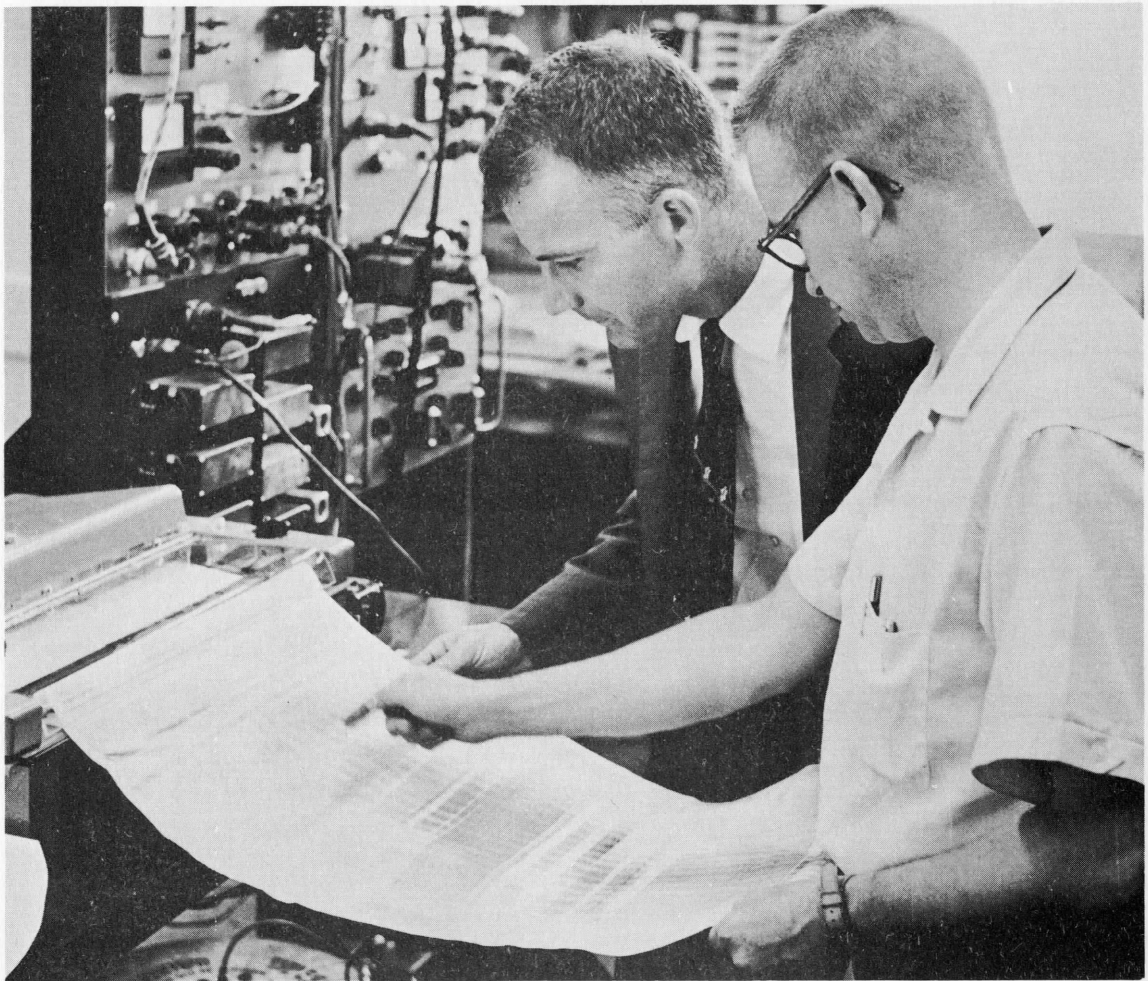


THE DIRECTOR'S REPORT

1 January through 30 June 1959



*Solar Radio Noise Spectrograph**

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

The High Altitude Observatory is an independent non-profit research and educational institution closely associated with the University of Colorado. Its major research objectives are study of the sun and the sun's effects on the earth.

*Cover: Warwick (left) and Lee examine some of the first test records from the new HAO solar radio noise spectrograph which they have developed. The spectrograph, completed in June, measures solar radio emission received in the HAO radio interferometer over the spectrum range 14.5 Mc/s to 35 Mc/s. Its range will later be extended to over 50 Mc/s. (Photo by Christiane Gallet.)

SUMMARY

The solar-weather research of HAO has led us to a most surprising result, described under HIGHLIGHTS. For a third consecutive winter half-year we have found a strong change in wind circulation at jet stream levels on the days following large increases of the sun's electrified particle emission. The result holds promise for substantial improvements in our knowledge of and ability to predict weather changes, if it proves after further research to be genuine and if we can discover its physical causes.

Financing for our new Boulder research center was completed through the generosity of many friends. Construction will be well under way before the year is over.

The hydrogen atomic bomb blasts of August 1958, made at high altitude over the Pacific Ocean, have come under detailed scrutiny here. Matsushita, particularly, has extensively studied the ionospheric and geomagnetic effects of these blasts, and found substantial influences both from the associated shock wave and from the high energy particles released.

A solar flare of 9 June 1959 occurred near the solar edge, and gave us the opportunity for excellent observations of the sunlight scattered by a dense cloud of electrons that rose from the flare region. The observations of the polarization of this light failed to reveal the marked deviations from the radial direction expected on the basis of one of

the leading new theories for the origin of sun-produced cosmic rays.

We shall be doing more to test this new theory in future work.

Solar observations continued in the post-IGY period at a level nearly equal to that of the IGY. There is strong justification for continuation of intensive observations at least until solar activity reaches the expected minimum around 1964. Many new areas of solar-terrestrial research have been discovered during the IGY, and there are many new phenomena to be compared with the day-to-day changes of the sun's activity.

I. HIGHLIGHTS

Further Evidence for a Solar-Weather Effect

About once a month, on the average, the earth collides in space with an abnormally dense cloud of electrically charged particles that has been ejected from the sun one to three days earlier. The result is a large auroral display that lights up the northern sky, at high latitudes, with flickering rays and streamers of light. Along with the auroral displays go disturbances of delicate magnetic compasses, interference with long-distance radio communications, and the generation of strong currents of earth electricity.

It now appears that the charged particle clouds from the sun can also affect the weather. This is very hard to believe, because extremely small amounts of energy are involved in the charged particle clouds, whereas weather disturbances involve energies millions of times larger. Moreover, it has not seemed reasonable to expect that the arriving solar clouds, though they might excite auroras at 100 mile altitudes, could extend their effects down to the first ten miles or so of the atmosphere, to the realm of the weather. This is just what seems to occur, nonetheless.

But, let me back-track a bit. Nearly five years ago, as I reported in a Scientific American article, I noted what seemed to be abnormally large developments of winter and spring storm systems following days of outstanding displays of the aurora and the associated disturbances of earth magnetism. But these observations were little more than hunches. HAO's first systematic attack on the problem came in the winter of 1956-57 (1). We found what appeared to be a definite effect in the atmospheric circulation at jet stream levels. When we found essentially the same effect in the winter half-year of 1957-58, we began to believe that we were dealing with a real phenomenon (2). Our work on the winter season of 1958-59 clinches the reality of the effect, in our minds, and turns us to the search for explanations of what is truly a baffling solar-terrestrial relationship. Let me, therefore, describe the effect in a little detail.

It involves the development patterns of "low pressure troughs" in the atmospheric circulation during winter, at jet stream levels of about 30,000 feet altitudes. Low pressure troughs are regions where

(1) Director's Quarterly Report, 1957 I, page 5.

(2) Director's Quarterly Report, 1958 I-II, page 11.

October through March
1956-57, 1957-58, 1958-59

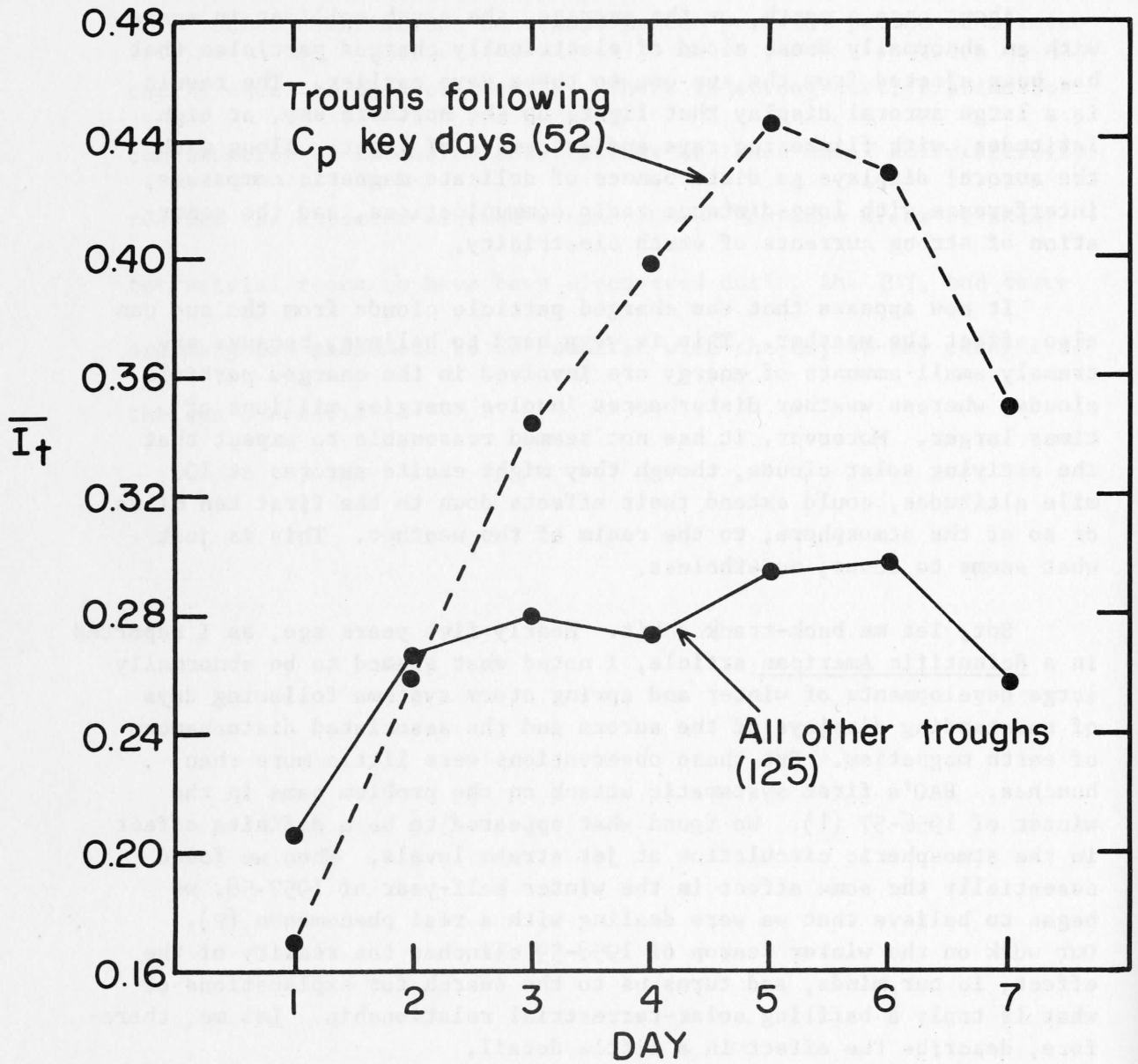


FIGURE 1

Low pressure areas (troughs) that are preceded by solar corpuscular showers (C_p days) become larger, at maturity, than other troughs.

the atmospheric pressures are lower than at the same heights in their surroundings. It has long been known that there are certain geographical regions that favor the development of low pressure troughs. The Aleutian Island region and the Icelandic area are examples. A fair-sized minority of all low pressure troughs amplify to much larger size as they move eastwards from the Aleutian center in the prevailing winds. When they do, surface weather is simultaneously disturbed, and many of the classic winter and spring blizzards over North America develop when particularly large amplifications occur. Such amplifications will sometimes give parts of Florida colder temperatures than parts of Alaska.

Which specific low pressure troughs will be singled out to make up this fair-sized minority of systems that develop to large size? This is where the solar corpuscular clouds, surprisingly enough, appear to play a part. The chances for large amplification of a trough as it moves away from the Aleutian region appears to be more than doubled if it made its first appearance in the Aleutian area on the second, third or fourth day after a bright aurora or an abrupt and strong geomagnetic storm.

During the three winter half-years of 1956-59 (October through March) more than half of all troughs so "tickled" by solar charged particles developed to large size. Only about one in five of the troughs not "tickled" became large ones. The odds are more than a million-to-one against a chance result as pronounced as the one we have found.

Figure 1 shows the average size of the low pressure troughs as they moved downwind from the Aleutians during the seven days following their first detection in the Aleutians. The dashed line shows the average size of the troughs that followed auroras; the solid line shows those not preceded by auroras. The difference is striking.

This work has been carried out by Macdonald and Roberts at HAO, assisted earlier by Dr. David W. Woodbridge, now of Army Ballistic Missile Agency, and Mr. Theodore W. Pohrte of the Colorado School of Mines. It has been sponsored, thus far, entirely by HAO's Institute for Solar-Terrestrial Research.

What about the use of this discovery for forecasting? Our opinion is that efforts to make practical use of the relationship would be premature. In the first place, we do not know whether the effect is confined to years of great solar activity, like these recent ones. In the second place, the result in its present form

states merely that a given trough will subsequently develop to large size. It does not say how soon or where. It may develop over the Rockies, with chill, wet winds in the west, and warm weather in the east; or it may develop quite oppositely, with icy weather in the southeast, and clear, dry weather over the Rockies. The maximum development may come in just two or three days of migration from the Aleutians, or it may take more than a week. And in nearly half of the cases a large development may not occur at all.

But the course of meteorological research is slow, if methodical. Even a result so striking and unexpected as this must not be prematurely hurried to a perhaps disillusioning application. Far better to treat the result as a tantalizing clue to the understanding of still hidden physical causes.

What may these causes be? It is too soon to know, but let me speculate a bit freely, and perhaps recklessly, for a moment. Firstly, it seems abundantly clear that the clouds of particles from the sun are hopelessly too weak to push about weather systems by their direct heating effects. This is so even if we assume that their entire energy is completely given up as heat at the most favorable altitude, a very unlikely circumstance.

It is likely, thus, that trigger effects are involved, and that these release, through small amounts of energy pushing in just the right place, large amounts of energy stored up in the lower atmosphere itself. But what kinds of trigger effects? My inclinations favor a mechanism involving the secondary effects from X-rays generated when the solar clouds impinge on the upper air. Such X-rays have been observed beneath strong auroras at Minneapolis (3). Perhaps these X-rays can cause the formation of freezing nuclei in the stratosphere. These then, as they fall lower, become centers for the growth of ice crystals and thus have a "cloud seeding" effect that can modify weather on a large scale.

There are specific experiments to perform to test out this idea. We hope to start some of these here at HAO before long. If the idea about forming freezing nuclei and ice crystals is correct, these crystals should scatter sunlight and thereby be detectable. With the help of the Office of Naval Research, we will try to measure the scattered light halos very close to the sun, at stratospheric heights from a balloon. And if this is successful, perhaps we can

(3) Journal of Geophysical Research, 64, 597, 1959.

ultimately extend our studies to aircraft operating at the "tickling-ground" in the Aleutians, where perhaps we will find larger numbers of freezing nuclei on the days after auroras.

Moreover, there is a real but remote prospect in all of this for finding the clue to man-made trough amplification. The odds are probably totally against it, because even the relatively puny clouds of charged particles from the sun are sizeable enterprises by human standards. But we are given pause by the extraordinary artificial auroras that were produced during the high altitude atomic bomb experiments in the Pacific on 1 August and 12 August 1958. Could such artificial auroras, at optimally chosen times and places, trigger off the development of continental scale storm systems like the ones we have been considering here? The answer is for the future. But it is one that has implications for all mankind.

II. NEW RESEARCH BUILDING

It is probably fair to include the good news about our new research building in Boulder, even though the final gifts making it possible were not obtained until well after the end of the report period. As this report is being finished, the contract has been signed and construction is beginning. Estimates call for completion of the building within about one year. It will provide us with over 22,000 square feet of space.

We faced a last minute crisis before the contracts were signed, however. On June 1st, the Max C. Fleischmann Foundation of Nevada made a completing grant to the High Altitude Observatory to bring our fund to the \$250,000 estimated as necessary for the construction. When bids came in, this sum was found to be about 10% short of what was required to enable us to build as we had planned. We were then faced with the threat of severe curtailments of specifications to stay within our budget. In this situation, we appealed to a number of our good friends for additional help, which we needed to obtain within 30 days in order to be able to execute the contracts. Again the University of Colorado and the Max C. Fleischmann Foundation of Nevada came to our assistance, and provided funds that permitted us to sign the contracts and get construction started.

We still need to find about \$5,000 to restore to the construction program some built-in items such as sinks, book cases, etc. that were in our plans but not as part of the contracts let to outside builders. When these final funds are obtained, as I hope they will be by the end of the year, the University itself will purchase and

install these items. So we will be most grateful for any final boosts with this last cost for the new \$280,000 research center.

The next report will contain a full listing of those who contributed so generously to the realization of our dream of so many year's standing. To all of them, our heartfelt thanks.

III. PROGRESS IN INSTITUTE FOR SOLAR-TERRESTRIAL RESEARCH

A. Solar-Weather Studies

In HIGHLIGHTS, above, I have described the surprisingly promising progress of the solar-weather studies that have made up a main part of the work of HAO's privately supported Institute for Solar-Terrestrial Research. The findings are so encouraging that we are planning to push this research very hard in the coming years, and also are going to try to get to the heart of the physical processes that bring about the observed effects.

As a consequence, we have decided to seek new sponsorship for an additional four-year program of research under the Institute, at the same level of effort as in the four years now nearing a close. In accordance with our long-standing policy on this question, however, we shall not seek renewals of support by past sponsors. Instead, we shall endeavor to develop support from entirely new sponsors for this important basic research effort. We will, of course, be happy to have words of endorsement from our past backers, with our potential new ones!

We are again seeking financing from three areas of interest, each of which we are asking to contribute \$50,000, making a total research fund of \$150,000 to be spent over a four year period.

B. International Seminar on Solar-Weather Relationships

During the period we sought National Science Foundation support to sponsor, jointly with the Institute of Geophysics of the University of California and the American Geophysical Union, a first international conference on solar-weather relationships. We are aiming to carry it out in the spring of 1960, and will set aside some Institute funds to assist with its conduct.

C. Astro-Geophysics Fellowships

As in past years, we have offered graduate student fellowships from the Institute program. We had, once again, a large number of applications for the limited fellowships that we offer. We have a total complement of about 12 graduate students for 1959-60, several supported by the Institute. As graduate students advance towards research problems for their Ph. D. theses, it is our intent to award them support from specific research projects, in many cases government contract research programs. This way, the Institute funds then become available to "gamble" on beginning students whose graduate study would be impossible without such financial aid.

D. High-Resolution Coronagraph and Spectrograph at Climax

As mentioned in the last report (4), Newkirk is at work on plans for a large coronagraph and spectrograph for Climax. This will be built with funds from the National Science Foundation, and from private contributions to HAO. We decided, during the period, that it will probably also be necessary to meet about \$15,000 of the total cost with Institute funds. The exact amount will depend on what the actual optical construction costs turn out to be when bids are received.

IV. DEPARTMENT OF ASTRO-GEOPHYSICS

The strength of the astro-geophysics program is growing steadily. An indication of this increase in strength has been the excellent response obtained by our announcement of graduate fellowships, both in the number and the quality of the applications.

The staff of the National Bureau of Standards has given valuable assistance to the work of the Department, contributing teaching time unstintingly, and presenting graduate course material of appropriately high caliber.

Warwick, serving as Assistant Director of HAO for Astro-Geophysics, has acted as de facto head of the Department. We hope soon, however, that suitable University academic appointments can be made that will recognize the special nature of the HAO-University relationship.

(4) Director's Quarterly Report, 1958 III-IV, page 25.



FIGURE 2

Mary Lou James, wife of Climax observer Bob James, hangs out her laundry from the porch of their Climax home. House at the right was completed in January and occupied by the Curtises. Living room, dining room, and kitchen are on the second floor keeping them high above the six foot snow drifts so prevalent in Climax winters.

V. OTHER RESEARCH PROGRAMS OF THE HAO

A. Staff

A momentous development in the evolution of HAO's research activity occurred in June with the assumption of a full time research appointment by Dr. Bernhard Haurwitz. Haurwitz, formerly head of the Department of Meteorology and Oceanography at New York University, also holds the chair of Professor of Astro-Geophysics in the University of Colorado. His coming marks the beginning of a substantial strengthening of the program of atmospheric physics of HAO, and specifically, the development of heightened interest in the basic physics of the first 50 miles of the earth's atmosphere.

This program was further strengthened in June when Mr. Paul R. Julian joined the HAO staff. Julian, a student under Dr. Hans Panofsky at Pennsylvania State University, had about completed a thesis in which he studied the linkages between winds in the stratosphere some thirty thousand feet up and winds in the troposphere directly above the ground. He will receive his Ph. D. shortly from Pennsylvania State.

At the end of the period Tandberg-Hanssen returned to the University of Oslo taking a year's leave of absence from HAO.

Chapman, our most peripatetic staff member, left us at the end of January to spend a month at the Sacramento Peak Observatory. In March he went to the Geophysical Institute at the University of Alaska. He returned to Boulder at the end of June.

In March Hansen visited IGY installations in the Hawaiian Islands as a representative of the Solar Technical Panel of the U.S. IGY Committee. His objective was to arrange for improved flow of Hawaiian solar radio noise patrol data to the World Data Centers and to plan further use of the solar optical flare patrol data taken in Hawaii. The optical flare patrol, under the direction of Dr. Walter Steiger, produces excellent pictures and fills the otherwise serious "Pacific gap" in the world wide chain of flare patrol stations.

Athay made a February trip to Europe and Africa to investigate possible sites for the planned joint HAO-Sacramento Peak expedition to the coming solar eclipse. His investigations indicated that the southern tip of Fuerteventura in the Canary Islands gave the best promise of both clear weather with reasonable accessibility. This site has also been recommended by the International Astronomical Union Commission on eclipses.

Athay received a visiting teaching appointment at the California Institute of Technology during the spring semester, for which he took a brief leave of absence immediately following his return from Africa. While in California he surveyed the present research and future plans in solar physics at the Mt. Wilson Observatory, and at Caltech

A fourth observer was added to the Climax observing team when Mr. Robert B. James joined the staff in February. The added staff member, long necessary to the scientific work, was made possible by the completion of a fourth house at the observing site. (see Figure 2). Built with the help of a loan from the Regents of the University of Colorado, the new house was occupied in January by the Curtises. The cost of the house will have to be repaid over a period of about five years.

Mrs. Barbara F. Dolder, who had served as half-time assistant to Trotter for two years, returned in June to a full time job as housewife and mother. Miss Penny K. Kimmel joined the secretarial staff in January. In June Miss Marcia Montgomery replaced Miss Florence Sigismund as switchboard operator when the latter returned to the east with her family.

During this period Dr. John W. Firor of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, began an extended visit at HAO to attempt to develop new electronic "image tube" techniques for the detection of the infra-red coronal lines. These coronal lines, because of their faintness and their long wavelengths require extremely long exposures on difficult-to-use photographic films. The electronic techniques may reduce the time required for observation to feasible values. If successful, these techniques will be of great importance in coronal and other solar research.

B. Research in Progress

The principal advances in the different areas of HAO's research activities are singled out below. Several areas of work reported recently in more detail, or to be reported in detail soon, are included only by their listing.

1. Active Solar Region Analysis

Several simultaneous lines of attack on problems of the physics of active regions are being pursued. Billings hopes

to develop some new approaches to the problem of the role played by magnetic fields in the concentration of coronal material in the active regions.

2. Solar Effects in the Ionosphere

In the last report I indicated that Warwick, Boischot and their colleagues had discovered absorptions of radio signals from the radio star Cassiopeia A that suggested absorption from the ions of the auroral belt. Subsequent observations have not altered this view. However, further critical tests are not likely before the end of the year.

3. Studies of Artificial Geomagnetic and Ionospheric Disturbances

The August 1958 Pacific atom bomb tests continued to be of great interest to us. Matsushita completed a study of the ionospheric and geomagnetic properties of the August 1st and 12th blasts, and reached the following conclusions regarding their heights of detonation.

Blast code name	1958 Date	Time (UT)	Height (miles)
TEAK	1 August	10 ^h 50 ^m 05 ^s	44 - 50
ORANGE	12 August	10 ^h 30 ^m 08 ^s	25

AEC releases, made subsequently, have specified 38 miles altitude for TEAK and 19 miles altitude for ORANGE. Matsushita studied also the separate effects of the expanding shock waves and of the clouds of ions from bomb debris as a cause of ionospheric and geomagnetic influences. Both induced significant phenomena.

Mr. John M. Malville, a graduate student in astro-geophysics, also made detailed studies of the high altitude bomb blasts, concentrating his effort principally on the explanation of the auroras induced by the bombs. He showed that the auroral arcs observed near Apia in the Samoan Islands probably resulted from electrons released by the fission products of the trigger-bomb presumably used to detonate the H-bomb which produced the principal blast effect. The auroral effects were found consistent with the release of a 20 kiloton TNT equivalent bomb of fission type. The unusual auroral violet colors reported from Apia were also found consistent with such an origin for the aurora.

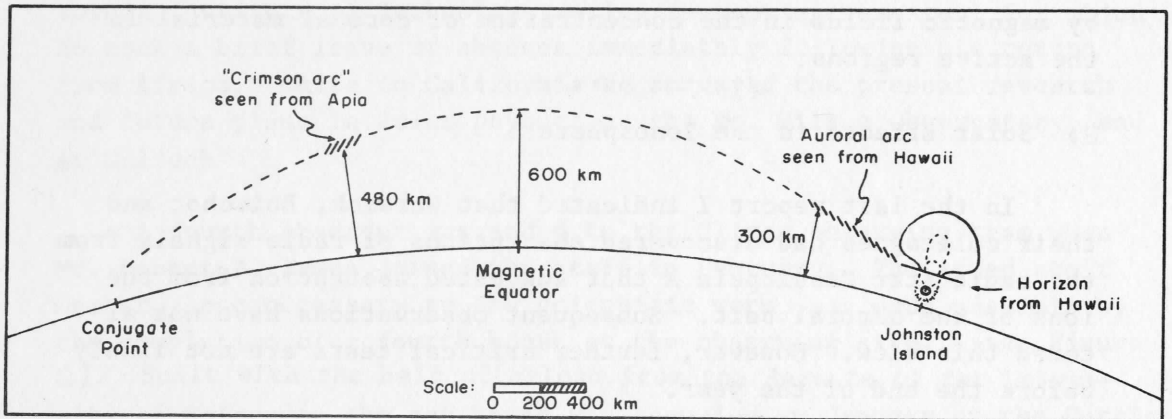


FIGURE 3

Diagram showing the location of two artificial auroral displays seen at the time of the 1 August 1958 nuclear bomb blast at Johnson Island. A mushroom cloud was visible from Hawaii as was the auroral arc shown at the right. Electrons created by the blast traveled along lines of magnetic force of the earth's field and created the crimson auroral arc seen at Apia Island south of the earth's magnetic equator. This phenomenon was studied by Malville.

4. Studies of Geomagnetism

Matsushita continued his studies of geomagnetic disturbances of natural origin, and their interconnections with ionospheric disturbances.

5. Solar Activity Observing

After the close of the IGY, the demand for intensive observation of solar flares and associated solar activity has scarcely slackened. As a consequence, HAO and the Sacramento Peak Observatory have continued a very substantial solar observing service, at levels very close to those prevailing during the IGY.

6. Chromospheric Spicule Studies

New spicule spectra obtained by the Climax observers have enabled substantial progress in interpretation of the properties of these chromospheric layers. The observations of the spectrum lines from ionized calcium lead Athay to the conclusion that there must, for these lines, be an additional source of spectrum line widening. I expect to describe this tantalizing result in somewhat greater detail in a coming report.

7. Eclipse Research

Perfectly functioning equipment, and dense clouds in the Canary Islands make this a sad, sad, short story to be told in the next report.

8. Solar Data Center

Work on the definitive volume of IGY solar data is being vigorously pursued under Hansen's direction. The HAO solar Data Center is also functioning in IGC-59 (International Geophysical Cooperation, 1959) with high efficiency as a depository for the international observations that continue to come in with IGY-like regularity and scope.

9. K-Coronameter Observations and Analyses

Newkirk and the Climax observational staff have been pursuing a program of vigorous effort to build a model of the solar corona from k-corona observations that will explain the observed solar radio noise emission at wavelengths of about a fifth of a meter. Using observations from Climax to gain a picture of the density of electrons in the corona, Newkirk has then traced the paths of rays of radio emission in the corona using the Bendix G-15 computer of the University.

Improvements have been made in the coronameter recently. We expect that data from the fall will prove particularly valuable.

On the 9th of June 1959, a distinctive flare developed, followed directly by strongly looped prominences. Newkirk was able to obtain excellent k-coronameter observations that showed a strong rise of the density of electrons shortly after the flare, just in the location of the loops of the prominences (see Figure 4). The rise was well enough measured to allow rather clearcut determinations of the actual electron density (10^{10} per cm^3) rise from the flare. Moreover, the coronameter showed that in spite of this rise in electron abundance, the direction of polarization of the light scattered from the electrons remained in a vertical direction outwards from the sun's edge. This conclusion is interesting because one of the most promising new theories of the origin of the white light from such events, which bears in turn the origin of cosmic rays and solar radio noise, calls for deviations from a radial direction, along the lines of magnetic force that follow the prominence loops. Newkirk's data, thus, argue against the new theory.

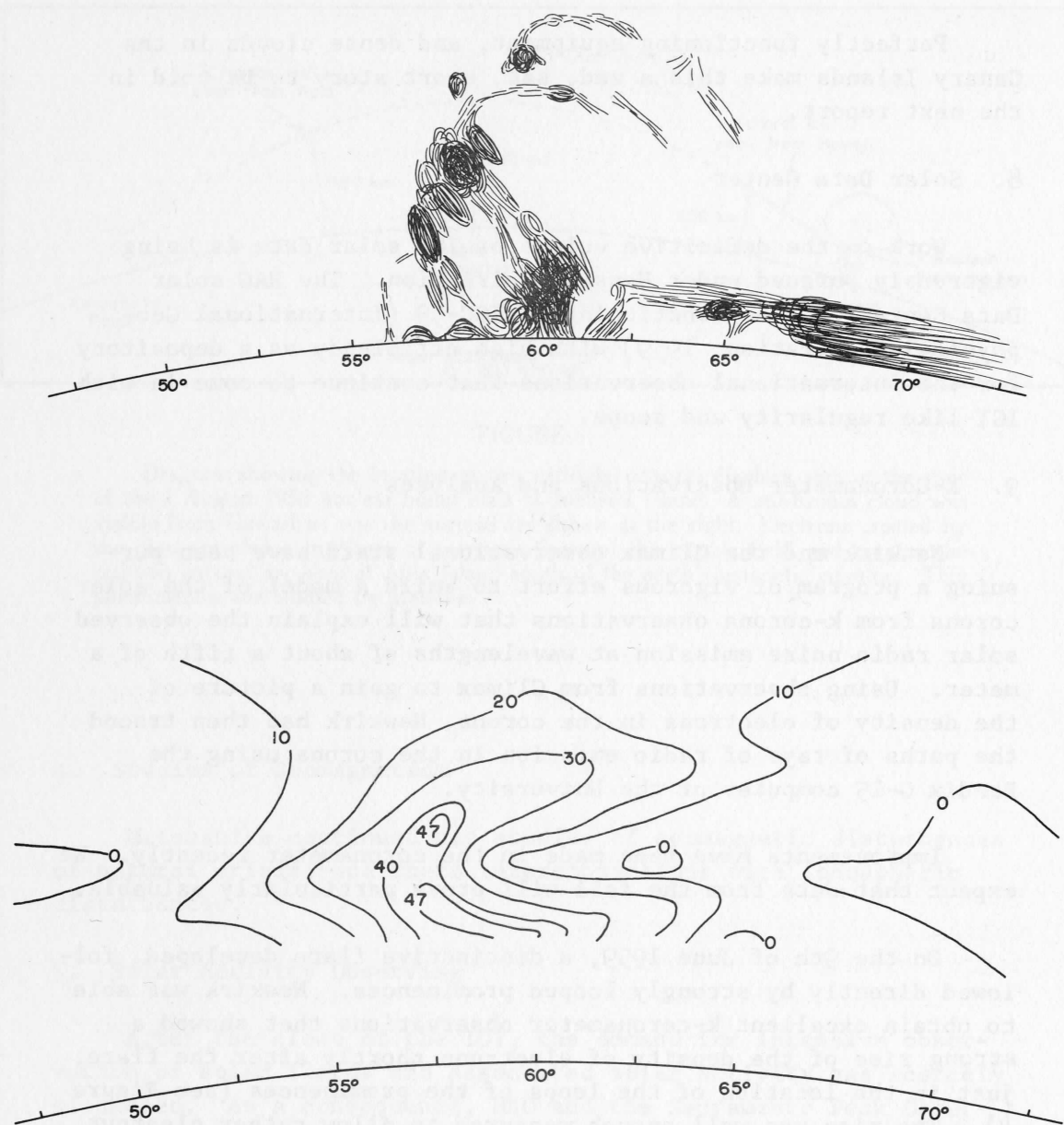


FIGURE 4

Phenomena associated with the loop prominence of 9 June 1959. Above (at A) is a composite drawing of the prominence as taken from the flare patrol film. The prominence appears to be condensing out of the corona. Below (at B) is a contour map giving lines of equal brightness of the k-corona. The contours outline roughly the regions of enhanced density of electrons in the corona. Notice how the brightest knots of the prominence appear as concentrations of free electrons and that the contours form an envelope around the prominence. The density is about 10^{10} electrons/cm³ in the brightest knot. This is about 100 times the usual density in the corona in such regions.

The analysis of the 9 June event was carried out under Newkirk's guidance principally by a summer undergraduate scholarship student, Miss Jane Shelby, a Westinghouse Science Talent Search winner enrolled at Swarthmore College during the winter.

10. High Altitude Balloon Studies of Solar Aureole

An open gondola balloon flight was carried out from the Strato-Bowl near Rapid City, South Dakota on 7 August, to an altitude of about 38,000 feet, with Cooper aboard as scientific observer, and Cdr. Malcolm Ross of the Office of Naval Research, as pilot. The flight will be described in the next report.

11. Alfred P. Sloan Research Fellowship Program

Zirin's work under the Sloan Research Fellowship has yielded interesting progress. He has been studying the heating and cooling processes involved in the maintenance, in the solar atmosphere, of the two rather distinct temperature regimes, one hot and one less so, that seem evident in flare, prominence and chromospheric phenomena, and in the "super-hot" regime of the corona. This work will be described in more detail in a coming report.

12. Large Coronagraph for Climax

Construction of the large coronagraph and spectrograph at Climax will become a first priority matter at HAO after the eclipse expedition to the Canaries is out of the way. Meanwhile, optical designs are being completed, with the generous help of Mr. George K. Schnable of the Sacramento Peak Observatory. And we hope to have the optical construction well under way before the close of the year.

13. Dynamical Meteorology

In future months the work of Haurwitz, just begun during this period, will comprise an important aspect of HAO's research. One of Haurwitz's initial research programs will involve an attack on the problem of the flow of an idealized circulation cell involving an initially static system subjected at a specific moment to a differential rate of heating. From this may come conclusions relevant to the rates of establishment of stable circulation states that will be of significance in real atmospheric problems.

14. Chromosphere Monograph

Athay's work on the chromosphere monograph, being jointly written with Richard N. Thomas, is essentially completed. A part of the work was carried on during Athay's extended teaching visit at the California Institute of Technology, during the spring.

VI. RELATED PROGRESS AT OTHER INSTITUTIONS

A. The Van Allen Radiation Belts

Artificial satellites and interplanetary research rockets continue to provide spectacular advances in our knowledge of the properties of space near the earth. Perhaps the most spectacular advance of the IGY was the discovery, by Dr. James A. Van Allen and his colleagues, of the existence of two radiation belts above the earth's surface, centered roughly over the equator. At the equator these belts are approximately 4,800 and 14,500 miles above the earth. They are caused when electrons, and possibly also protons, are "trapped" in the earth's magnetic field in such a way that they constantly oscillate back and forth high above the earth, south to north latitudes. Their oscillation occurs because the shape of the earth's magnetic field causes them to be reflected, as they near the earth's surface, at the southmost and northmost points of their flights. (see Figure 5). The belts are called "radiation belts" because the fast-moving electrons, when they impinge on the metal skins of rockets and satellites, produce x-ray radiation. This x-ray radiation would be dangerous to any intrepid astronauts who chose to fly in space vehicles that remained any substantial length of time in the radiation belts.

The inner belt appears, from the somewhat fragmentary probings to date, to be relatively steady in intensity, while the outer fluctuates widely. Van Allen and his associates found on 3 March 1959, for example, that the outer belt displayed a strength of radiation some 100 to 200 times greater than was present on the 6th and 7th of December 1958, during another probing. The fluctuations of the outer belt are apparently caused by variations in the injection of electrified corpuscles from the sun into the "trapped orbits" above the earth. Just before the 3 March probing, there were strong auroras and a geomagnetic storm, which we labelled an "M-region storm" here at HAO. (M-region storms are disturbances of the earth's magnetic field of a 27-day recurrent character, which tend to become most abundant in years of declining solar activity. They appear to have their origin in

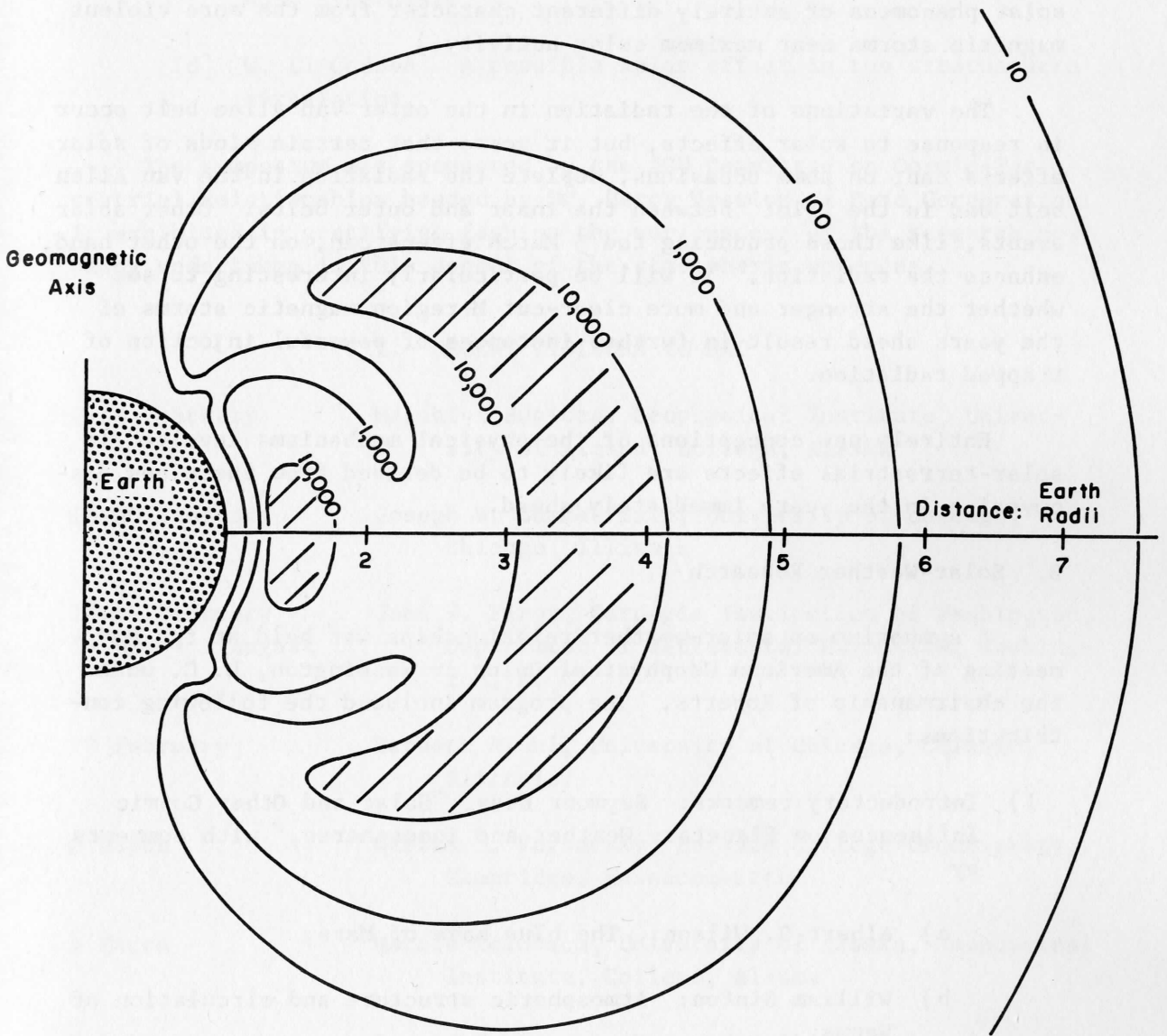


FIGURE 5

Diagram showing in idealized fashion the results of the discoveries by Dr. J. A. Van Allen and his colleagues of strong radiation belts trapped in the earth's magnetic field.

The shaded contours are regions where the satellite-borne radiation counters found intensities hundreds of times higher than expected. The outer radiation belt, between three and four earth-radii from the sun's center, appears to be replenished and depleted, on occasion, by corpuscular emission from the sun.

solar phenomena of entirely different character from the more violent magnetic storms near maximum solar activity.)

The variations of the radiation in the outer Van Allen belt occur in response to solar effects, but it seems that certain kinds of solar effects can, on some occasions, deplete the radiation in the Van Allen belt and in the "slot" between the inner and outer belts. Other solar events, like those producing the 3 March effect can, on the other hand, enhance the radiation. It will be particularly interesting to see whether the stronger and more clear-cut M-region magnetic storms of the years ahead result in further instances of powerful injection of trapped radiation.

Entirely new conceptions of the physical mechanisms involved in solar-terrestrial effects are likely to be derived from these new discoveries in the years immediately ahead.

B. Solar-Weather Research

A symposium on solar-weather relationships was held at the May meeting of the American Geophysical Union in Washington, D. C. under the chairmanship of Roberts. The program included the following contributions:

- 1) Introductory remarks: Seymour Hess, "Solar and Other Cosmic Influences on Planetary Weather and Ionospheres," with comments by
 - a) Albert G. Wilson: The blue haze of Mars,
 - b) William Sinton: Atmospheric structure and circulation of Venus,
 - c) B. F. Burke and R. Gallet: The ionosphere of Jupiter.
- 2) Introductory remarks: Clarence E. Palmer, "Influences of Variable Solar and Other Cosmic Phenomena on Terrestrial Weather," with comments by
 - a) Ralph Shapiro: Changes of persistence of pressures over Europe following geomagnetic activity,
 - b) R. A. Craig: Comments on future potentialities on solar-weather research,

- c) Glenn Brier: Weather singularities and the Bowen meteor dust hypothesis,
- d) W. L. Godsen: A possible solar effect in the stratosphere circulation.

The symposium was sponsored by the AGU Committee on Cosmic-Terrestrial Relationships headed by Dr. Harry Vestine of Rand Corporation. It exhibited in gratifying fashion the seriousness of the research now being undertaken in this aspect of the atmospheric sciences.

VII. RECENT VISITORS TO HAO

2-13 February	Masahisa Sugiura, Geophysical Institute, University of Alaska, College, Alaska
16-20 February	Joseph W. Chamberlain, University of Chicago, Chicago, Illinois
16-27 February 15 May - 1 August	John W. Firor, Carnegie Institution of Washington, Department of Terrestrial Magnetism, Washington, D. C.
27 February	Herbert Riehl, University of Chicago, Chicago, Illinois.
2 March	Carlos M. Varsavsky, Harvard College Observatory, Cambridge, Massachusetts
4 March	Harold Leinbach, University of Alaska, Geophysical Institute, College, Alaska
5-6 March	Donald H. Menzel, Harvard College Observatory, Cambridge, Massachusetts
9-11 March	John T. Jefferies, Sacramento Peak Observatory, Sunspot, New Mexico
9-11 March	Jack B. Zirker, Sacramento Peak Observatory, Sunspot, New Mexico
9-12 March	Max A. Woodbury, New York University, New York, New York
10 March	Richard A. Schleusener, Colorado State University, Fort Collins, Colorado

12 March	Richard M. Goody, Harvard University, Cambridge, Massachusetts
20-21 March	John R. Winckler, University of Minnesota, Minneapolis, Minnesota
29 March - 1 April	Malcolm Correll, DePauw University, Greencastle, Indiana
30-31 March	Eugene N. Parker, University of Chicago, Chicago, Illinois
30 March - 1 April	John W. Evans, Sacramento Peak Observatory, Sunspot, New Mexico
31 March - 1 April	F. N. Frenkiel, The Johns Hopkins Applied Physics Department, Silver Spring, Maryland
1 April	Earl G. Droessler, NSF, Washington, D. C.
2-4 April	Marianne C. Bretz, Lick Observatory Mount Hamilton, California
6-10 April	Ralph Shapiro, AFCRC, Geophysics Research Directorate, Boston, Massachusetts
6-10 April	Fred W. Ward, AFCRC, Geophysics Research Directorate, Boston, Massachusetts
6-10 April	Louis Berkofsky, AFCRC, Geophysics Research Directorate, Boston, Massachusetts
13-16 April	Alan Maxwell, Radio Astronomy Station of Harvard College Observatory, Fort Davis, Texas
15 April	Charles A. Whitney, Smithsonian Astrophysical Observatory, Cambridge, Massachusetts
29 April	Vincent J. Schaefer, Schenectady, New York
30 April	William A. Fowler, California Institute of Technology, Pasadena, California
15 May	L. Jacchia, Smithsonian Astrophysical Observatory, Cambridge, Massachusetts



FIGURE 6

This photograph shows one of the largest outbursts of solar particles ever detected in the earth's atmosphere. It was made in a balloon at approximately 90,000 feet altitude above Minneapolis by Drs. Edward P. Ney and P. S. Freier of the University of Minnesota. It shows tracks in a photographic film made by protons from the sun penetrating the earth's atmosphere to the balloon altitude. The photograph was made on 12 May 1959, the day after a very large (importance 3+) solar flare which produced the protons shown here. The energetic particles are present with about 1000 times the normal cosmic ray abundance. The photograph is enlarged from a section of film about 1/100 of an inch long, and the criss-crossing of the tracks of many particles is evident. On a day of normal activity it would be necessary to expose ten such films for this length of time to find a single track in the emulsion.

25-26 May	E. G. Bowen, Commonwealth Scientific and Industrial Research Organization, Sydney, Australia
29 May	Sydney G. Reed, Office of Naval Research, Washington, D. C.
3 June - 20 June	Marshall H. Cohen, Cornell University, Ithaca, New York
5 June	Fred Singer, University of Maryland, College Park, Maryland
12-16 June	Edwin W. Dennison, Sacramento Peak Observatory, Sunspot, New Mexico
22-28 June	R. Müller, Wendelstein Observatory, Germany
25-27 June	John R. Platt, Department of Physics, University of Chicago, Chicago, Illinois
27 June	A. M. Khan, Meteorological Service of Pakistan, Pakistan
30 June	Robert E. Holzer, University of California at Los Angeles, Los Angeles, California

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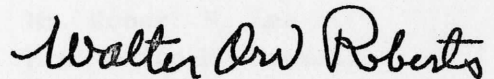
B. Solar Activity Reports:

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