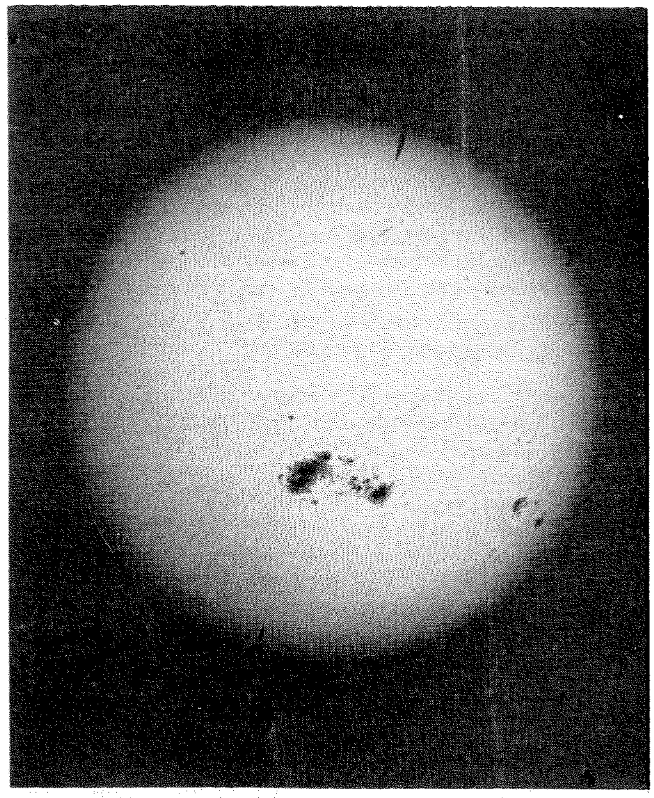
Blame it on Sunspots

by R. S. RICHARDSON



IN RECENT YEARS sunspots have been blamed for everything from depressions to headaches—including epidemics, radio static, the fecundity of rabbits and the weather. But slightly more than a century ago, when Heinrich Schwabe, an apothecary in the little town of Dessau, Germany, announced his discovery of the sunspot cycle—certainly one of the most important astronomical discoveries of the last century — it created scarcely a ripple. Apparently either nobody read it or else those who did failed to realize its significance. Not until six years later, when the announcement appeared again in the third volume of Humboldt's great work, *The Cosmos,* did recognition finally come. The trouble had been that whereas Schwabe spoke only to a handful of professional astronomers largely preoccupied with their own researches, Humboldt had a vast audience who read whatever he cared to write and accepted it as authoritative. Which demonstrates the value of having a publicity agent in science as well as other professions.

In 1849, six years after Schwabe's original announcement, Wolf of Zürich began a program of sunspot observations which has been continued by his successors to the present day without a break. Wolf's daily counts of individual sunspots and sunspot groups, when properly combined, constitute the famous Wolf relative sunspot numbers (see p. 20), the longest and most homogeneous index of solar activity that we possess. Wolf not only carried his observations forward in time, but by searching through the old records he was able to extend his relative numbers for each month as far back as 1749, and to estimate the times of maxima and minima clear to the invention of the telescope in 1610.

The average interval from one sunspot minimum to the next since 1749 is 11.1 years, although this interval has been as short as 9.0 years and as long as 13.6 years. It is probable that the sunspot cycle is only roughly periodic, like the eruptions of a geyser. A lot of people have spent a lot of time trying to predict the course of sunspot activity by superposing curves of different period and amplitude based upon the behavior of cycles in the past. So far, however, none has met with much success. The only way we seem to be able to predict sunspot activity with accuracy is backward.

Seventeen complete cycles have been observed since January 1749. The largest Wolf relative number for any one month was in May 1778, when the index reached 238.9. The third highest occurred during the cycle which is now in progress, in May 1947, when it attained a value of 201.6, being just nosed out for the place money by December 1836, with a count of 206.2.

Although the cycle from 1775 to 1784 is the highest on record, the present cycle which began late in 1943 has no rivals when it comes to the size of the spot groups involved. Previously the record for size was held by the great spot group of January 1926, with an area of 3700—meaning that it covered 3700 millionths or 0.37 of one per cent of the visible surface of the sun. (The size of sunspots is highly deceptive. They always appear to be much larger than they really are.) A sunspot group is considered "large" if it has an area greater than about 1000. Such groups can usually be seen through a very dark screen without the aid of a telescope.

When in February 1946 a spot group developed that had an area of 4900 we felt confident that it had set a record that would stand for many years. Our faith was somewhat shaken, however, when in July of the same year another group appeared with an area of 3700. Then in February 1947 a moderate-sized group passed across the disk that might be called a "sleeper," for at first it gave no hint of the rapid development it was to undergo. When the group reappeared on March 3, after a solar rotation of about a month, it had grown considerably and become more compact than in February. On its third return in April the group, although beginning to break up, had an area of 5400 and extended over 6.3 billion square miles of the solar surface. Thus this spot group (above) is the largest of which we have any record. Yet its place is still not too secure, as seen by the fact that in 1949 alone there were 59 spot groups large enough to be seen by the unaided eye.

In the last 50 years attempts have been made to correlate sunspot activity with practically every type of phenomenon imaginable: wars, earthquakes, the weather, the fecundity of furbearing animals in Canada, outbreaks of cerebrospinal meningitis and other diseases, the stock market, and I believe that even horse racing has come in for its share of attention. Of the many correlations that have been suspected, however, only a very few have withstood the test of time.

The oldest and best established correlation is that between the frequency of sunspots and terrestrial magnetic activity. Averages of terrestrial magnetic activity taken over a fairly long period, such as a year, follow the sunspot curve with remarkable fidelity. Occasionally magnetic records at stations all over the world will be subject to sudden and violent disturbances. These disturbances, which begin simultaneously to within about a minute and which last for about a day, are called magnetic storms. Great magnetic storms have been found to occur so often when a large spot group is near the center of the sun's disk that there seems little doubt the two must be connected in some way, although many large spot groups fail to produce storms, and a few storms have occurred when only small spots were visible.

Origin of Magnetic Storms

The cause of magnetic storms is still unknown, despite the fact that the data bearing upon them has been minutely analysed and much theoretical work has been done in an effort to interpret the results. At present two rival theories hold the field. One ascribes the origin of magnetic storms to charged particles ejected from active spot groups; the other to turbulent air motions in the ionosphere set off by bursts of ultra-violet radiation. Both theories have their loyal adherents who refuse to yield an inch to the opposition.

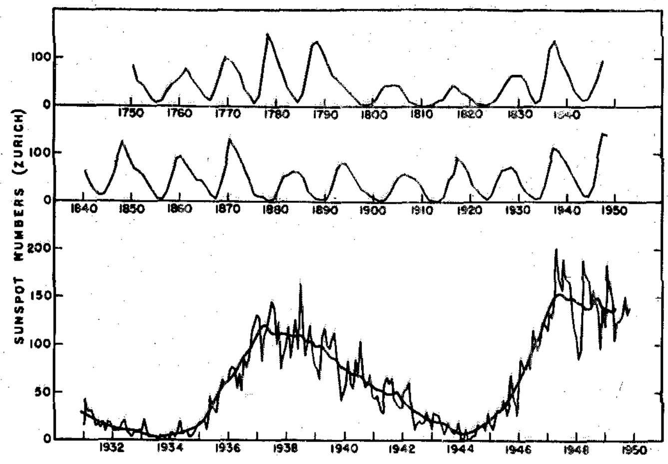
If the sun is viewed through some instrument such as the spectrohelioscope, which shows the surface in the light of one element only as the red line of hydrogen, occasionally one will be startled to see bright patches break out near a spot group that certainly were not there a minute ago. The patches grow rapidly until within ten minutes the whole region in and around the spot group is ablaze with brilliant ribbons of flame. Soon the ribbons begin to fade and after perhaps an hour will have disappeared entirely, leaving the region essentially the same as before. This phenomenon is called a *flare.*

Flares and Fadeouts

Flares have been found to occur simultaneously with fadeouts in high frequency radio transmission over the daylight side of the earth. A fadeout occurs during a flare because the ionosphere suddenly ceases to reflect the waves back to the earth, somewhat as if reflections from a mirror were cut off by thrusting a screen in front of it. Apparently there is a burst of ultra-violet light emitted during a flare which is able to pass down through the atmosphere without hindrance until within about 50 miles of the surface. Here for the first time it meets certain molecules (possibly ozone) which absorb the ultra-violet light strongly and as a consequence become highly ionized. Radio waves from a station, upon encountering this low-lying level, set the ions in rapid motion, but the air is so dense that they are quickly brought to rest by jostling against other particles around them. Thus the energy of the radio waves, instead of being reflected, as in the high rarefied layers of the ionosphere, is dissipated away in random collisions.

In February 1942, army radar stations in England experienced severe interference due to a high level of radio noise in their receivers. When bearings were taken on the source of interference they were found to point in a direction close to the sun. It was concluded that the noise was created by a large spot group then in transit across the disk. Here appeared to be a new method of exploring the solar atmosphere by means of waves short for radio but a million times longer than the longest infra-red rays we can photograph.

Although microwave technique has only been applied systematically to solar research since the war, already valuable results have been obtained. One of the most startling was the discovery that the fairly steady constant emission from the quiescent sun corresponds to a temperature of 1,000,000 degrees C! Since the surface of the sun that we see in the sky is known to have a temperature of only 5600 degrees C, such a figure might seem preposterous if we did not already have good reasons for believing that the temperature of the corona is around a million degrees. Hence the source of radio noise was tentatively identified with the corona, and later work has confirmed this view.



Radio noise usually rises sharply while a large spot group is crossing the solar meridian, and in addition there may be "bursts" when the intensity of emission increases by as much as a hundredfold in less than a minute. Enough bursts have been recorded almost in coincidence with flares to show that there is undoubtedly a connection between them, although all flares cannot be associated with bursts. As a general rule, the bigger flares are most likely to be associated with bursts, but the relationship is not a simple one.

Origin of Cosmic Rays

A recent theory advanced to account for cosmic rays assumes that they originate in flares in the sun or stars. Twenty years ago it was predicted that the changing magnetic field in a sunspot could accelerate charged particles up to cosmic ray energies. Three unusual increases in cosmic ray intensity have occurred, two soon after brilliant flares were observed, and a third after a radio fadeout indicating a flare. It seems scarcely credible that three such exceptional events could be the result of chance. The fact that many other brilliant flares failed to produce an increase in cosmic rays is attributed to the action of the sun's magnetic field, which prevents particles from escaping except near the poles. On very rare occasions, however, the magnetic fields of the sun and spot may combine temporarily to open up a long narrow "tunnel" through which charged particles can escape permanently from the solar surface. Calculations show that such tunnels actually existed during the three times in question. The theory still has many difficulties to meet, but it would appear that a promising lead has been obtained, at any rate.

Modern life has produced such a host of obscure and baffling ailments called neuroses, that the term has been taken over in other fields to such an extent that when an instrument performs in an erratic fashion we say jokingly that it must be "neurotic." Similarly, sunspots have been blamed for such a wide variety of disasters that befall us that they seem equally well suited as a universal scapegoat.