EXPLORATORY STUDY TO DETERMINE FAVORABLE LOCATIONS IN THE UNITED STATES FOR CONSTRUCTION OF A SOLAR FURNACE

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SUMMARY

The total receipt of radiant solar energy at the earth's surface is dependent upon the clarity of the atmospheric envelope and the number of sunshine hours. For short-wave solar radiation, water vapor and clouds are the two major absorbers and scatterers. The graphs of solar radiation and the average number of sunshine hours shown in this report indicate that the stations in the Southwest United States have the most favorable climatic conditions for the location of a solar furnace that will provide thermal radiation of high intensity throughout the year. This is substantiated by the frequency data. The curves and frequency for Yuma and Phoenix, Arizona, and Albuquerque, New Mexico, are quite similar and indicate favorable conditions. For the warmer months the conditions at Fresno and the Central Sierra Station, both in California, reflect the marked increase in clear sky conditions within the influence of the Pacific high pressure cell. The cloud conditions during the winter months detract from the suitability of the California Valley for year round operations.

The moisture flow over the eastern section of the United States and the resultant clouds contribute significantly to the lower values of radiant energy received at the surface in this section. The curves and frequency data for Blue Hill Observatory in Massachusetts are typical for the North Atlantic states. These same conditions occur over much of the plains and central states. There is not much difference in the data for Blue Hill and Lincoln, Nebraska. A localized area of similar latitude but dissimilar in other respects to those of the Northern Atlantic Coast is the coastal section of the Pacific Northwest as shown by the data for Friday Harbor, Washington.

On a climatological basis the arid Southwest appears to be the logical site for the solar furnace. However, the particular site chosen should be based upon further study of local weather conditions. A micro-climatic study should determine: (1) the influence of topography, such as exposure to moisture bearing winds, the decrease of water vapor with increased elevation, and increased cloud amounts at high elevations; (2) proximity to large bodies of water; (3) ground reflectivity; (4) the source of dust and pollution.
# CONTENTS

## Summary

1. Introduction 1  
2. Data 1  
3. Selection of possible climatic locations in the United States 1  
4. Analysis of data at 8 locations 3  
5. Discussion 4  
6. Recommendations 6  
7. Acknowledgments 6  
8. References 7

## Figures

1. Solar radiation and hours sunshine, Phoenix, Arizona 9  
2. Solar radiation and hours sunshine, Fresno, California 9  
3. Solar radiation and hours sunshine, Yuma, Arizona 10  
4. Solar radiation and hours sunshine, Albuquerque, New Mexico 10  
5. Solar radiation, Central Sierra, California 11  
6. Solar radiation and hours sunshine, Lincoln, Nebraska 11  
7. Solar radiation and hours sunshine, Blue Hill Observatory, Milton, Massachusetts 12  
8. Solar radiation and hours sunshine, Friday Harbor, Washington 12  
9. Solar heat, United States 13  
10. Total hours of sunshine, United States 14
TABLES

1. Station locations

2. Hourly intensities of solar radiation (direct and diffuse) received on a horizontal surface at selected stations

3. Daily intensities of solar radiation (direct and diffuse) received on a horizontal surface at selected stations

4. Comparison of seasonal sunshine and solar radiation on a horizontal surface for elements for selected areas

5. Average number of hours and percentage possible sunshine at selected stations

6. Average cloudiness at selected stations

7. Average number of clear, partly cloudy, and cloudy days at selected stations

8. Insolation on a surface perpendicular to the rays of the sun for a typical cloudless day in January, April, July, and October at Blue Hill, Massachusetts

9. Comparison of average daily solar radiation at Blue Hill, Massachusetts
EXPLORATORY STUDY TO DETERMINE FAVORABLE LOCATIONS IN THE UNITED STATES FOR CONSTRUCTION OF A SOLAR FURNACE

1. Introduction

The attention of the Armed Forces Special Weapons Project is focused on determining a site in the United States where a solar furnace can be built that will provide maximum intensity and maximum frequency of solar radiation throughout the year. The solar furnace is to be used for the testing of many kinds of materials used by all the Armed Forces agencies.

As a preliminary analysis of the possible locations where geographic and climatic factors will contribute most advantageously to the operation of a solar furnace (tentatively designed to produce intensities of solar radiation up to 100 cal/cm² sec), this study has utilized all available original and published source material that could be assembled from Department of the Army Test Site observations and from the solar radiation tests and experiments of other research institutions in the Boston area.

2. Data

Hourly and daily solar radiation observations recorded on a horizontal surface were used to produce the frequency distributions for Yuma, Arizona; Albuquerque, New Mexico; Central Sierra, California; and Blue Hill Observatory, Milton, Massachusetts. These observations were tabulated from all the records available in the Boston area. At a later date this Division expects to receive frequency distributions from 95 Weather Bureau stations whose solar radiation observations for approximately 5 years duration are now at the National Weather Records Center at Asheville, North Carolina for EAM processing. When these data are received, it will be possible to add much salient information to the solar radiation frequency distributions contained in this interim report. Sunshine data, except for Yuma, Arizona, were taken from the Weather Bureau's Climatological Data and Technical Paper No. 12. The sunshine hours for Yuma were taken from "Handbook of Yuma Environment", the Office of The Quartermaster General Environmental Protection Branch Report No. 200. The map of Annual Total Sunshine Hours for the United States was excerpted from the Weather Bureau's Annual Sunshine Hours Map of the World. Material for the graphs on solar radiation were taken largely from solar radiation studies of I.F. Hand and G.A. Crabb, Jr.

3. Selection of Possible Climatic Locations in the United States

The possible sites showing favorable climatic conditions or contrast to these conditions, that have been selected for presentation in this paper are listed in Table 1. They consist of:

(1) Five inland stations in the Southwest that have the highest annual average solar radiation and sunshine hours for the United States:
(a) Phoenix, Arizona (elevation 1,114 feet) represents the moderate level, southwest desert area. The maximum intensity and the maximum duration of intensity occur in the late spring and early summer when cloudiness is at a minimum.

(b) Fresno, California (elevation 277 feet) illustrates the West Coast low altitude summer dry climate with intense solar radiation during the season of minimum cloudiness and rain.

(c) Yuma, Arizona (elevation 138 feet) illustrates a low latitude, low altitude desert station with insolation consistently high through the summer half of the year and high at intervals during the winter.

(d) Albuquerque, New Mexico (elevation 4,042 feet) shows the extreme values that are typical of middle altitude stations in upper subtropical latitudes of the Southwest.

(e) Central Sierra, California (elevation 6,900 feet) typifies a high altitude, middle latitude station. Although a summer dry climate characterizes the Central California area, the cloud amounts at high elevations deplete the radiation. The pattern at Central Sierra, except for July, is about the same as that at the low altitude station of Fresno.

(2) Two stations, one on the Northern East Coast and one on the Northern West Coast, that have low amounts of solar radiation and sunshine:

(a) Blue Hill Observatory, Milton, Massachusetts (elevation 640 feet) is representative of stations along the Northern Atlantic Coast. The pattern is similar to that of Boston with a spring "plateau" and a summer peak, except that the effects of industrial pollution are apparent in lesser amounts of insolation at Boston.

(b) Friday Harbor, Washington (elevation 7 feet) differs markedly from Blue Hill Observatory on the Northern Atlantic Coast. The latitudes are similar but the effects of elevation and to a greater extent the general differences in the wind and cloudiness patterns along the two coasts account for the dissimilarities.

(3) One station in the Central Plains for comparison with coastal stations and inland locations of higher elevations:

(a) Lincoln, Nebraska (elevation 1,180 feet) is representative of the middle latitude, middle altitude stations, with a spring "plateau", a high summer peak and a marked decline of insolation in the fall.

In selecting the above stations for study, consideration was given to their proximity to Army, Navy and/or Air Force installations.
4. Analysis of Data at Eight Locations

The solar radiation data that are used in this report (Figures 2, 4, 6, 7 and 8 plotted as weekly means of daily totals and figures 1, 3 and 5 plotted as average daily totals; also Tables 2 through 4) are from observations taken on a horizontal surface. This includes a combination of direct and diffuse radiation. Tables 5, 6 and 7 present data on sunshine and cloudiness that supplement the information on insolation.

Since the furnace when in use would be turned to follow the direct rays of the sun, the most applicable observations would be energy received normal, or perpendicular, to the sun. Normal incidence, however, is not regularly recorded and the data available are scattered and limited; also it is not possible to convert solar radiation values taken on a horizontal surface to normal incidence without knowing the values of diffuse sky radiation. (Hand and Wollaston, 1953).

Normal incidence, therefore, has been computed only from the data available at Blue Hill Observatory, Massachusetts (Tables 8 and 9). Table 8 shows the average hourly insolation on a surface perpendicular to the sun and Table 9, a comparison of the normal incidence with that received on a horizontal surface during January, April, July and October. Hand (1950) made a detailed analysis of normal and diffuse insolation on clear days at the time of the solstices and equinoxes for latitude 42°N.

In a recent article by Cuniff (1955), normal monthly curves of solar radiation at normal incidence are shown for Blue Hill Observatory, Milton, Massachusetts; Madison, Wisconsin; Lincoln, Nebraska; Albuquerque, New Mexico; Boston, Massachusetts and Table Mountain, California. All the curves except Table Mountain show great year-to-year variation. Since the measurements are taken only at times when the sky in front of the sun is cloudless, the variations in the curves indicate that factors other than clouds, particularly smoke and haze, contribute greatly to the depletion of solar radiation for brief or long intervals. Kimball (1930) in preparing monthly means of solar radiation and atmospheric transmission considered the differences at various United States stations in the depletion of solar radiation by atmospheric dust. Thus, it is important to make a study of pollution and depletion factors in any area tentatively selected as favorable for year-round operation of a solar furnace.

This study uses the energy received on a horizontal surface for comparing different sections of the country rather than estimating the normal incidence. As supporting information, graphs of the average number of sunshine hours available for all stations except Central Sierra, California, are combined with the graphs of total radiation received in gram-calories per square centimeter per day (Figures 1-8). It is apparent that areas of high sunshine hours show a high incidence of solar energy. The maps of total hours of sunshine (U.S. Weather Bureau, 1954) and solar heat per square foot per average day (Hand, 1953) show the maximum sunshine hours and the maximum solar heat concentrated in the South-west States. (Figures 9 and 10).

Frequency distributions of hourly and daily amounts of solar radiation for Albuquerque, New Mexico, Yuma, Arizona, Blue Hill
Observatory, Milton, Massachusetts, and Central Sierra, California for January, April, July, and October are tabulated in Tables 2 and 3. From these tables the number of days and hours having various intensities of solar radiation can be determined and a comparison made of the stations.

An areal comparison of sunshine and radiation elements in eastern Massachusetts, Washington, D.C. and Arizona is given in Table 4. The eastern Massachusetts and Washington, D.C. areas show identical values in all elements compared except the annual sunshine hours and winter solar radiation, which are greater for the more southern latitude of Washington, D.C.

5. Discussion

Discussions with scientists at Harvard University, and at the Massachusetts Institute of Technology, where a solar radiation furnace capable of concentrating 400/cal/cm² min has been used for testing materials in recent years, have aided an appreciation of the climatic problems that may be involved in operating a much larger furnace anywhere except in areas of maximum solar radiation and sunshine hours. Discussions with Dr. Brooks, and members of his research staff at Blue Hill Observatory, and with Mr. Cuniff, Weather Bureau representative in charge of solar radiation observations at the observatory, resulted in the evaluation of the current available original data of usable proportions that could be used; i.e., solar energy received on a horizontal surface. The discussions helped exhaust the possibility that some mathematical, empirical or theoretical means could be employed to convert solar radiation observations on a horizontal surface to the energy values of direct rays. This conversion would require observations of diffuse sky radiation, which are not regularly recorded at any station selected except Blue Hill.

The problem of selecting a general location for further study is a comparatively simple one since all the climatic evidence points favorably to the Southwest. A final determination, however, should be based on further investigation of the immediate environment and local climate.

To illustrate the extent to which two sites under the influence of the same general climatic controls may differ because of exposure to cloud bearing winds and configuration of the land, the insolation for the months of maximum intensity, May, June and July, is tabulated below for two additional stations, Grand Lake and Grand Junction, Colorado.
### Percentage Total Days Solar Radiation on Horizontal Surface

<table>
<thead>
<tr>
<th>Station</th>
<th>Elev.</th>
<th>600-</th>
<th>650-</th>
<th>700-</th>
<th>750-</th>
<th>800-</th>
<th>850-</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ft.</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>%</td>
</tr>
<tr>
<td>Grand Lake, Colorado</td>
<td>8,380</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>9</td>
<td>16</td>
<td>9</td>
<td>57</td>
</tr>
<tr>
<td>Grand Junction, Colorado</td>
<td>4,849</td>
<td>11</td>
<td>9</td>
<td>13</td>
<td>19</td>
<td>18</td>
<td>4</td>
<td>74</td>
</tr>
</tbody>
</table>

*Percentage Total for 3 months, May, June and July. 1 to 3 year record.

At Grand Lake, elevation 8,380 feet, surrounded by cloud-capped Rocky Mountain peaks and ridges, 57 percent of the days observed had total daily insolation greater than 600 langleys. At Grand Junction, 3,531 feet lower than Grand Lake, where the mountain ridges lower and the Colorado plateau begins, 74 percent of the days observed had insolation greater than 600 langleys. However, the number of days having insolation greater than 850 langleys were twice as many at Grand Lake as at Grand Junction. When clouds are not present, the higher location has a clearer and thinner atmosphere than the lower.

Therefore, it is important in selecting a site to determine whether maximum duration of lesser intensities is preferred to maximum intensity for shorter periods. This, of course, would depend on the nature and consistency of the demands on the furnace.

In addition to the effects of elevation and exposure, a site located too near a large body of water would be subject to marine climatic influences which may augment or weaken the general climate controls. Land and sea breeze effects, fog along the coast of California and high humidities in Gulf air flowing into Arizona may influence locally the conditions in some areas of the Southwest. Dust from the desert or smoke and pollution from the industries of cities are often factors in depleting the amounts of solar radiation received.

For these reasons and others meteorologically too intricate to define without further studies of the areas considered in this report, it is strongly urged that any site selected for preliminary consideration should be subjected to micro-meteorological investigation and analysis.
6. Recommendations

The most favorable area in the United States for the location of a solar furnace is in the arid Southwest. It is recommended that the specific site within the Southwest for building the furnace should be determined only after a micro-meteorological investigation of the local environment.

Comparative analysis of stations presented in this study justifies the construction of the furnace at some location of moderate elevation with meteorologic conditions similar to those at Grand Junction, Colorado, or at a higher elevation if a study of cloud frequencies proves the feasibility.

7. Acknowledgments

This report was prepared under the direction of Dr. D. H. Miller, Chief, Environmental Analysis Section. The author had the benefit of consultation with Dr. C.F. Brooks and Mr. C.V. Cuniff at Blue Hill Observatory and with Mr. Enrique Ho Leong at the Massachusetts Institute of Technology. Mr. Owen Parmele and Miss Gertrude Barry assisted in the preparation of the statistical tables and charts.

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Prepared by:

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AUSTIN HENSCHEL
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Environmental Protection Division
8. References


Hand, I.F. 1950. Insolation on clear days at the time of solstices and equinoxes for latitude 42 N. Heating and Ventilating, 46, pp. 92-93.


U.S. Signal Corps

U.S. Weather Bureau

U.S. Weather Bureau

U.S. Weather Bureau

U.S. Weather Bureau

U.S. Weather Bureau

Visher, S.S.
Fig. 1: Av. Daily Total Solar Radiation and Av. Mo. Hrs. of Sunshine

Fig. 2: Av. Daily Total Solar Radiation and Av. Mo. Hrs. of Sunshine
YUMA, ARIZONA

Av. Daily Total Solar Radiation on Horizontal Surface (gm cal/cm²)
- Average Monthly Hours of Sunshine

ALBUQUERQUE, NEW MEXICO

Av. Daily Total Solar Radiation on Horizontal Surface (gm cal/cm²)
- Average Monthly Hours of Sunshine

Fig. 3: Av. Daily Total Solar Radiation and Av. Mo. Hrs. of Sunshine

Fig. 4: Av. Daily Total Solar Radiation and Av. Mo. Hrs. of Sunshine
Fig. 5: Av. Daily Total Solar Radiation and Av. Mo. Hrs. of Sunshine

Fig. 6: Av. Daily Total Solar Radiation and Av. Mo. Hrs. of Sunshine
Fig. 7: Av. Daily Total Solar Radiation and Av. Mo. Hrs. of Sunshine

Fig. 8: Av. Daily Total Solar Radiation and Av. Mo. Hrs. of Sunshine
### TABLE 1: SELECTED STATION LOCATIONS NEAR MILITARY BASES

<table>
<thead>
<tr>
<th>Station Locations</th>
<th>Elevation (ground) Ft.</th>
<th>Army, Navy and/or Air Force Installations Near Station Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phoenix, Ariz.</td>
<td>1,114</td>
<td>Luke Air Force Base</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Naval Air Facility - Litchfield Park</td>
</tr>
<tr>
<td>Fresno, Calif.</td>
<td>277</td>
<td>Between Castle Air Force Base, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Naval Air Station - Moffett Field</td>
</tr>
<tr>
<td>Yuma, Ariz.</td>
<td>138</td>
<td>Army Test Station</td>
</tr>
<tr>
<td>Albuquerque, New Mex.</td>
<td>4,042</td>
<td>Kirtland Air Force Base</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kirtland AFSD</td>
</tr>
<tr>
<td>Central Sierra, Calif.</td>
<td>6,900</td>
<td>Between Stead Air Force Base and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beale AFB/N</td>
</tr>
<tr>
<td>Lincoln, Nebr.</td>
<td>1,180</td>
<td>Naval Air Station</td>
</tr>
<tr>
<td>Blue Hill Observatory,</td>
<td>640</td>
<td>Army, Navy and Air Force Installations</td>
</tr>
<tr>
<td>Mass.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friday Harbor, Wash.</td>
<td>7</td>
<td>Army, Navy and Air Force Installations</td>
</tr>
</tbody>
</table>

15
# Table 2: Hourly Intensities of Solar Radiation (Direct and Diffuse) Received on a Horizontal Surface at Selected Stations

<table>
<thead>
<tr>
<th>Station</th>
<th>Month</th>
<th>$&gt;20$</th>
<th>$=60$</th>
<th>$=100$</th>
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<tbody>
<tr>
<td>Albuquerque</td>
<td>Jan</td>
<td>154</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>New Mexico</td>
<td>Apr</td>
<td>266</td>
<td>148</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>Jul</td>
<td>278</td>
<td>191</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Oct</td>
<td>228</td>
<td>102</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Length of Record: 3 to 4 years (1949-1953)</td>
</tr>
<tr>
<td>Yuma, Arizona</td>
<td>Jan</td>
<td>167</td>
<td>26</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>Apr</td>
<td>272</td>
<td>188</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Jul</td>
<td>276</td>
<td>182</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Oct</td>
<td>239</td>
<td>147</td>
<td>0</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Length of Record: 3 to 4 years (1952-1955)</td>
</tr>
<tr>
<td>Central Sierra,</td>
<td>Jan</td>
<td>103</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>California</td>
<td>Apr</td>
<td>202</td>
<td>134</td>
<td>4</td>
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<tr>
<td></td>
<td>Jul</td>
<td>255</td>
<td>207</td>
<td>6</td>
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<tr>
<td></td>
<td>Oct</td>
<td>167</td>
<td>73</td>
<td>0</td>
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<td></td>
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<td>Length of Record: 5 to 6 years (1946-1952)</td>
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<tr>
<td>Blue Hill,</td>
<td>Jan</td>
<td>51</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>Apr</td>
<td>147</td>
<td>66</td>
<td>0</td>
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<td></td>
<td>Jul</td>
<td>236</td>
<td>110</td>
<td>0</td>
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<tr>
<td></td>
<td>Oct</td>
<td>111</td>
<td>13</td>
<td>0</td>
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<td>Length of Record: 4 years (1951-1954)</td>
</tr>
</tbody>
</table>

*Compiled from original observations taken by:

1. Weather Bureau
2. Signal Corps
3. Corps of Engineers

**Average less than 1.
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<tbody>
<tr>
<td>Albuquerque</td>
<td>Jan</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>10</td>
<td>14</td>
<td>21</td>
<td>8</td>
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<td>93</td>
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<td>Apr</td>
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<td>90</td>
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<td></td>
<td>Jul</td>
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<td></td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>12</td>
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<td>Oct</td>
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<td>20</td>
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<td>89</td>
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<td>Missing Observations: 1 in July, 1 in October.</td>
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</tr>
<tr>
<td>Yuma, Ariz.</td>
<td>Jan</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>18</td>
<td>18</td>
<td>31</td>
<td>12</td>
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<td>93</td>
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*Compiled from original observations taken by: (1) Weather Bureau, (2) Signal Corps, (3) Weather Bureau and Army Engineers Snow Investigations.
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<th>Element Compared</th>
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<th>Eastern Mass.</th>
<th>Arizona</th>
<th>D.C. Area</th>
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<tr>
<td>Hours sunshine (total)</td>
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<td>4,000</td>
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</tr>
<tr>
<td>Hours sunshine (per day)</td>
<td>Summer</td>
<td>9</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Hours sunshine (per day)</td>
<td>Winter</td>
<td>5</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>No. clear days (total)</td>
<td>Year</td>
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<td>250</td>
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<td>Sunshine (percent of possible)</td>
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<td>Sunshine (percent of possible)</td>
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<td>80</td>
<td>50</td>
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<tr>
<td>Radiation (langleys per day)</td>
<td>June</td>
<td>550</td>
<td>700</td>
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<td>Radiation (langleys per day)</td>
<td>December</td>
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<td>250</td>
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*Data interpolated from small scale maps in Visher's Climatic Atlas of the United States.*
### Table 5: Average Number of Hours and Percentage of Possible Sunshine at Selected Stations*

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<thead>
<tr>
<th>Station</th>
<th>No. Yrs.</th>
<th>Record Thrue 1948</th>
<th>Jan Hrs</th>
<th>Feb %</th>
<th>Mar %</th>
<th>Apr Hrs</th>
<th>May %</th>
<th>Jun %</th>
<th>Jul Hrs</th>
<th>Aug %</th>
<th>Sep %</th>
<th>Oct %</th>
<th>Nov %</th>
<th>Dec %</th>
<th>Annual %</th>
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<tbody>
<tr>
<td>Albuquerque, N. Mex.</td>
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<td>216</td>
<td>70</td>
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<td>71</td>
<td>298</td>
<td>76</td>
<td>315</td>
<td>80</td>
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<td>84</td>
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### Table 6: Average Cloudiness (0 to 10) at Selected Stations*

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<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
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<tbody>
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### TABLE 7: AVERAGE NUMBER OF CLEAR, PARTLY CLOUDY, AND CLOUDY DAYS AT SELECTED STATIONS

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<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
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<table>
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<th>Dec</th>
<th>Annual</th>
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<td></td>
</tr>
<tr>
<td>October</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>.670</td>
<td>1.020</td>
</tr>
<tr>
<td>Langley's per min.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunrise</td>
<td>6:15 A.M.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunset</td>
<td>5:15 P.M.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Values computed from Weather Bureau Climatological Data, Annual Summaries, since 1945.*
### Table 2: Comparison of Average Daily Solar Radiation at Blue Hill, Massachusetts

<table>
<thead>
<tr>
<th>Clear Day</th>
<th>Typical Day (Clear and Cloudy)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average insolation</strong></td>
<td><strong>Average insolation</strong></td>
</tr>
<tr>
<td>received on surface perpendicular to rays of sun</td>
<td>received on a horizontal surface at the ground</td>
</tr>
<tr>
<td>Langley's per day</td>
<td>Langley's per day</td>
</tr>
<tr>
<td>January</td>
<td>659</td>
</tr>
<tr>
<td>April</td>
<td>846</td>
</tr>
<tr>
<td>July</td>
<td>947</td>
</tr>
<tr>
<td>October</td>
<td>707</td>
</tr>
</tbody>
</table>

*Computed from Weather Bureau Climatological Data, and Hand since 1945.*

**From "Solar Radiation During Cloudless Days" Fritz, (1949).**

***From "Average Solar Radiation in the United States" Fritz and MacDonald, (1949).***