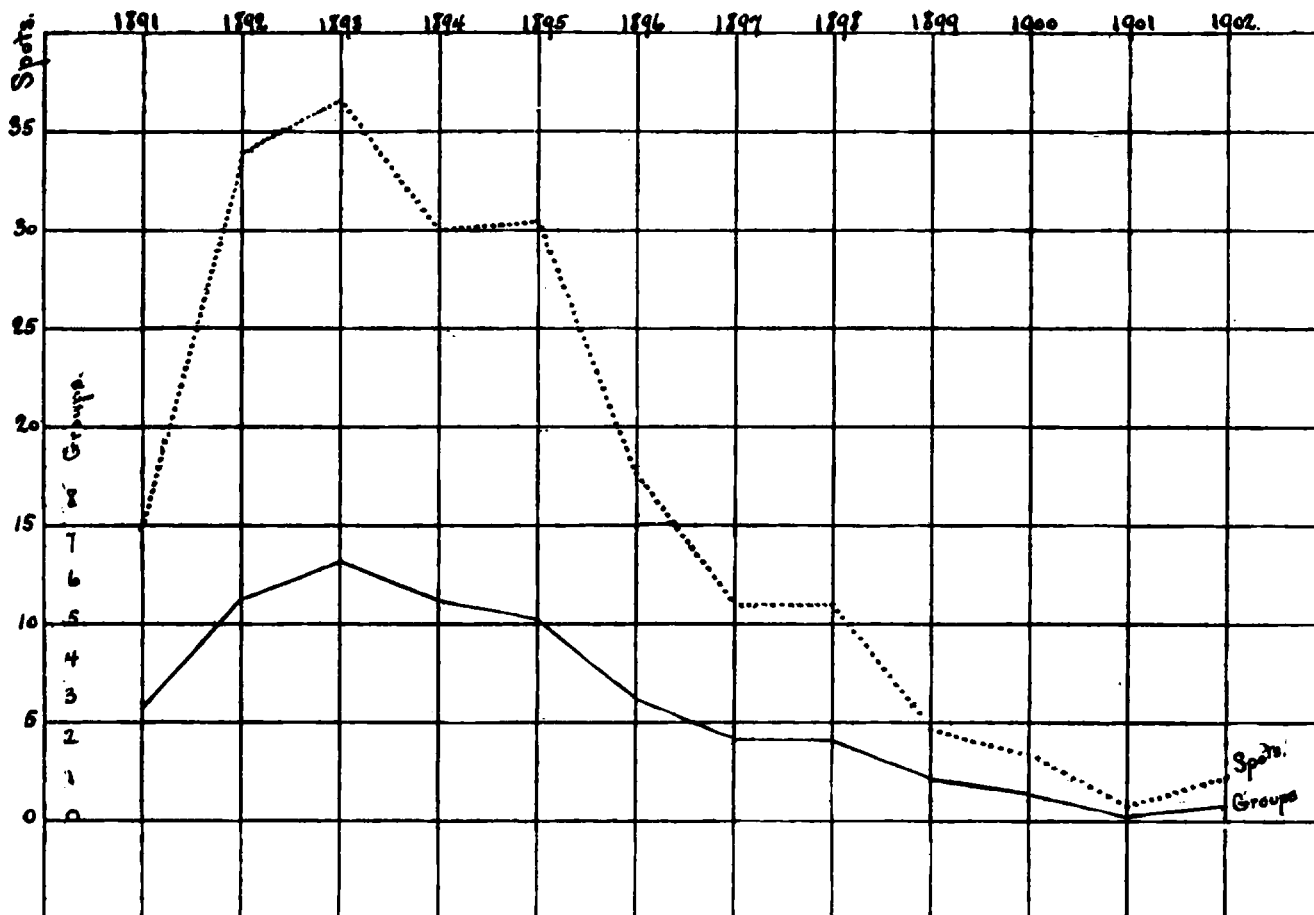
All the observations were faithfully and accurately made, and represent the conscientious labors of one who has been occupied in an active business career and pursuing other astronomical and meteorological studies as a recreation. He is not unmindful of the many shortcomings, and the difficulties involved in a discussion of the results.

List of the author's published sun-spot observations:

- 1890. September to December.—Mon. Rev. I. W. and C. S.
- 1891. January to December.—Mon. Rev. I. W. and C. S.
- 1892. January to December.—Mon. Rev. I. W. and C. S.
- 1893. January to May.—Mon. Rev. I. W. and C. S.
- 1894. May to December.—Mon. Rev. I. W. and C. S.
- 1895. January to June, August to December.—Mon. Rev. I. W. and C. S.
- 1895. Review Solar Observations, 1891 to 1895, (June).—Pub. A. S. P., Volume 8, No. 45.
- 1896. January to December.—Mon. Rev. I. W. and C. S.
- 1896. Review Solar Observations, 1895, (August to December), and 1896.—Pub. A. S. P., Volume 9, No. 15.
- 1898. Large Sun-spot of September.—P. A., Volume 6, No. 8.
- 1899. Review Solar Observations, January to August.—P. A., Volume 7, No. 8.
- 1899. Review Solar Observations, September to December, P. A., Volume 8, No. 4.

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Plate XXIV.



1900. Review Solar Observations.—P. A., Volume 10, No. 5.

1901. Review Solar Observations.—P. A., Volume 10, No. 7.

1896 to 1902. Daily record contributed to Solar Section British Astronomical Association, and results published in B. A. A. Memoirs.

Abbreviations.—Mon. Rev. I. W. and C. S., Monthly Review of the Iowa Weather and Crop Service, Des Moines. Pub. A. S. P., Publications of the Astronomical Society of the Pacific, San Francisco, Cal. P. A., Popular Astronomy, Northfield, Minn.

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## THE DUCK HAWK—(FALCO PEREGRINUS ANATUM) —IN IOWA.

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BY B. H. BAILEY.

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Few birds of the United States are more widely and generally distributed, and probably no one species is more isolated as to the individual pairs than the Duck Hawk, (*Falco peregrinus anatum*).

The Duck Hawk, Great Footed Hawk, Peregrine Falcon, etc., as he is variously called, is a "Noble Falcon," one of the really blue blooded Falconidae. Some years ago I met this species in Linn county, and the pair with which I became acquainted having been observed before and since by my friend, Mr. Geo. Burge, of Mt. Vernon, I have obtained largely from him the following facts concerning these birds. In the south-eastern part of Linn county, and extending to the north-eastern part of Johnson county, the Cedar river has cut its channel through the limestone hills of this region, and has left on either side cliffs known locally as the Palisades, raging from a few feet to nearly 100 feet in height.

On the face of these rocks grow lichens of various hues, and bushes interspersed with stunted cedar trees. In many places weathering has produced fissures and crannies which have been for years the resort of the Turkey Buzzards (*Cathartes aura*) and an occasional Gt. Horned Owl (*Bubo virginianus*). Here in 1892 Mr. Burge first noted the presence of the Duck Hawk.