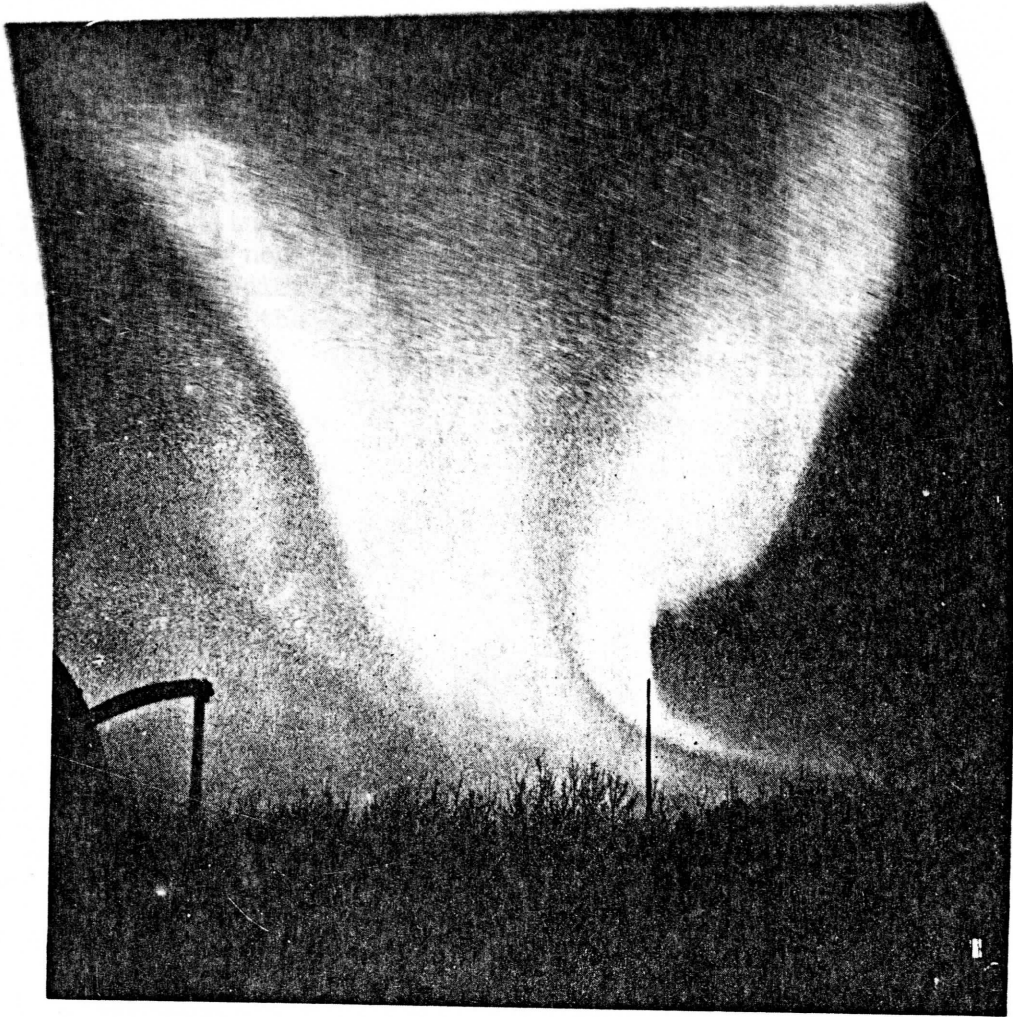


THE
QUARTERLY REPORT

1956-3

JULY 30 - SEPTEMBER



*Aurora from the Arctic Circle**

*High Altitude Observatory
of the
University of Colorado
Boulder and Climax, Colorado*

The High Altitude Observatory of the University of Colorado is a non-profit research and educational institution dedicated to the study of the sun and its effects on the earth.

* Cover: Aurora from the Arctic Circle. A striking picture of the aurora taken with the camera facing northeast from the roof of the Geophysical Institute of the University of Alaska at College, Alaska. The brilliant arches and rays shown in this photo by Dr. Victor Hessler, of the Geophysical Institute, change form and shape rapidly. Their origin is undoubtedly to be sought in electrified particle emission from the sun.

SUMMARY

The highlight of the quarter was the first successful rocket launch to escape the earth's atmosphere during a solar flare. The Naval Research Laboratory's 'Project Socrates' accomplished this feat on July 20th, sending the rocket to 50 miles altitude within minutes of our warning of the flare from Climax.

The six-week solar-weather seminar, sponsored by the HAO Institute for Solar Terrestrial Research, was immediately followed, late in July, by a special national meeting of the American Meteorological Society to consider solar-weather problems. HAO and the University served as hosts. The meeting commanded a considerably larger attendance than we had anticipated, which was most gratifying.

During the quarter we installed our new corona-detecting instrument, the "K-coronameter," at Climax. This new instrument records a component of the sun's corona that we have hitherto been unable to measure. The instrument was successfully operated at Climax in September, and will be put into regular service during the International Geophysical Year, which begins next July. Before that we plan to use it for special researches. Its results may find application in geomagnetic storm forecasting.

During the summer the sun's activity rose to a very high level of disturbance. There were large and frequent sunspots, strong belts of coronal emission, violent active-region prominences, and intense solar radio noise emission. With this high increase we have obtained outstandingly excellent records of many prominence and corona spectrum lines,

from which we expect to make substantial gains in understanding the temperatures of solar outbreaks.

The rise of solar activity has been a surprise to many astronomers because some of us expected that after several cycles of high sunspot activity the level of disturbance at this maximum, as in past epochs, would fall relatively low. Unless a sharp change in the trend occurs, however, this maximum will reach or exceed the highest level yet recorded.

I. HIGHLIGHTS OF THE QUARTER

Project Rockoon

A high altitude research rocket fired on 20 July breached the X-ray-stopping atmospheric barrier above our heads, and brought back to earth-bound scientists a hint of the potency of the invisible X-rays emitted by solar flares. The HAO and the Sacramento Peak Observatory played a small but crucial role in this new discovery. The story is worth telling, I think, in its entirety.

For several years Dr. Herbert Friedman, Dr. Talbot Chubb, and a small group of associates at the Naval Research Laboratory have been vitally interested in measuring the X-ray and far ultraviolet emissions of the sun and particularly the emission of regions of abnormally strong solar activity. We at HAO have also been much interested; the very high temperatures we have found for active coronal centers suggest that strong corona regions may sometimes bathe the upper atmosphere of the earth in strengthened X-ray beams.

Consequently, we were most enthusiastic when the NRL group decided to undertake "Project Rockoon," to fire a series of 10 instrument-carrying research rockets of a balloon-borne type known as Rockoons. The rockets were to be fired to the 50 mile level, at which height the X-rays are no longer strongly absorbed by the air. Their rockets were to be fitted with devices to radio earthwards their measurements of X-ray emissions. We developed a special telescope to assist in the detection of solar flares on the ship from which the rockets were to be fired, so that the NRL group could "push the button" at just the moment when a strong flare erupted. Flares are among the most violent of solar phenomena and are probably the source of at least a major part of the heat of the corona. With big flares we almost always have abrupt and extensive short wave radio fadeouts in the daylight hemisphere of the earth. The minute-to-minute detection of flares is therefore of major interest to solar observatories throughout the world.

Friedman, Chubb and their colleagues departed from San Diego in mid-July aboard the U.S.S. Colonial, which had on board ten Rockoons for firing during the period from 16 July to 29 July. A Rockoon is a combination balloon-rocket device, in which the balloon stage goes up first, carrying in its shrouds a rocket all poised for firing. After it reaches altitude--some 60,000 feet up--it can sit there for six to eight hours, waiting for the radio signal that will push the plunger on the rocket-firing mechanism.

The plan was to send the balloon up in the morning, then await the occurrence of a flare--at which instant the waiting scientist would trigger off the rocket. The Climax and Sacramento Peak staff were alerted to keep especially intensive watch of the sun during these times;

the radio transmitters at our sites were held in readiness to relay to the ship news of a flare detected at either station. Unfortunately, the skies at the Pacific Ocean location of the U.S.S. Colonial were entirely clouded and the shipboard flare detector was useless.

A number of days went by with no success--either things were not ready to fire, or there weren't any flares to announce. At five minutes past noon, on the 20th of July, Richard Hansen, then at the eyepiece of the new scanning spectrograph at Climax, detected the beginnings of a significant brightening of the light of the Balmer-alpha line of the hydrogen spectrum. This is the tell-tale sign of a flare.

Hansen had to sprint the hundred or so yards from the telescope to the radio to announce the flare to Sacramento Peak; they, in turn, relayed instantly to the U.S.S. Colonial. Fortune was with us and the message got through instantly. If the flare had been large, it would probably have prevented its own announcement by interfering strongly with the radio message. The rocket fired--and flew successfully to about 49 miles altitude.

There it telemetered back to the mother ship a fascinating message--one that adds a new chapter to our book of knowledge about the sun. The X-ray emission of the sun was enhanced by a factor of about one hundred, for the X-rays of shorter wave length than 10 angstroms--implying a temperature perhaps as high as 10 million degrees (A.) in the source region. And all this enhancement, presumably, came from the small area of the sun covered by this rather minute flare--one that would otherwise be almost unnoticed in the catalogs of solar flares, designated as a "sub-flare" because it didn't even reach the category we normally dignify by the full-fledged designation of "flare." The flare did show up on our SCNA (sudden cosmic noise absorption) detector* however, and from that record we derived better estimates of its starting and ending times than Hansen could measure. To date this is the only flare for which a rocket has been aloft to measure X-ray and ultraviolet emissions.

The observation is significant not so much for the specific information obtained, though that is fully sufficient to justify the effort, but it is particularly valuable in pointing the way to more intensive rocket studies next summer at the start of the IGY (International Geophysical Year). To us at HAO it will be vitally interesting to learn how long the X-ray enhancement lasts after a flare. We'd like to see it outlive the visible-light flare, thereby hinting a coronal origin. To gain the full lifetime story will take several rockets, or the sustained flight of a satellite. And we can't forget that this was an extremely small flare. What will we see when we catch a big one?

*Described on Page 11 of the Director's Quarterly No. 1956-1 and in Figure 2 of the same report, on Page 7.

II. INSTITUTE FOR SOLAR-TERRESTRIAL RESEARCH

Solar-Weather Relationships

The first National Meeting of the American Meteorological Society to be devoted to the special subject of solar-weather relationships climaxed the six-week long solar-weather seminar at Boulder on July 25th to 27th. The registered attendance of over 90 substantially exceeded our expectations, and contributed immensely to the success of the sessions.

My last report describes the program and goals of the seminar. The AMS meeting, rather than being a comprehensive study program, was devoted to a brief presentation of original contributions to the study of possible solar-weather effects. Twenty-eight papers were presented.¹⁾ As the meeting closed the sentiment was expressed by Mr. E. D. Farthing of TWA, Program Chairman, that consideration should be given, three years from now, to another special AMS meeting devoted to the same subject. The sponsorship of the Institute for Solar Terrestrial Research made both of these activities possible, and we sincerely believe that they have materially assisted in stimulating wider interest in the field; from this more rapid research progress should result. We are grateful to the National Science Foundation, the American Meteorological Society and to the American Astronomical Society for their assistance and endorsement of the program, and to Mr. Farthing for his devoted work on the program of the AMS meeting.

At the close of the seminar we began laying plans for a careful search for possible solar effects in upper level wind flow maps, probably at the 300 mb level (approximately 30,000 feet above sea level). The work will be initiated during the next quarter and will involve a cooperative program with two members of the faculty of the Colorado School of Mines. It will also be carried on with the close cooperation of Mr. Robert Curtis of Continental Air Lines and Mr. Henry Harrison of United Air Lines.

Analysis of the K-Corona

As mentioned in my last report, we have recently completed a new instrument called a "K-coronameter" to record the strength of the emission of light from the "K-corona" of the sun. The K-corona, sometimes called the "electron-corona," is that part of the sun's atmospheric halo that comes from white light of the sun's face scattered

1) Abstracts were published in the Bulletin of the American Meteorological Society, Vol. 37, Pages 290-296 for June 1956. Extra copies are available from HAO. Full seminar notes and a statement of findings of the solar-weather seminar were issued as Technical Report No. 1 from the Institute for Solar-Terrestrial Research. A limited number of copies of the Report are still available from HAO.

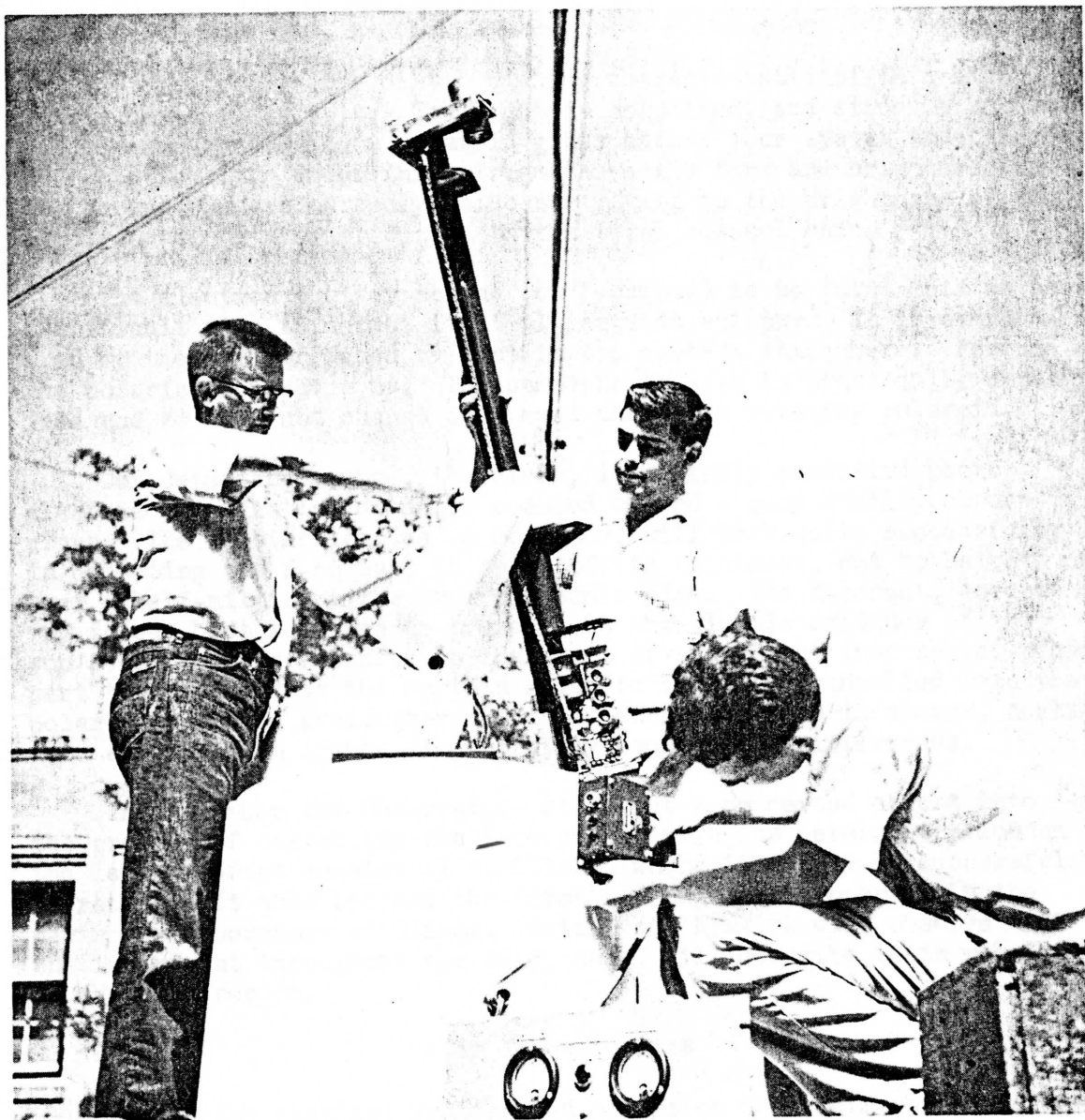


Figure 1

Members of the HAO staff putting finishing touches on the electronic K-line flare detector designed for use in "Project Rockoon." The device was intended for use from shipboard to warn of the occurrence of flares and permit the instant launching of rockets for study of the flare X-ray energy by the Naval Research Laboratory. Robert H. Lee (left), Charles J. Garcia (center) of the HAO, and Douglas McNutt (right) of the Naval Research Laboratory, are shown making adjustments to the drive mechanism.

by free electrons. One distinguishing characteristic of this light allows us to measure it. The light is polarized, and strongly so, as can be seen by holding a polaroid glass before your eye at an eclipse and rotating it. Under this circumstance the form and brightness of the corona changes markedly--also testifying to the brightness of the electron-corona's contribution to the total coronal halo.

The electron scatter corona (or K-corona) is so faint that we have a difficult time to detect it at all outside eclipse. It is overpowered by the halo produced by dust in the earth's atmosphere. Fortunately the polarization saves us. The atmospheric halo is practically unpolarized and so does not change as viewed through a rotating polaroid.

Our detecting device, therefore, is a highly sensitive photoelectric polarization detector mounted behind a good quality coronagraph. The combination, as we now know, will work quite successfully in detecting the K-corona, in spite of its faintness, out to heights of over a half-million miles from the sun's edge. The K-corona, according to our best surmises at present, is the visible evidence of the sun's corpuscular emission in the start of its flight into space. The part that later hits the earth's magnetic field is channelled into the polar regions and produces radio interferences, magnetic storms, northern and southern lights, and possibly even weather influences.

In September the Observatory staff put a concerted effort into the problem of assembling the K-coronameter in its permanent place on the large 26-foot equatorial at Climax, where it is now in successful operation. It thus becomes the first coronagraph to operate in the new solar laboratory at Climax. Axtell and Newkirk will observe with the instrument throughout the fall, and I will describe their results in the next report.

Solar Index Studies

During the quarter, Trotter and others on the staff gave considerable thought to the desire of Dr. Hurd Willett of M.I.T., and others at the solar-weather seminar, for a new comprehensive solar index to describe the distribution as well as the intensity of over-all solar activity. We concluded that the best first step would be to draw up idealized solar maps against which we would compare actual solar maps. The ideal maps would represent different numbers of active solar centers with different spatial distributions and different intensities. They would be classified if possible, in progressive series, perhaps according to two independent criteria, such as intensity of activity, and closeness of spacing of active centers. Trotter has now begun experiments with the actual classification of recent solar activity according to such a scheme.

During this period we also gave attention to the problem of determining the most reliable index to represent the combined emission from

all the regions of intensified coronal activity on the sun at a given time. Mr. E. D. Farthing of TWA has been using an index designed to measure the total emission of the corona; our efforts to compare this index with qualitatively derived indices based on Trotter's weekly and quarterly coronal maps suggest that the Farthing index weights rather weakly the strong coronal centers, and that it possesses large accidental fluctuations as a result of observational errors in detection of the corona. We shall continue to study this index problem in the months ahead.

III. OTHER RESEARCH PROGRAMS OF THE HAO

A. Staff

At the end of September Dr. Marianne Bretz, from the Universitäts-Sternwarte at Gottingen, Germany, joined our staff. Dr. Bretz has done extensive research on the sun's spectrum, comparing the strengths of spectrum lines near the sun's center with the same lines near the solar edge. From this she has derived information about temperature and other physical conditions near the surface layers of the sun. Her Ph. D. thesis, recently completed, was supervised by Dr. P. ten Bruggencate, who recommended her visit at HAO. It is anticipated that she will be with us for two years.

Wlérick and Matsushita, both visiting foreign scientists, terminated their stays at Boulder during the quarter. Matsushita will return for a brief stay next summer when he attends an international scientific meeting in Boulder. Their contributions to the work of HAO have been most valuable.

Chapman left us at the close of July, to return in a year. Correll concluded his stay at HAO in late August, but will be back next summer. His summer work will be written up soon for presentation in the *Astrophysical Journal*. He found an apparent connection between the point of concentration of composite trajectories of prominences, and the outbreak of solar flares for a particularly well-observed period in 1951.

B. Research in Progress

As in other reports, I reserve detailed reporting for but a few of the programs in progress, and give this usually when the work passes some significant milestone.

1. Active Region Analysis

At the close of the quarter the Climax equipment was all ready for intensive observation of solar regions that might exhibit outstanding activity. In the next report we shall describe the excellent new observations made in November, which represent another definite advance in our understanding of the physics of active regions.

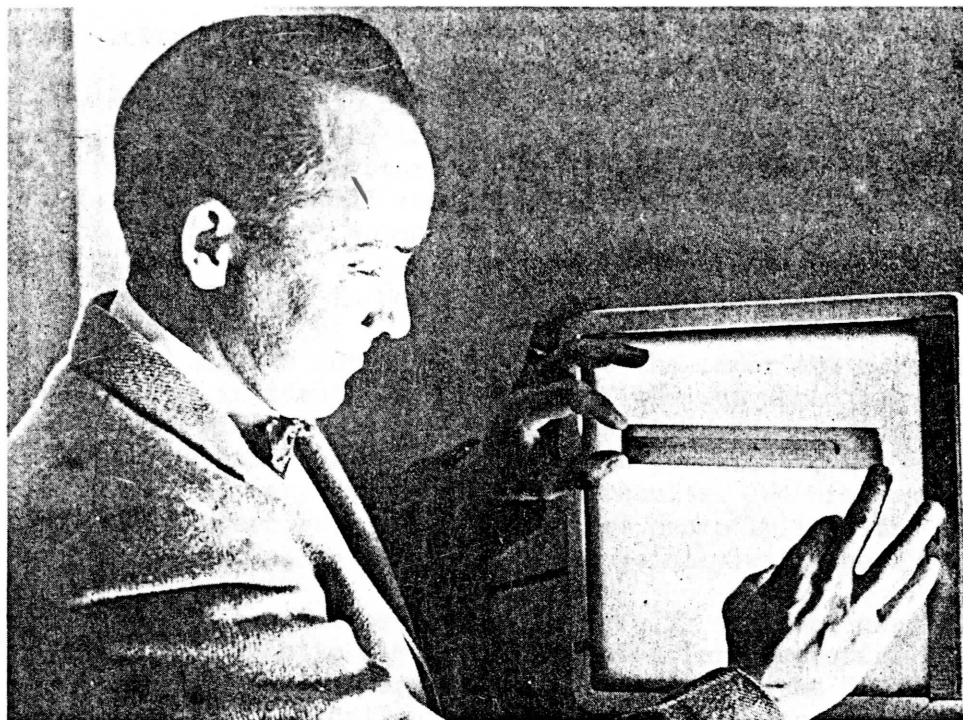


Figure 2

One of the most gratifying recognitions of the progressing work of the HAO is represented by Dr. S. A. Mitchell's gift to the Observatory of his historic spectra from the 1905 eclipse. Here, Dr. R. G. Athay, who has spearheaded HAO's eclipse analysis, examines one of these superlative early spectra.

Dr. Mitchell, dean of American eclipse observers, might be embarrassed by my quoting one of his stories about this film, since he sent them in a personal letter, but I hope he will excuse me for repeating one that relates to the comments of the solar pioneer, Dr. G. E. Hale of the Mount Wilson Observatory, when he saw one of these films: "I had known George E. Hale in my early years at Yerkes Observatory. In one of my summers at Pasadena, I showed Mr. Hale the original film of 1905. It was most interesting to watch him examine the film with the help of an eye-piece I gave him. I could see him getting more and more excited, especially as he viewed the ultraviolet end. Then he exclaimed, 'By George, Mitchell, this is the most beautiful film I have ever seen. What an enormous lot of valuable information it has added to our knowledge of the sun.'" And so it has. It give us a deep sense of pride and gratitude to be trusted to keep these valuable films.

2. Solar Effects in the Ionosphere

First efforts to detect cosmic radio noise were successfully made by Warwick during the period, with temporary antennas. No discrete radio noise sources were, however, identified. About a half-year's work still remains before Warwick will be ready to erect the permanent antennas.

3. Solar Effects in Geomagnetism

The summer's work has underlined the important role of solar radio noise in identifying regions of the sun whose passage across the middle of the sun's face will produce disturbances in earth magnetism. Dr. Helen Dodson, in particular, has advised us informally of very important recent results. We are making every effort to incorporate the new findings promptly into the geomagnetic forecasting we have been doing jointly with the NBS group.

Roberts and Matsushita have carefully examined very high latitude geomagnetic disturbance records for the period of the unprecedented 23 February cosmic ray increase (see HIGHLIGHTS, Report 1956-1). Excellent copies of original records were lent us by the National Research Council of Canada, through the courtesy of Dr. R. G. Madill. These show a remarkable effect at two stations that lie within the auroral zone. Baker Lake, only 7° from the pole of the earth's magnetic field, showed a definite effect about 30 minutes after the flare which occurred at 03:34 UT. At lower geomagnetic latitudes there was no effect at all. The simple but novel explanation is that high-speed solar particles arriving at these latitudes produced the effect, probably through secondary influences in the atmosphere. Other flares failed to reveal a similar effect, but we know that this particular flare, for reasons entirely unknown, produced unprecedented terrestrial effects.

4. Observations of K-corona (see Institute Program above).

5. Solar Activity Observing

We have installed at Climax a new camera for detection of prominence motion by use of a small coronagraph that eclipses and photographs the entire periphery of the sun's disk. The instrument is designed also for quick-change operation as a solar flare detector. It has the virtue of being located on the same equatorial as the 5-inch coronagraph-spectrograph, so it can be used for visual monitoring of the sun's limb and face, for active prominences and flares, during exposures at the spectrograph. This will allow us to keep close tabs on the development of active regions whose spectra we are endeavoring to photograph in rapid sequence. To use it as a flare instrument we must await a new

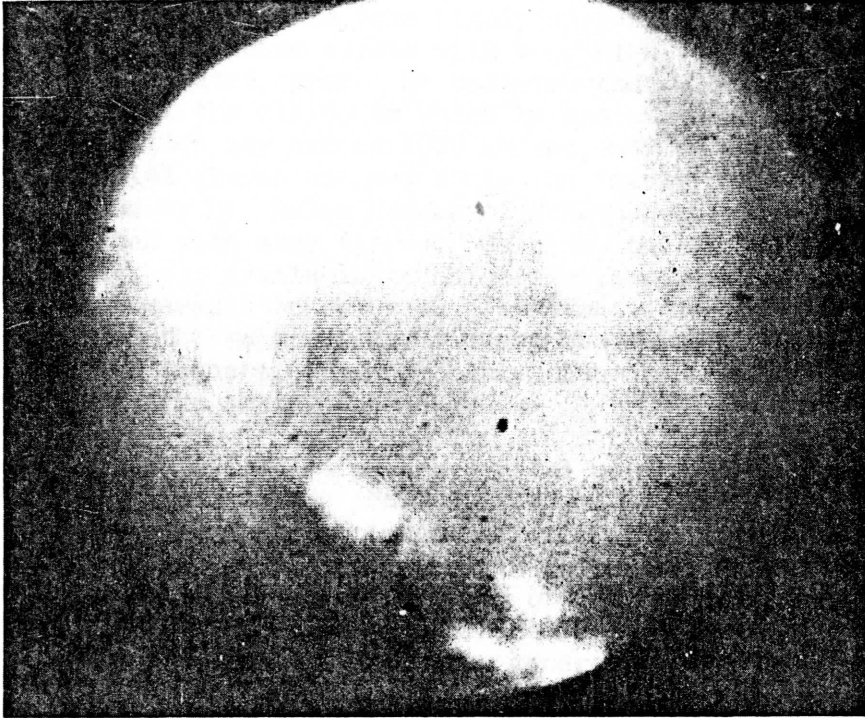


Figure 3

Photograph of the picture tube of the flare detector built for "Project Rockoon." The image of the sun is shown after the ultraviolet light emitted by calcium atoms has been converted to visible light by the instrument. The bright patches are active regions of the sun's face in which still brighter "flares" are sought.

birefringent filter from the firm of B. Halle Nachfl. in Germany. The filter is completed, and needs only to be shipped to us.

Solar activity dropped somewhat during the quarter, but is nonetheless at a high level. We had especially complete solar coverage during the quarter, and the systematic solar activity observations, in spite of not too good skies, were of high quality.

6. Temperature and Motions in the Corona
7. Temperature, Motion and Radio Emission in Prominences

J. Warwick has done some highly suggestive work in the association of radio noise bursts with very high velocity prominences of flare-associated types. He believes that prominences ejected at the time of the flare, to which he has attached the name "spray," whose velocities may exceed 1000 km/sec, may be a common feature of substantial flares and may cause the "early part" radio noise bursts found by Dr. Helen Dodson of McMath-Hulbert Observatory to be associated with many flares. We plan, therefore, as soon as time, money, and available techniques will permit, to make instrumental improvements to carry on a systematic search for these ejections on the solar disk. Present observing techniques, both at HAO and elsewhere, would probably miss them, except perhaps in occasional lucky shots.

Evidence in support of our general notion that prominences in highly active regions possess extremely high temperatures gradually mounts. Our observational effort, under Zirin's prodding, is directed now towards observing in active center prominences certain temperature-sensitive lines of helium whose presence with high intensity will be strongly indicative of temperatures of 30,000 A or more, well above those generally attributed to prominences. We feel that the reason that the high temperatures have generally been overlooked is that observing effort has been mainly concentrated on the stable, larger and more brilliant prominences away from active centers, because it is much easier to record their spectra accurately. Particularly useful results have come from the study of the excellent spectra of the limb flare and prominences taken at Climax on 24 June 1956.

8. Solar Granulation Analysis

The sun's face possesses a fine network of minute structural detail when viewed in white light under good seeing conditions. This network reminded early solar observers of "rice grains scattered on a grey paper," and from this description has persevered the name "granulation."

Wlérick's research on solar granulations, based on the photographs made by Dr. W. A. Miller at RCA Laboratories, is now concluded and has led him to two principal conclusions. The first is that the use of moving average procedures for analysis of the existence of preferred sizes for solar granulations is fraught with danger. In particular, he showed the apparent grouping of granules with a strong preference for a 2,300 km spacing, previously reported by Stuart and Rush of HAO, was a spurious result, coming from the nature of the running mean used. He found that the granules actually possess a broad distribution of spacings, with no strong peak at 2,300 kms.

The second result found by Wlérick is that the large-scale

brightness fluctuations, corresponding to spacings of darker and brighter areas of more than 10,000 kms, are highly significant physically and appear to transport more energy to the sun's atmosphere than do the small classical "granules." These results are both the subjects of papers now submitted for publication.

9. Chromospheric Spectra

We now have new spicule spectra of quality even better than those described under HIGHLIGHTS in the last report. Athay is collaborating with Dr. Elske van P. Smith of the Sacramento Peak Observatory in study of chromospheric spicules from spectroscopic observations.

10. Electronic Flare Pickup (see HIGHLIGHTS, above.)

11. Measurement of Older Coronal Spectrograms

12. Guide Book on Solar Activity

13. Danger Island Eclipse of 12 October 1958

Over-all standards for the equipment to go to the Danger Island eclipse have been set and we have begun the earliest stages of the design of instruments. Very tough size and speed standards are being set up, making the equipment even fussier than that for the 1952 Khartoum eclipse. But we are getting started on the work now, far sooner, relatively, than for the Khartoum effort.

14. Venusian Aurora

A recent paper by a Russian astronomer, N. A. Kosyrev,²⁾ purports to show that the spectrum of the dark side of Venus reveals the emissions of an aurora like that of the earth. Kosyrev eclipsed the bright part of the Venus planetary disk, during crescent phase of the planet, and looked past the edge of the dark limb with his spectrograph. What he saw showed spectrum lines of an aurora, or so he thinks.

This is observational evidence for a spectrum of a sort that G. Herzberg suggested we should try at Climax years ago. We tried, and found nothing. But our equipment was difficult to manage for such an experiment at that time. Now the new large 26-foot equatorial at Climax will make observation much easier. Moreover, a coronagraph should do the job much better than Kosyrev's instrument.

2) Kosyrev, N. A., *Izvestia Krimski Astrophysical Observatory*, 12, 169, 1954.

Thus Newkirk hopes to gain the support of the Office of Naval Research to try to take such spectra. We have some doubts of the reliability of Kosyrev's spectra, but should readily confirm them if they are as bright as Kosyrev reports. Evidence of a Venus aurora would add a highly useful technique to our study of the corpuscular emission of the sun, and its effects on planets. We might also solve the problem of whether Venus has a magnetic field.

IV. RELATED PROGRESS AT OTHER INSTITUTIONS

A. Solar-Weather Research

This time I shall confine myself to mentioning one or two principal highlights of the findings of the summer solar-weather seminar and of the special solar-weather meeting of the American Meteorological Society. The full findings of the seminar, and abstracts of the meeting papers are published in the Bulletin of the AMS.³⁾ Other research in the field will be reviewed in a later report.

Summer Seminar

A principal conclusion from the summer seminar, with respect to solar emissions of possible significance to weather phenomena, is that special attention should be paid to emissions of wave lengths shorter than 1500 A from the sun, including coronal emission; it is in this range that there appears some hope of finding, for brief intervals, large enough energy changes to be significant. Theoretical and observational work are both needed, however, to tie down to observed features of the sun the times of large increases. There was, of course, a general recognition, also, of the importance of understanding the role of solar corpuscular emission in its impact on the upper atmosphere.

The principal need in understanding of the physics of solar-weather relationships was the development of possible mechanisms that could propagate sudden increases of solar energy in corpuscular streams or short wave radiational bursts from above 50 kms, where the energy will be absorbed, to the lower stratosphere or troposphere where weather effects can show up. It was agreed that under certain conditions the circulation of the atmosphere may be sufficiently unstable to be upset by relatively small solar or other effects. It was also agreed that there are possible mechanisms for amplification of small solar, cosmic, or terrestrial disturbances, but none of these has yet been developed to the point where it is based on a sound physical theory.

3) Roberts, W. O., Bulletin of the American Meteorological Society, 37, 477, 1956.

Roberts, W. O., Bulletin of the American Meteorological Society (in press) (Both of these are available as reprints from HAO)

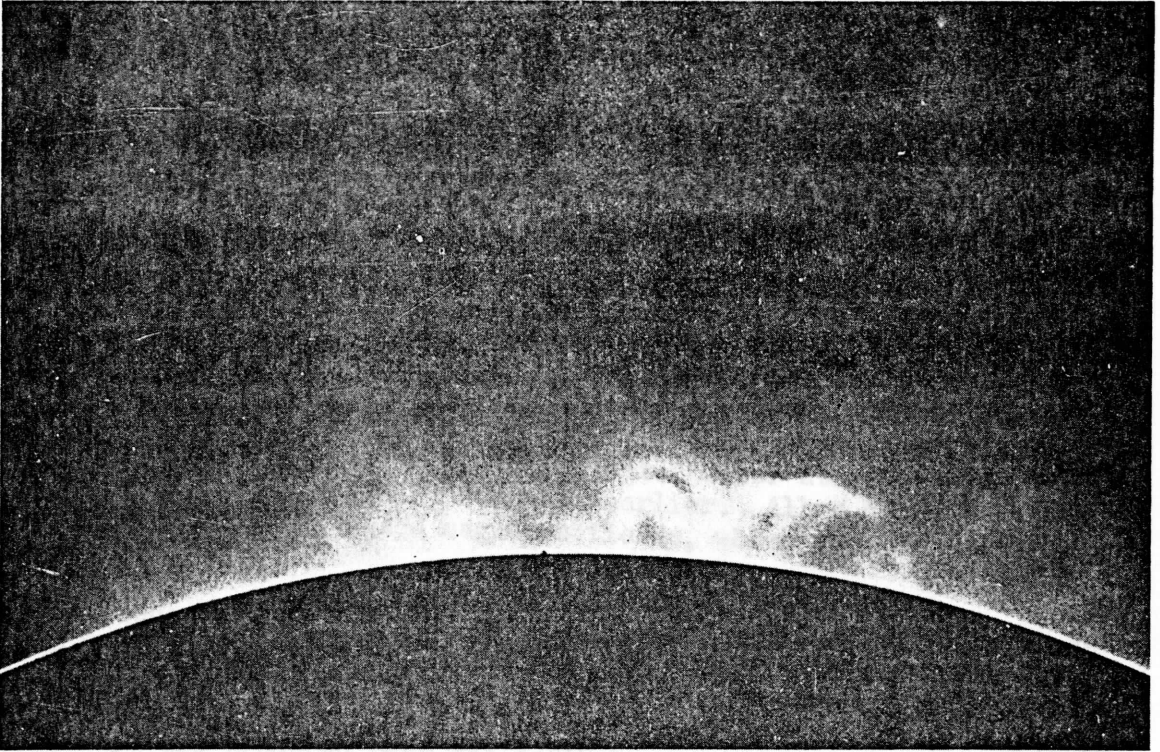


Figure 4

A magnificent new photograph of structure in the green coronal line, from a movie of the corona taken at the Sacramento Peak Observatory on 22 November 1956. The artificial eclipse photograph through a birefringent filter produced by R.B. Dunn to isolate the 5303 Å "green coronal line." Studies of the subtle motions of these coronal forms and of their relation to the more spectacular solar prominences are under way at HAO and at the Sacramento Peak Observatory.

There was general agreement on the need for extension of empirical studies of the atmosphere to higher levels than the ones principally studied today.

Special American Meteorological Society Meeting

From the special AMS meeting there were many interesting new papers. One only, will I describe here--since it relates very directly to work previously discussed in these pages. It is the announcement

by Dr. Dave Fultz, of the University of Chicago, of the initiation of new experimental atmospheric circulation studies with his "dishpan" model of the atmosphere. On these he sets up a model of the atmospheric circulation, and then, with a heated wire, introduces the analog of auroral zone heating by solar corpuscles. His first tests indicated that auroral zone heating produced, with relatively small energy, disruptions of the otherwise stable circulation patterns. The future of this work will be watched with greatest interest.

B. Solar Research

C. W. Allen⁴⁾ has taken another look at comets' tails as indicators of the electrified corpuscles emitted from the sun, and presumably responsible for auroras--earthly or Venusian. His results suggest that possibly the density of ejected solar atomic particles is higher than we have generally conceded earlier. Allen has not considered the effects of space magnetic fields, which may, of course, be highly important.

Dr. Eugene Parker,⁵⁾ likewise has taken a quantitative look at gas clouds impinging on earth from the sun. Unlike Allen, he is primarily interested in what their magnetic fields are like, and how they affect cosmic rays in planetary space. He concludes that the sun's effects on cosmic rays are produced near the earth by magnetic gas clouds captured by the earth's gravitational field. These clouds have their origin in the sun, in Parker's theory, and their effects on cosmic rays from space follow solar activity as the nature of the captured clouds varies with solar activity. The effect of high solar activity is a slight lowering of the general cosmic ray background intensity. Sudden increases, with solar flares, on this view, come from cosmic rays directly ejected from the sun.

The theory is still highly speculative, and in particular the mechanism of capture of the solar gas clouds, with their embedded magnetic fields, is beyond the scope of present theories.

V. RECENT SCIENTIFIC VISITORS AT HAO

1-3 July	Dr. Vincent Schaefer, Munitalp Foundation
2-7 July	Dr. George Gamow, George Washington University
5-6 July	Dr. Richard N. Thomas, Harvard College Observatory
18 July	Mr. Fred Hoyle, California Institute of Technology
22-26 July	Dr. John W. Evans, Sacramento Peak Observatory
23 July	Dr. George Field, Harvard University
22 July	Dr. Walter Steiger, University of Hawaii

4) Allen, C. W., Observatory, 76, 101, 1956.

5) Parker, E. N., Physical Review, 103, 1518, 1956.

6 August	Dr. Harrison Brown, University of California at Los Angeles
6-10 August	Dr. Leo Goldberg, University of Michigan Observatory
13-15 August	Dr. Irving Schell, Tufts University
22 August	Dr. Donald Menzel, Harvard College Observatory
17 August	Dr. Masahisa Sugiura, Geophysical Institute, University of Alaska
4-7 September	Dr. Richard N. Thomas, Harvard College Observatory
2-8 September	Dr. Leona Marshall, Fermi Institute for Nuclear Studies
10 September	Dr. Eugene N. Parker, Fermi Institute for Nuclear Studies
14 September	Dr. John W. Evans, Sacramento Peak Observatory
20 September	Dr. Gerard Kuiper, Yerkes Observatory
26 September	Mr. Richard Dunn, Sacramento Peak Observatory

VI. PUBLICATIONS FROM HAO DURING THE QUARTER

Chapman, Sydney and Sugiura, M.: "Arc-Lengths Along the Lines of Force of a Magnetic Dipole," *Journal of Geophysical Research*, 61, 485, 1956.

Riehl, Herbert: "The Atmospheric Circulation at 500 MB in the Auroral Belt," *Journal of Geophysical Research*, 61, 525, 1956.

Zirin, Harold: "The Temperature and Equilibrium of Hydrogen in Solar Prominences," *The Astrophysical Journal*, 124, 451, 1956.

"Possible Responses of Terrestrial Atmospheric Circulation to Changes in Solar Activity," Technical Report No. 1, Institute for Solar-Terrestrial Research, 1956.

Papers given at American Astronomical Society meetings in Berkeley
24-28 August 1956:

Athay, R. G., and Smith, Elske v. P.: "Chromospheric Profiles of the Early Balmer Lines," Abstract in the *Astronomical Journal* (in press).

Wlérick, Gerard, Axtell, James, and Lee, Robert: "Photoelectric Observations of the Electron Solar Corona," Abstract in *Astronomical Journal* (in press).

Athay, R. G. and Orrall, F. Q.: "Physical Conditions in Solar Prominences," Abstract in *Astronomical Journal* (in press)

Zirin, Harold: "Comprehensive Graded Height Spectra of Solar Prominences," Abstract in *Astronomical Journal* (in press)

Wlérick, Gérard: "Solar Granulation: The Frequency Spectrum of Photospheric Brightness at Long Spatial Wavelengths," Abstract in Astronomical Journal (in press).

Athay, R. G., and Thomas, R. N.: "Some Comments on Photospheric Models," Abstract in Astronomical Journal (in press).

Billings, D. E.: "New Determination of Coronal Temperature from Emission Lines," Abstract in Astronomical Journal (in press).

Billings, D. E., Lee, R., and Newkirk, G.: "A Television Device for Detecting Solar Flares," Abstract in Astronomical Journal (in press).

Dunn, Richard B. and Warwick, Constance: "Coronal Observations with Monochromatic Filter," Abstract in Astronomical Journal (in press).

Walter Orr Roberts

Walter Orr Roberts
High Altitude Observatory
Boulder, Colorado
31 December 1956

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