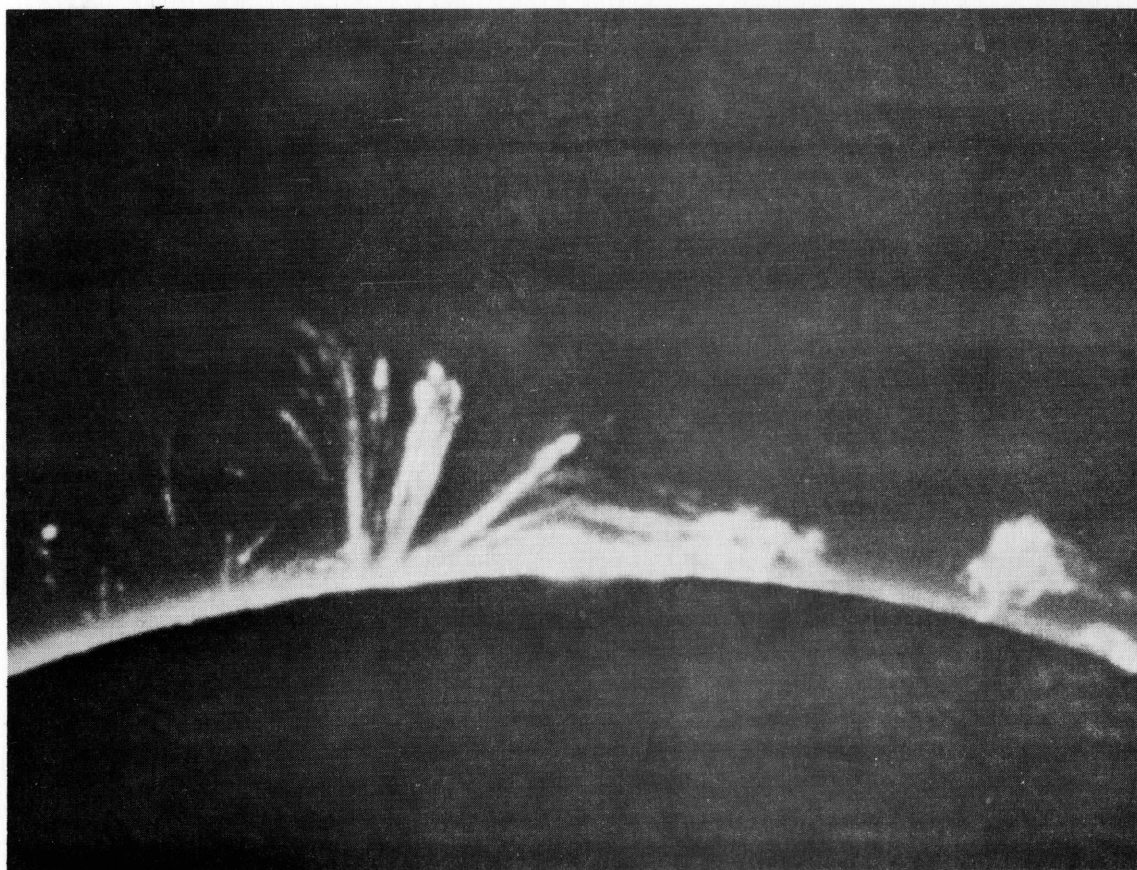


THE  
DIRECTOR'S QUARTERLY REPORT  
1956-1  
1 JANUARY TO 31 MARCH



Radio Noisy Prominences\*

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.

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\* Cover: A "radio-noisy" prominence of the type studied by Wild and Zirin, who suggest (see page 11) that the sustained "radio noise storm" emission at meter wavelengths may have its origin in prominence streamers and loops like these.

## SUMMARY

The meteoric rise of solar activity during the first few months of the year merits the spotlight in this report. On February 9th we recorded, with our new 5-inch coronagraph installed at Climax last August, the faint and rare emission of the "yellow coronal line", telltale sign of extraordinary solar activity. Subsequent days brought a remarkable sequence of solar and terrestrial effects--particularly in cosmic rays--reported in some detail below.

Another highlight of the quarter was the successful completion of the photoelectric "k-coronameter," with which we detect and measure the distribution of the polarized white light of the corona scattered by free electrons. This was an important milestone in the development of instruments for day-to-day detection of the sun's corona.

Work began in January under our Institute for Solar Terrestrial Research. A major part of this effort will be directed towards solar-weather relationships. The first important activity of the Institute program will occur in the summer, when we shall conduct a seminar of six weeks duration. During the seminar the most promising areas of solar-weather research will be evaluated, and programs of further study mapped out, not only for work at HAO but also at other institutions. An impressive group of meteorologists will participate.

In January J. Paul Wild, radio astronomer from the Radiophysics

Division of the Commonwealth Scientific and Industrial Research Organization in Australia, joined us for a two-month visit. During this time he combined forces with Harold Zirin for an observational attack on the problem of the origin of meter-wave solar radio noise "storms". Using film files from the Climax coronagraph, they found evidence that radio-noisy sunspot regions are generally characterized by solar prominences of looped and "coronal" character. These exhibit pronounced downflow towards the solar surface from tightly closed loops, or from apparently "empty" reaches of the solar corona. Inherent in this observation is the suggestion that these distinctive prominences are in some way directly related to the formation of the radio noise signals.

The following report is for private use and information only. It describes unpublished work of a number of investigators and should therefore be treated as of the nature of a private communication, pending correction or publication. Public reference to this material should be withheld unless specifically approved by the authors of the work, or unless the material has subsequently been published.

## I. HIGHLIGHTS OF THE QUARTER

### Solar Activity Surges Upwards

At about 10:30 p.m. on the night of the 22nd of February I was called to the telephone of my home in Boulder by Richard Hansen, phoning from the Observatory station at Climax. Hansen reported excitedly that he and David Dodgen had just been checking the operation of the cosmic-ray counters in our laboratory Quonset. To their amazement the counters were racing madly at a completely unprecedented rate. The furious clicking of the counter relays indicated that cosmic rays were bombarding the earth at a vastly increased rate—or, as they at first suspected, that the apparatus was broken down. On the hunch that the increase was real, they immediately telephoned Dr. John Simpson, of the Fermi Institute of the University of Chicago, for whom we operate the cosmic ray equipment. Dr. Simpson, they found, had already been called to his laboratory because of the increased counts of his similar "neutron pile" there in Chicago. Obviously the effect was real.

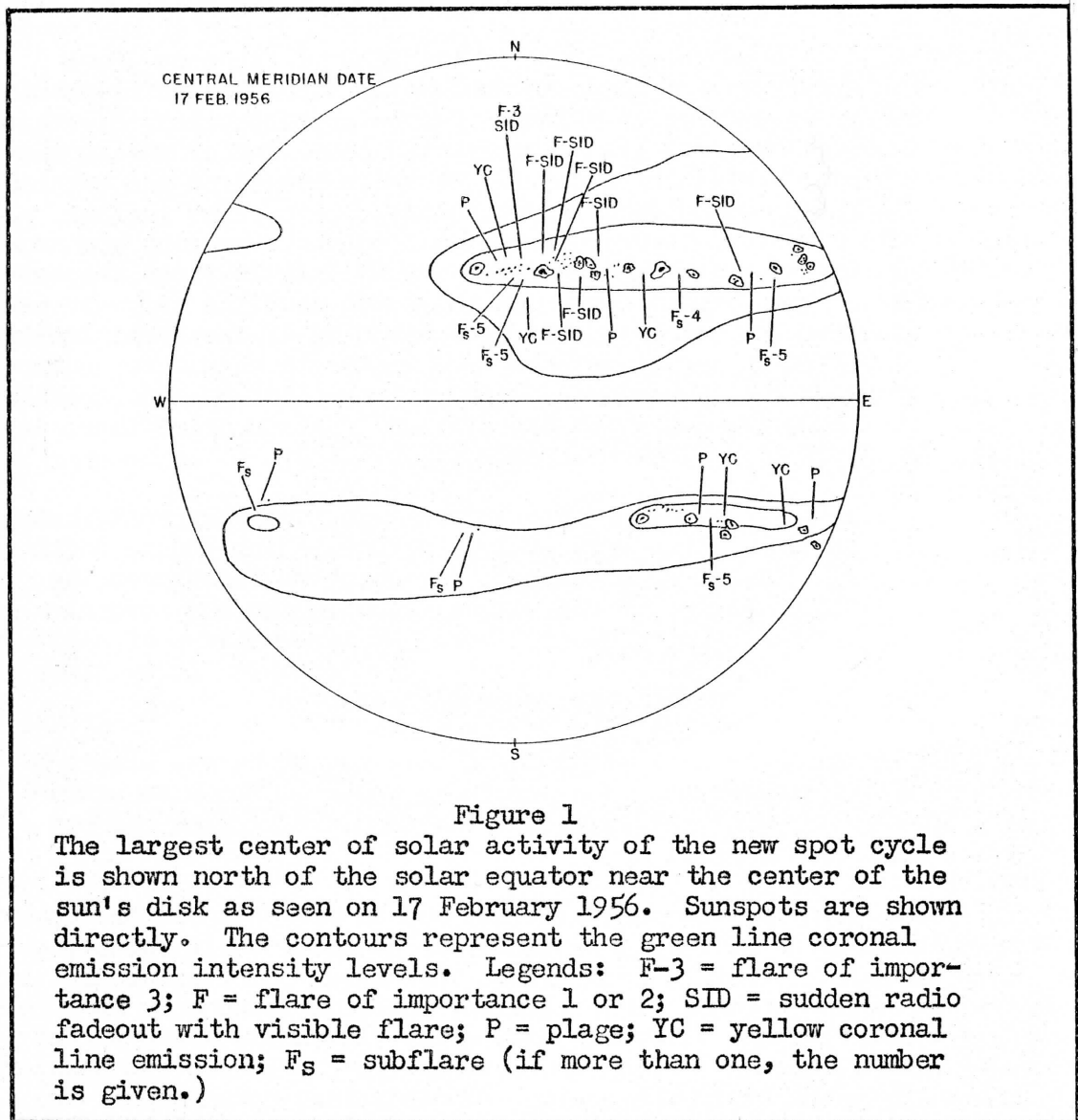
The increase was, when the facts were all in, not only real, but worldwide. Confirmation came from Italy, England, Peru, India, South Africa, the Soviet Union, Canada; cosmic ray counters throughout the world recorded an increase that was without parallel in the several decade long history of cosmic ray research. Climax, because of altitude and latitude, recorded the largest increase: a factor of forty times normal for the kind of cosmic rays detected there!

We were not caught unawares by the cosmic ray outburst, although its magnitude was a surprise. The preceding weeks had seen an extraordinary upsurge of solar activity, and the cosmic ray pulse was but one of its manifestations.

The first sign that unusual activity was in progress was the behavior of a disturbed region  $20^{\circ}$  north of the solar equator, as it rotated on to the sun's visible face on February 9th. The Climax observers found that it exhibited yellow coronal line emission, which is found only in outstanding active regions. The next day, alas, Climax was cloudy. The observers at the Sacramento Peak Observatory, however, were on the alert for unusual prominences in the region. Indeed, they found them: the fastest moving prominences yet discovered, with knots exhibiting speeds of well over 1,000 miles a second, actually about three times the previous all-time record.

The region was more like an explosion than an ordinary prominence. Dr. Mohler, of the McMath-Hulbert Observatory in Michigan, detected the motion just by watching in the eyepiece of the observing telescope: an extraordinary situation, since the sun's 90-million mile distance means

that even a few hundreds of miles per second speed cannot be seen without special time-lapse motion picture techniques. Dr. Mohler and his colleagues studied with fascination the ejection and the associated,



but less apparent, brightness and form changes in the prominences. Dr. Mohler later described the event as one of the most unusual in his long experience as a solar observer.

Subsequent days brought a spectacular development of sunspots. They became large enough to be readily seen with the naked eye-protected,

of course, by dark film or smoked glass. Figure 1 shows the appearance of the sunspots on 17 February, after the sun had made about a quarter-turn. On this drawing we have also indicated the locations of the principal solar flares, and the outlines of the regions of strong coronal emissions.

As the spots crossed the sun's face we watched for sun-induced terrestrial disturbances. At least 20 importance solar flares occurred, some of them quite notable, and more than twice as many "subflares." With these flares and subflares were associated more than 15 sudden fadeouts of short wave radio communications. Five magnetic storms occurred, one of which was of outstanding character; four of these had distinctive worldwide sudden commencements. Radio noise storms and outbursts occurred on all radio frequencies regularly monitored. Robert Lee recorded a very striking sudden fadeout of cosmic radio noise, discussed below and demonstrated in Figure 2, page 7.

The outstanding activity, however, occurred early in the evening of February 22nd (at 03:31 Universal Time on 23 February). The primary event was a large solar flare detected at Kodaikanal Observatory, India, and at Tokyo, Japan. The flare was exactly at the location of the 9th of February yellow coronal emission, though by now the region was very near the opposite edge of the sun. Unfortunately for us in the Western Hemisphere, the flare occurred well after sundown, and it took two or three days for us to learn authoritatively of its size, brightness and location.

The cosmic ray outburst began about 12 or 15 minutes later, and gave rise to the excitement at Climax that I have described above. Now that the full story of the associated effects is coming in, we know that this was one of the most remarkable of solar-terrestrial events of all time, with effects of striking character in cosmic rays, the ionosphere, earth magnetism, and other upper atmospheric phenomena.

Perhaps equally as important as the cosmic ray increase, were some new effects found by the National Bureau of Standards group in auroral latitudes; namely, polar radio blackouts in the dark earth-hemisphere without accompanying geomagnetic disturbance. Effects are usual in the sunlit hemisphere, but night hemisphere effects of this sort, unless there are magnetic disturbances, have not previously been known. A full study of these effects is in progress, and a preliminary report on them will be made at a meeting of the International Scientific Radio Union in Washington D. C. in May, by Mr. A. H. Shapley of NBS and me.

#### Detection of the Electron Corona

One component of the sun's corona of great importance, the electron corona, or k-corona is particularly difficult to observe outside of natural solar eclipse. It is possible that this part of the corona may have

time-variations and space distributions that differ appreciably from those of the spectrum lines of the corona. These differences, we think, will be very significant for an understanding of the formation of the corona and its earth effects.

The detection of the electron corona, masked by scattered sunlight, must be made not by virtue of its confinement to a portion of the spectrum, as with the emission line corona, but by virtue of its polarization. Photoelectric polarization-detecting devices, coupled with special coronagraphs designed to reduce parasitic polarization, make such observations, possible, in principle at least. Dr. Bernard Lyot, early in the 1930's, showed that a suitable polarization detector could discern this element of the corona near to the sun's edge. Wlérick has now found it possible to detect the electron corona photoelectrically with a refined device of principle similar to Dr. Lyot's. He has made observations from Boulder that have revealed the corona, to a height of 0.6 solar radii in a particularly strong region of electron corona emission.

We believe that direct observations of the electron corona, coupled with the more conventional observations, will give us an added way to try to separate the effects of coronal temperature from coronal density, in developing a theory of the corona, and will also permit us to determine the three-dimensional shape of coronal streamers projected into space. Such streams, there is reason to believe,<sup>1)</sup> may be the pathways in interplanetary space taken by the aurora-producing corpuscles that cascade into the earth's high latitudes, disturbing radio communications and earth magnetism. If so, their day-to-day observation will be of great geophysical significance, and may assist in the forecasting of their effects on radio communications and weather.

We expect to devote a part of the work of the Institute for Solar-Terrestrial Research to defining the space trajectories of these streamers.

## II. INSTITUTE FOR SOLAR-TERRESTRIAL RESEARCH

It is a great pleasure to announce officially that the HAO Institute for Solar Terrestrial Research is under way. We wish only that Mr. Ralph S. Damon, whose enthusiasm for the Institute was so great, were with us to share in our satisfaction. His untimely death in January cost the HAO a valued friend and Trans World Airlines a most able president.

Work under the Institute program of the HAO began in a modest way in January. The activity was mostly of a preliminary sort aimed at planning for later research projects.

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1) Pecker and Roberts. J. Geophys. Res. 60, 33, 1955.



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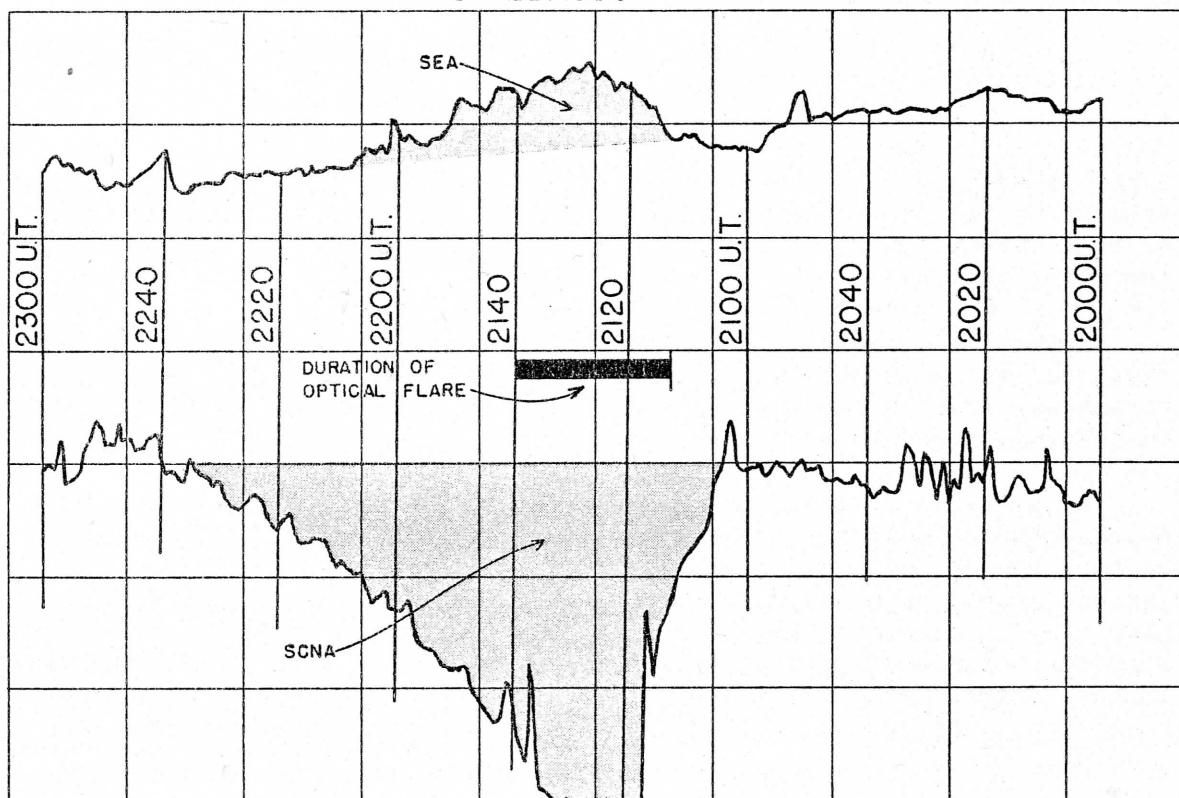


Figure 2

Graphs traced from original "indirect flare detectors" designed for the IGY by R. H. Lee. Upper trace shows the amount of radio noise at 27 kc/s and exhibits a small but definite increase (Sudden Enhancement of Atmospherics) at the time of the solar flare. The lower trace shows the drop in radio signal strength from galactic radio noise at about 18 mc/s (Sudden Cosmic Noise Absorption) at the flare time. Note that the SCNA precedes the visible light flare and lasts considerably longer than the flare.

The principal HAO staff members who plan to be engaged immediately in the Institute program include Newkirk, Roberts, Axtell, and Athay. Athay will rejoin the staff in June after a year's leave of absence at Harvard College Observatory. Axtell, a graduate student at the University of Colorado, has been working with Wlérick on the k-coronameter and will continue the program, aimed at detection of electron streamers, after Wlérick leaves in the fall. His work, if successful, will be made the subject of his Ph.D. thesis.

## Indices of Solar Coronal Emission

We held several conferences this quarter to evaluate the usefulness, the reliability, and the physical meaning of indices of coronal brightness for the whole sun and the visible hemisphere of the sun. One index, computed by Mr. E. D. Farthing of Trans World Airlines, has been used for a number of solar-weather studies. It is based on east solar limb observations of the green and red coronal lines, and seeks to estimate the average intensity of emission of a small region of the sun's disk near the solar center.

Several alternative indices are possible, and the computations for these suggest that some might possess higher reliability for research purposes. Indices for the sun's whole visible face and for the entire solar surface should also have geophysical importance.

As a result of this work, we have begun issuing, under the routine data reporting program of the Observatory, indices of the whole solar surface and of the visible solar disk. The first to be published will include indices for the last quarter of 1955 which will appear soon. We have also commenced publication of indices for small segments of the solar surface corresponding to one day's solar rotation. These are issued monthly in the Central Radio Propagation Laboratory F-series, Part B, publications of the National Bureau of Standards, and can be sent to interested users.

## Seminar on Solar-Weather Research

The plans for the solar-weather seminar from 18 June to 27 July are rapidly becoming firm. The seminar will include a group of about 20 solar astronomers and meteorologists who will meet daily to review systematically the progress in all known fields of solar-terrestrial research with possible relevance to problems of solar-weather connections. Each day's meeting, which will last from one to one-and-a-half hours, will be led by a person assigned to cover some aspect of solar weather research, and to lead a "free-for-all" discussion of the pros and cons of the observational data or the theoretical analysis presented. We will hope to outline the most promising directions for future work in some detail, but will not expect to come up with results of forecasting significance at this early stage.

Acceptances for attendance have been received from the following:

- Dr. Glenn Brier, U.S. Weather Bureau
- Dr. Sydney Chapman, HAO and Geophysical Institute of the University of Alaska
- Mr. Robert Curtis, Continental Air Lines
- Mr. E. D. Farthing, Trans World Airlines
- \*Mr. Paul Julian, Pennsylvania State University
- Dr. Julius London, New York University

\*Mr. Jack Nord~~ø~~, M.I.T. and Inst. for Theoretical Astrophysics  
Norway  
Dr. C. E. Palmer, Institute of Geophysics, U.C.L.A.  
Dr. Hans Panofsky, Pennsylvania State University  
\*Mr. Irwin Ruff, New York University  
Dr. Ralph Shapiro, Air Force Cambridge Research Center  
Dr. Willem Vanderbyl, Netherlands, and Kansas State College  
Dr. E. H. Vestine, Carnegie Institution of Washington  
Dr. Hurd C. Willett, M.I.T.

Those marked by asterisks (\*) are graduate students working for advanced degrees in other institutions, to whom fellowships, or help with expenses have been extended.

From our own staff the following will participate:

Dr. R. Grant Athay  
Dr. Donald E. Billings  
Dr. Gordon A. Newkirk  
Dr. Walter Orr Roberts  
Dr. Harold Zirin

We are happy to report formally that the seminar will be supported not only from the Institute program, but also by a grant from the National Science Foundation. The seminar has also been endorsed by the American Meteorological Society and the American Astronomical Society.

The last three days of the seminar, July 25, 26, and 27 will be a special three-day meeting of the American Meteorological Society devoted to solar-weather investigations. The program is now being completed, and will be published soon in the Bulletin of the American Meteorological Society. Attendance is invited for all who are interested.

### III. OTHER RESEARCH PROGRAMS OF THE HAO

#### A. Staff

During January, February and part of March we had the pleasure of an extended visit from J. Paul Wild, distinguished radio astronomer from Australia. Wild joined the staff for intensive research on solar prominences, in which he was joined by Zirin. His work, which is briefly reported below, was sponsored principally by the Air Force Cambridge Research Center.

Another distinguished visitor was Dr. Helen Dodson, of the McMath-Hulbert Observatory who spent ten days with us in February. Her visit stimulated our work enormously. She discussed solar-terrestrial ties in the flare-ionosphere field, and gave us the benefit of her vast experience

with the observed physical characteristics of solar flares. She also discussed at length the origin of solar radio noise, and sun-induced geomagnetic disturbances. Her visit was sponsored by the National Bureau of Standards.

The Observatory suffered a serious loss when Mrs. Kathryn Virnelson, my assistant, decided to resign her post. Her services have been of inestimable value to the Observatory during its formative years. Mrs. Virnelson was married in March to Mr. Alan H. Shapley, of the National Bureau of Standards. She will stay with us until the completion of the summer seminar, which she will manage. Her place as Assistant to the Director will be taken by Mrs. Mary L. Andrews, who joined us in March.

## B. Research in Progress

### 1. General

In the last report we attempted to give a brief descriptive explanation of the major research projects under way at HAO. From now on, we plan only to list these projects, but to single out individual ones from time to time for a somewhat more thorough description. Consequently, many programs on which we are hard at work will have no detailed description, until a particular advance, or obstacle, makes it especially timely.

### 2. Active Region Analysis

During the first quarter of the year we were unusually fortunate in obtaining very complete solar observations of several outstanding regions of solar activity, including the region responsible for the cosmic ray increase described above. Coverage at Climax and Sacramento Peak, when combined, gave us unusually complete data. Moreover, we had new types of equipment in operation at both stations: at Climax, the graded-height spectrograph described in earlier reports; at Sacramento Peak, a new birefringent filter apparatus with which excellent photographs can be made of the shape of coronal structures at the sun's edge.

As a result of the good coverage with these instruments, we plan a complete study of the life history of the big active region described earlier, in its successive limb passages. In particular, the observations of 9 March at the east limb are outstanding. From this we hope to obtain a fuller description of the temperature and density structure of an active region than has been possible before. Roberts, Newkirk, and Zirin visited Sacramento Peak early in April to lay firm plans for this work, which will be supported under our Air Force solar research contract, supervised by Newkirk.

### 3. Solar Effects in the Ionosphere.

The IGY recorder for indirect detection of solar flares described in my last report, 1955-5, was experimentally operated during the quarter with profitable results. Figure 2 shows the traces obtained from the original records for the flare of 10 February 1956, from the recent region of great activity. A clearcut simultaneous effect shows in cosmic radio noise and in the ionospherically reflected atmospheric radio noise of distant thunderstorms. During the IGY we will routinely operate such a recorder to give us a more complete list of solar flares.

J. Warwick's program on refraction and absorption effects in the ionosphere and Matsushita's work on "sporadic E layer" effects and "polar blackouts" continued successfully.

Chapman's work on thermal conductivity in the corona, and its ionospheric implications was put into shape for publication during his stay in Alaska.

### 4. Solar Effects in Geomagnetism.

The surge of solar activity this quarter had accompanying effects in geomagnetic disturbances and auroras. We are working on these, and on more general study of such phenomena, in a cooperative effort with a group from the National Bureau of Standards.

### 5. Observations of the Electron Corona (See Highlights, above).

### 6. Solar Activity Observing.

This work continues, stimulated by the upswing of solar activity.

### 7. Temperature and Motions in the Corona.

The work continues also with Billings and Schwartz carrying on the principal activity.

### 8. Temperature and Radio Emission of Solar Prominences.

Emphasis in this program, sponsored under our Air Force Cambridge Research Center contract, was directed towards the radio noise emission of solar prominences, as a result of the visit of Wild. This work led to the finding that sunspots accompanied at their limb passage by a distinctive type of prominence, (characterized by downflowing loops and streamers) are likely to emit the sustained radio noise of meter wavelengths of the kind generally

designated as a "noise storm." The results were presented by Zirin and Wild at the March American Astronomical Society meeting, and will be published soon in the Australian Journal of Physics.

The cover figure shows the type of prominence that seems to produce such a noise storm. Figure 3 (page 13) shows another kind of radio noise emission for which Zirin and Wild studied the prominence associations. In this case they found an abrupt outwards-moving surge-type prominence to be accompanied by sharp radio noise bursts at 167 mc/s. Often they were unable to find prominences that could be associated with such bursts, but in some cases an association was unmistakable. Where there was an association, the bursts seemed to be connected with the initial impact of the out-going prominence material on the lower corona.

#### 9. Solar Granulation Analysis.

Wlérick is working on a paper that deals with the importance of the large scale structure in white light photographs of the sun.

#### 10. Chromospheric Research.

Plans for the 12 October 1958 eclipse are moving ahead slowly. Dr. Athay will return in June and will continue analysis of the 1952 eclipse, as well as planning for 1958.

Some recent spectra taken by the Climax observers with the coronagraph reveal interesting chromospheric features. They show the greater width of H-alpha emission in the chromosphere at the location of plages as compared to the "normal" chromosphere. I reported on these spectra at the March American Astronomical Society meeting.

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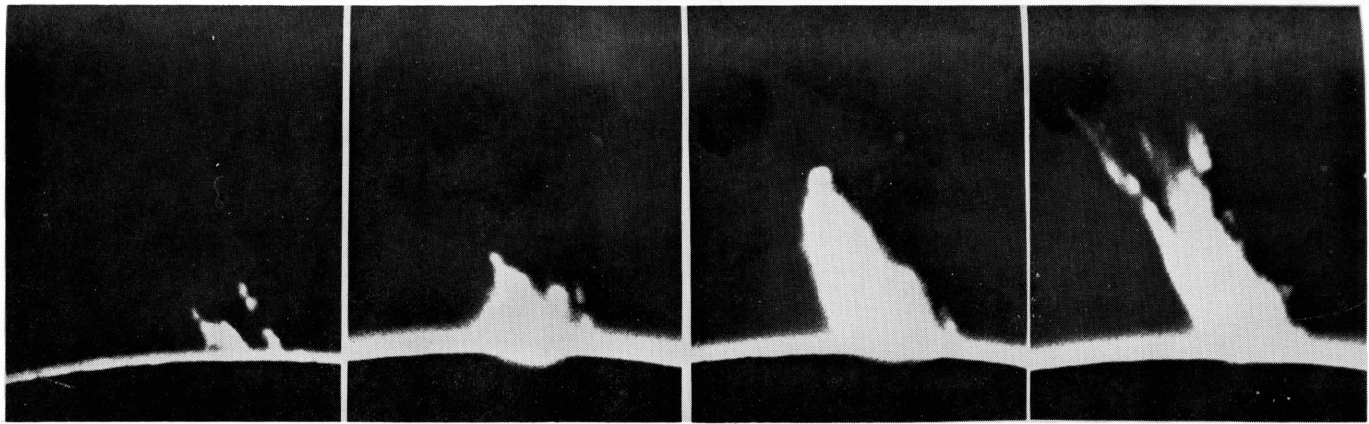


Figure 3: A giant surge prominence and associated radio noise bursts. Below are shown the heights at different times for selected features of the prominence. At the lower right is a sunspot drawing, with the location of the limb surge indicated. The times of photos A, B, C, and D are given on the burst diagram (center). It is likely that the surge began some minutes before A, but reached the solar edge just at time A.

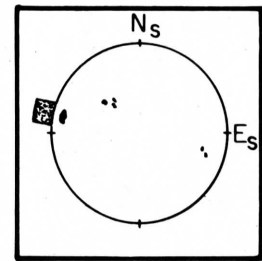
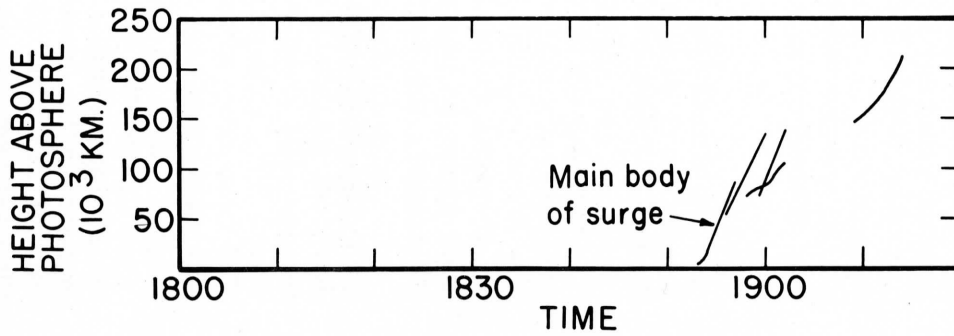
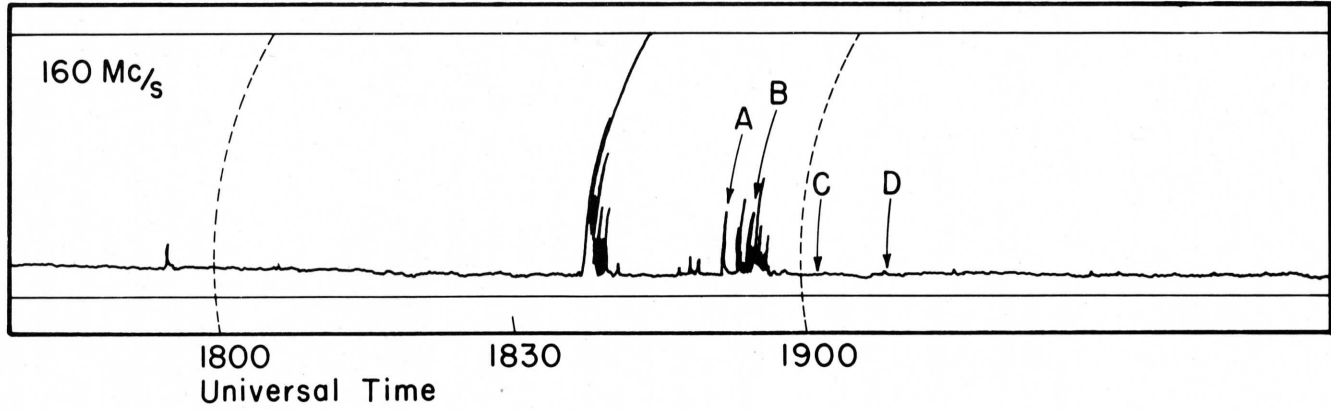


A

B

C

D



20 APRIL 1950

Figure 3

#### 11. Electronic Flare Pickup.

This project ran into snags during the quarter. They derived from the failure of the 393A K-line filters to meet the necessary transmission specifications for flare detection. We have not decided whether the planned goals can be reached, but will have to bring the program to definite conclusions within a month or two, if the device is to aid in the Navy's balloon-borne rocket research program for which it is planned.

#### 12. Measurement of Older Coronal Plates.

This work is progressing satisfactorily.

#### 13. Guide Book on Solar Activity.

The Guide Book moves slowly forward under C. Warwick's supervision.

### IV. RELATED PROGRESS AT OTHER INSTITUTIONS

#### A. Solar-Weather Research.

During March we had a most fruitful visit from Dr. E. B. Kraus of the Snowy Mountains Authority, a water resources program in Australia. Dr. Kraus related to us his interesting studies<sup>2)</sup> of long period trends in tropical rainfall at different parts of the world. He has examined such areas as his own Snowy Mountains, the Nile basin (through Nile flow at Aswan), the West Indies, India, West Africa, Honolulu, and the U. S.

Dr. Kraus reports that there was a definite alteration of mean tropical rainfall about 1896, with greater rain before, and lesser afterwards. His data suggest the effect at all places at latitude less than about 35°, with certain definite exceptions, such as monsoon regions. The mean drop after 1896 or 1897 seems to have been about 20% for tropical stations.

Dr. Kraus did not offer any detailed explanations, but feels that extra-terrestrial theories have much to offer. He also believes that upsetting the heat balance of the tropics by decreasing the precipitation may affect wind flow at high latitudes, through dynamical linkages. Glacial periods, he believes, may thus be a consequence of tropical pluvial periods.

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2) Unpublished but being prepared for publication.



During the New York American Meteorological Society meetings in January, I had some discussions with Dr. A. Kochanski of the Air Weather Service about certain problems of average wind flow patterns at the 50mb, and 25mb. levels, which he and his associates have studied extensively.<sup>3)</sup> We at HAO feel there are possibilities that some of the abrupt changes of flow at these high levels are triggered by solar events, and particularly by solar corpuscular emission, and we hope that it will be possible for Dr. Kochanski to make some average flow maps for specific periods chosen on the basis of solar corpuscular data.

During the period we learned of a pending publication by Dr. E. G. Bowen,<sup>4)</sup> of Australia, who reports further evidence of association of meteor showers with singularities in precipitation 30 days later. Bowen also reports that the Bielid meteor shower, which has a periodic intensity fluctuation of about six years, appears to produce a related six year periodicity in the associated December-end rainfall peak. Bowen also considers the influence of changed precipitation on the heat economy of the atmosphere, and the possibility of large scale dynamic consequences of forecasting significance.

Dr. Fred Whipple<sup>5)</sup> recently criticised the Bowen hypothesis on the grounds that the shower meteors would add only a negligible fraction to the normal background of meteoric dust from "sporadic" meteors. Whipple also contradicts Bowen's assertion that noctilucent clouds can be conclusively associated with meteor showers. The arguments of Whipple, thus, will need to be considered carefully in the development of a sound physical theory of Bowen's observations.

Dr. F. H. Ludlam,<sup>6)</sup> summarizing a symposium in London last summer, cites evidence that the number of particles of "cosmic" dust is normally sufficient to provide nuclei for all observed terrestrial clouds. The evidence is based on studies of the intensity of the solar corona and zodiacal light, rather than meteors. It supports, in a general way, the notion that variations in interplanetary material can play a significant role in cloud physics, and thus in atmospheric circulation.

Stroud, Nordberg and Walsh, of the Signal Corps, analyzing wind and temperature changes at high levels,<sup>7)</sup> from measurements of smoke grenades fired from rockets, conclude that 12 rocket flights fail to reveal any unusual developments that can be attributed to direct solar radiational

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3) For example, Kochanski and Wasko, Bulletin of the A.M.S., 37, 61, 1956.

4) Bowen, Journal of Meteorology, 13, 142, 1956.

5) Whipple and Hawkins, Astron. J., 61, 14, 1956.

6) Ludlam, Nature 177, 320, 1956.

7) Stroud, Nordberg, and Walsh, J. Geophys. Res., 61, 45, 1956.

effects. This is further evidence that solar effects, such as the persistence-corpuseular energy relation of Shapiro, are through indirect dynamical links.

## B. Solar Research

Several reports in the recent solar literature have particular interest. A paper by Dr. J. A. van Allen and his associates offers the interesting new idea<sup>8)</sup> that soft X-rays (Brehmstrahlung from decelerated electrons) may be generated in the earth's upper atmosphere by the arriving solar corpuscles responsible for the aurora. The idea suggests, as Dr. Chapman has pointed out to us, the possibility that these rays may get lower enough in the atmosphere to explain some of the more perplexing auroral and ionospheric effects. There is a possibility, if the hypothesis stands up, that the mechanism could have a role in weather phenomena also.

Waldmeier recently issued a most important paper,<sup>9)</sup> in which he suggested that streams of coronal matter pass in arches over the mid-latitude quiescent prominences, and fall into the sun in polar regions, where they are associated with the transient coronal rays of about 15 hours lifetime, which he has studied extensively. The idea is a challenging one, though it does not square in detail with our own notions of the formation of the corona.

Dr. Sarah Lee Lippincott has recently published a useful paper giving additional data on solar spicules.<sup>10)</sup> This confirms and extends data published earlier by Rush and me.

Dr. Helen Dodson recently made a full study of the life history of the active region of 20-26 August 1954, one of the first of the new spot cycle. A summary has now been published.<sup>11)</sup> We are particularly interested in the region, because there is some evidence that a warning of the outbreak of the active region might have been derived by alert watchers from the appearance of limb prominences a few days before the outbreak. It suggests the importance of solar prominence patrols, somewhat neglected both observationally and analytically in recent years. We plan, partly as a result of her study, to intensify our prominence motion studies during the I.G.Y.

The new research field of radio "whistlers"<sup>12)</sup>—audio frequency

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8) Meredith, Gottlieb and van Allen, Phys. Rev., 97, 201, 1955.

9) Waldmeier, As. f. Ap. 37, 233, 1955.

10) Lippincott Astron. J. 61, 8, 1956 (Abstract).

11) Dodson, Astron. J. 61, 2, 1956 (Abstract).

12) For example, see papers by: Morgan and Dinger, Nature 177, 29, 1956, and Morgan and Allcock, Nature 177, 31, 1956.

radio waves picked up on ordinary amplifiers--has great promise for research on solar effects on earth. These whistling sounds apparently result from the electrical noise of lightning flashes, after the pulse has travelled along lines of the earth's magnetic field from one hemisphere to the other and back. Knowledge of the highest reaches of the atmosphere, the propagation medium for the whistlers, may come from the observations, which already suggest that at very high altitudes the ion densities are greater than usually assumed. We will watch this field most carefully.

Dr. Hatanaka, who has long been interested in the solar origin of radio noise, recently published a valuable paper<sup>13)</sup> in which he related polarization measures of radio bursts to the properties of magnetic fields of the solar coronal regions responsible for the bursts. He finds evidence that magnetic fields high above a sunspot region are perpendicular to the solar surface--an idea that conforms nicely to our own notions derived from solar prominence motions<sup>14)</sup> and from our efforts to explain solar corpuscular emission responsible for magnetic storms.<sup>1)</sup>

Drs. Horace and Harold Babcock, of Mount Wilson Observatory, recently published a paper<sup>15)</sup> in which they identified the solar origin of the M-region magnetic storms of the declining years of the sunspot cycle with "unipolar" magnetic regions of the solar surface--regions where a magnetic field of one sign only is detectable, and where, they postulate, solar corpuscles will have an easier time to escape from the solar atmosphere. We are not entirely convinced that the data justify making a general hypothesis and ourselves favor a somewhat different theory,<sup>1)</sup> which does not agree with the Babcocks' hypothesis. However, future observations which are most capably being made by the Babcocks will settle this point conclusively.

Another highly provocative paper, by Forbush and Vestine,<sup>16)</sup> shows that sudden commencements in magnetic storms are larger in size when they occur in the daytime hemisphere, and also are larger on days when the regular diurnal variation in the horizontal force of the earth's magnetic field is larger. This suggests that on some days, when ultra-violet solar radiation (responsible for the conductivity of the E-region in the equatorial belt) can be presumed stronger, the magnetic effects will be increased--which in turn suggests that the atmospheric currents responsible for the magnetic effects are close to the earth's surface and not high overhead.

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13) Hatanaka, Proc. Japan Acad. 31, 81, 1955.

14) Roberts, Proceedings, Jodrell Bank Radio Astronomy Symposium, August 1955 (in press).

15) Babcock and Babcock, Ap. J. 121, 349, 1955.

16) Forbush and Vestine, J. Geophys. Res. 60, 299, 1955.

Further tests of this notion are highly important in solar-terrestrial research--both for ionospheric and for upper atmosphere wind research.

#### V. CONFERENCES AND DISCUSSIONS

From January 4th to 6th Lee, Dodgen and I visited the Sacramento Peak Observatory to confer on problems of research and instrumental development.

On 15 January Wlérick, Chapman and Klein went to Sacramento Peak. Chapman lectured on corona and ionospheric relationships, and Wlerick conferred with the Sacramento Peak Staff on problems of observation and analysis of solar granules and monochromatic mottling.

From 15 January to 1 February I visited Ottawa, Boston, Washington, D. C. and New York. At Ottawa I delivered an invited lecture to the National Research Council. In New York I attended the meeting of the American Meteorological Society.

Newkirk went to the Astronomical Society of the Southwest meeting in Lubbock, Texas, 24 and 25 February, where he delivered a paper on solar-terrestrial research.

Zirin, Wild, Wlérick and I attended the American Astronomical Society meetings in Columbus, Ohio, 21 to 25 March. Papers were presented by Zirin, Wild, and me.

On March 16 and 17 I travelled to Denton, Texas, to deliver the annual Science Day lecture at Texas State College for Women.

Additional scientific conferences were held during the quarter with Mr. E. D. Farthing of TWA (3-5 January); Dr. Eugene N. Parker of the University of Chicago (10-12 January); Dr. William A. Miller of RCA (1-5 March); and Dr. Jules Aarons of the Air Force Cambridge Research Center (27-28 March).

#### VI. PUBLICATIONS FROM HAO DURING THE QUARTER

Chapman, Sydney and K. C. Westfold (University of Sydney, N.S.W., Australia): "A Comparison of the Annual Mean Solar and Lunar Atmospheric Tides in Barometric Pressure, as Regards their Worldwide Distribution of Amplitude and Phase," J. Atm. and Terr. Phys. 8, 1, 1956.

Athay, R. G. and R. N. Thomas: "Temperature Gradients in the Chromosphere;" Ap. J. 123, 299, 1956.

Athay, R. G. and R. N. Thomas: "Some Characteristics of a Chromospheric Model," Ap. J. 123, 309, 1956.

- Athay, R. G. and D. H. Menzel: "A Model of the Chromosphere from the Helium and Continuum Emissions," Ap. J. 123, 285, 1956.
- Billings, D. E., R. T. Hansen and C. Varsavsky: "Spectra of the Corona at Graded Heights," Astron. J., 61, 1, 1956 (abstract).
- Zirin, H.: "High Dispersion Spectra of Prominence and Coronal Emission Lines," Astron. J. 61, 14, 1956 (abstract).
- Newkirk, G. A. and W. O. Roberts: "Solar-Terrestrial Studies," Paper given at Astronomical Society of the Southwest, Lubbock, Texas.
- Matsushita, S.: "Sequential Es and Lunar Effects on the Equatorial Es," Journal of Geomagnetism and Geoelectricity, 7, 90, 1955.

*Walter Orr Roberts*

Walter Orr Roberts  
High Altitude Observatory  
Boulder, Colorado  
15 May 1956

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It is my sad duty to report the death of Mr. Erskine R. Myer, member of the Board of Trustees of the High Altitude Observatory since its founding in 1946. Mr. Myer has been a most valuable member of the Observatory family during these years. His firm hand has guided the progress of the Observatory in its formative years and we shall very much miss his wise counsel.

Walter Orr Roberts