Radio Reception and Sun Spots

Astronomy—Physics

DR. HARLAN T. STETSON, former professor of astronomy at Harvard, who will assume the directorship of the Perkins Observatory at Delaware, Ohio, in the Fall.

By JAMES STOKLEY

The present popularity of radio is largely due to the fact that there were few sun spots in 1923!

In general, radio reception is as good in summer as it is in winter!

In October of this year radio reception will probably be poorer than it has been since broadcasting came into popularity. Not until the year 1934 may we expect really good radio reception, comparable with that which we enjoyed in 1923!

These are some of the surprising conclusions to be drawn from the researches of a Harvard astronomer and a private radio engineer. Dr. Harlan T. Stetson, assistant professor of astronomy at Harvard University, is the astronomer. He has just returned from Siam, where he observed the eclipse of the sun on the ninth of May. In his absence, however, his collaborator, Dr. Greenleaf W. Pickard, a radio engineer of Newton Centre, Massachusetts, has continued the work. In fact, it was Dr. Pickard who began the researches.

In February, 1926, he began the accurate measurement of radio reception in his private laboratory at Newton Centre. Two years later a duplicate set of apparatus was installed at the Astronomical Laboratory of Harvard University, and the measurements carried on there under Dr. Stetson's direction. Some months before this, in July, 1927, Mr. Howell C. Brown of Pasadena, California, began making records of reception from San Francisco.

What these scientists are doing is to find the effect of sun spots on radio. If you watch the sun from day to day, either with the naked eye through a piece of smoked glass, or with a telescope equipped with proper eye pieces to dim the brilliant light, you will occasionally see dark spots on its surface. For the last year or two, you would have been able to see a spot nearly every day. About 1923, weeks and even months might have gone by without a spot, and the same condition will take place within a few more years.

From such observations, the astronomers have found that the number of the sun spots waxes and wanes in a regular cycle. Once in about eleven and a half years the sun spots become particularly numerous, then they decrease again. According to some astronomers we seem to have just passed the period of maximum spottedness. However, it is not possible to tell when the maximum occurred until the curve is well on the downward course. Frequently the number of spots may seem to decline and then increase again within a few months. Thus, there is expected to be an unusually large number of spots for this fall, which may prove to be the maximum.

Sun spots, astronomers have found, are really great whirlpools, or tornadoes, in the outer layers of the sun. In the view of Dr. George E. Hale, honorary director of the Mount Wilson Observatory in California, it is a huge funnel-shaped vortex. The gases travel from the inside upward and to the outside of the spot in an ascending spiral of increasing diameter. A similar motion takes place in a tornado, in which the air moves spirally upward and outward. It is just the opposite to the spiral motion of the water running out of a circular wash basin.

Gases ascend to the top of the funnel, then expand rapidly and are cooled to a temperature from 2000 degrees Centigrade or 3600 degrees Fahrenheit below the temperature of the surrounding surface. Thus, in the words of Prof. H. N. Russell, of Princeton, "A sun spot is the greatest refrigerating mechanism known to exist", strange as it may seem to think of a temperature hotter than an arc light on the earth as "cool".

DR. GREENLEAF W. PICKARD, prominent radio engineer, who started the present study of the relation of sun spots and radio reception.

The cooling of the gases accounts for the fact that the spot is darker than the surrounding part of the solar surface, but here also the effect is due to contrast, for actually the sun spot is very bright. In fact, it is studied in the observatory by its own light. With great instruments, such as the huge tower telescope in the Mount Wilson Observatory, an image of the sun eighteen inches in diameter is obtained, and the spot is allowed to fall upon the slit of the spectroscope which analyzes its light. The light from the spot alone is sufficient to pass through the prisms and then spread out into the spectrum to leave a record of itself on the photographic plate. It is from such spectrum photographs of these spots that most of the astronomers' knowledge of their character has been learned.

There is no question that the sun spots have some influence on the earth. Great displays of the aurora borealis, or "northern lights", frequently accom- (*Turn to next page*)

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pany the passage of a large spot across the face of the sun. When average temperatures of the earth are charted over a long period, together with the numbers of sun spots, it is found that the earth is much cooler at the time of the greatest number of spots. It is warmer than average when the spots are at a minimum.

In many ways a sun spot is like the cathode ray tube developed a few years ago by Dr. W. D. Coolidge of the General Electric Company's Research Laboratory. Cathode rays, which have been known for many years, are streams of rapidly moving electrons, the minute particles of which atoms of matter are made. Before Dr. Coolidge's invention, they could only be observed in large quantities inside a vacuum tube. His tube, however, permitted the scientist to obtain them as a copious beam in the open air.

In a sense, the sun spot is such a cathode ray tube. From it comes a beam of these rapidly moving electrons, and sometimes the beam is so powerful that it bridges the 93,000,000 miles that separates the sun from the earth. When a beam of electrons enters a highly rarefied gas, the gas is ionized. An ionized atom, or "ion", is one from which one of the electrons has been removed. When such an electron is removed, the atom has a positive electrical charge. The electrons from the sun, penetrating the rarefied gases in the upper atmosphere, ionize them and make them luminous. This effect is the aurora borealis.

The path of the beam of electrons is determined also by the magnetic field of the earth. But a stream of rapidly moving electrons presents many of the characteristics of an electric current, and is therefore accompanied by its own magnetic field. The interaction of the two fields, those of the beam and the earth itself, produces magnetic disturbances which are known as magnetic storms.

These effects of the sun on the earth have been known for a long time, and it was in the year 1908 that Prof. R. A. Fessenden, one of the pioneer radio engineers, studied the relations of magnetic disturbance and radio reception at night. He found that the signals were weakened when the magnetism was disturbed. The work of Dr. Pickard and Dr. Stetson represents a modern continuation of the work of Mr. Fessenden. Dr. Stetson has described the work.

"Every night shortly before 9 p. m. Eastern Standard Time, Sundays and holidays included," said Dr. Stetson, "down in a small secluded room in the basement of the Harvard Astronomical Laboratory an attendant tunes in on WBBM, Chicago, at 760 kilocycles. Not trusting his own impressions as to whether reception is excellent, good, fair, or poor, he closes the key to the automatic recorder, whose slender pen with an impersonal but almost uncanny intelligence writes a continuous record of the intensity of the incoming waves. It is with almost cruel accuracy and utter disregard for astronomical or electrical theories that it leaves its unprejudiced and indelible record of what happens for the scientist to analyze.

"In addition to the measurement of radio reception the sun is photographed at the Harvard Laboratory every clear day in cooperation with the Yerkes, Mount Wilson, and Naval Observatories, and a careful study made of the size, numbers and locations of the sun spots each day. It is believed from a preliminary study that the distance of the spots from the center of the disk, or the sun-earth line, is an important factor in the study of correlation of sun spots with radio reception and other electro-magnetic phenomena on the earth.

"It is in the reduction and analysis of these records that the startling discovery of the effect of sun spots on radio has become established.

"The apparatus employed is a super-heterodyne receiver especially constructed for the purpose and feeding into a self-recording galvanometer which registers in microvolts in the antenna the strength of the carrier wave received from the broadcasting station of WBBM, Chicago. The apparatus is so designed that the modulations of the carrier wave do not affect the record appreciably, and the results obtained are independent of the nature of the program broadcast.

"Realizing the importance of the investigation, the broadcasting station scrupulously maintains a constant energy output in its antenna current, and each night before the Harvard Laboratory begins work the receiving set is carefully calibrated by means of a small local oscillator in the laboratory placed in close proximity to the receiving set. The output of the local oscillator necessary to maintain full scale deflection upon the galvanometer of the receiver is then read from a microammeter in circuit and the constant of the apparatus for the evening is thus determined.

"In this way local sources of error both at the broadcasting and receiving ends are eliminated and the resulting measures of the variable reception from night to night may be attributed to the changing electrical conditions of the atmosphere through which the broadcasted wave travels en route from Chicago to Cambridge.

"Scientists differ in their ideas as to just what happens when a broadcasted wave travels over the earth. Some believe that an ether wave is propagated which is reflected back to earth from an ionized layer of the earth's atmosphere known as the Kennelly-Heaviside layer which lies some 70 kilometers above the earth's surface. Others maintain that the electric wave is refracted rather than reflected from such a layer.

"Whatever the mechanism, the wave appears to be turned back by this ionized layer of the earth's atmosphere. Any change in the intensity or degree of this ionization or electrification of the earth's upper atmosphere would have the effect of bending the ray more abruptly or less abruptly towards the earth and would at once be noticed in the intensity of radio reception. The more rapid changes of this sort are doubtless responsible for the phenomena of fading with which every radio fan is thoroughly familiar.

"According to our theory, the sun constantly bombards the earth's atmosphere with electrons or bundles of energy of high frequency which, in turn, tear apart the positive and negative charges of the atmospheric molecules. In other words, they ionize the atmosphere to a very considerable extent, thus producing the Kennelly-Heaviside layer. If the sun is more active on occasions, as when large spots appear on its surface, the degree of ionization increases, producing substantially the effect of lowering the Kennelly-Heaviside layer and upsetting the radio reception. When the sun is again less active, the atmosphere tends to return to its normal state of ionization and radio broadcasting reception tends to improve as the ionized layer lifts.

"For certain wave lengths it is possible that the effect of a rising and falling ionized layer might actually be the reverse of that noted in the broadcasting zone, giving improved reception during (*Turn to next page*)

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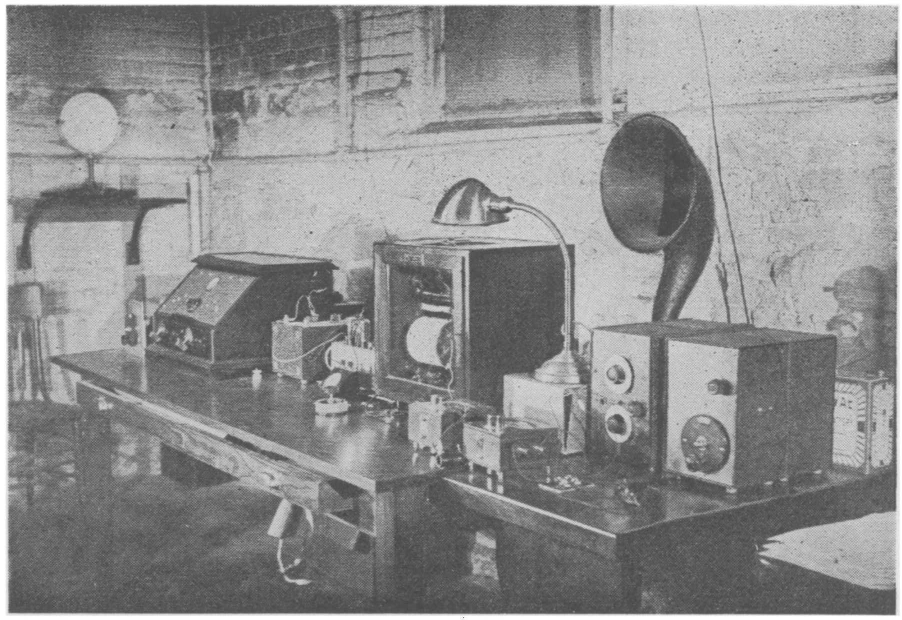
greater solar activity and poorer reception during less solar activity. Curiously enough, this is just what has been observed by Dr. Pickard at the Newton Centre Laboratory when working on long waves of 18 kilocycle frequency."

Not only is there a difference due to wave-length, but the direction that the radio waves travel is also a factor. There is a further difference between day and night.

"In announcing my results previously, I have emphasized the fact that the reception considered is at night, and now I will add the further qualification of West-East transmission path," said Dr. Pickard the other day. "For day reception, which Dr. Austin has been measuring at Washington since 1915, is in general inversely related to night reception, so that associated with high sunspot number and disturbances of terrestrial magnetism we find high values of day reception and low values of night reception. And, principally through the records taken by Mr. Brown at Pasadena over a more nearly north-south path, I am finding that night reception along a meridian obeys a different law. Owing to the shortness of this Pacific Coast series, I cannot at present give its relations to solar activity and other elements, although apparently it also follows a monthly cycle."

If the curve showing the number of sun spots is charted on a sheet of paper and the curve for radio reception is charted underneath it, it is found that there is a striking similarity. As the number of sun spots goes down, the radio reception goes up and a time of many sun spots is closely associated with a time of poor reception. Another striking feature of the curve is that it is quite regular. In about fifteen months the sun spots come to a maximum and then decrease.

In January, 1926, the spots were unusually numerous, and radio reception was poor. By August of the same year the spots had considerably decreased and radio reception had considerably improved. April, 1927, brought even more sun spots than January of the previous year, and even poorer reception. Then the spots declined and reception rose until the fall of 1927 had few spots and good reception. By July, 1928, there were even more spots than on the two previous occasions and even poorer reception.



APPARATUS FOR MEASURING RADIO RECEPTION, designed by Dr. Pickard and installed at the Harvard Astronomical Laboratory

The times of these maxima are about fifteen months apart, and so this autumn, probably about October, there should be another maximum number of sun spots and another time of poor reception. Dr. Stetson and Mr. Pickard both believe that the spots will be even more numerous than they have been in the past three occasions and that reception will be even poorer. Not until 1934, when spots are again at their minimum, will our radio reception become especially good.

It is a striking thing, brought out by this work, that in 1923 the sun spots were also at their minimum. Though at that time such careful observations were not made on radio reception, it is known that during that year conditions were unusually good. As this was the time when radio broadcasting was just coming into popularity, the good reception associated with the few sun spots contributed to a large extent to its present popularity.

Another favorite idea that is contradicted by Dr. Stetson's and Mr. Pickard's work is the belief in a difference between summer and winter radio reception.

"An important result of the study of the reception curve is to show how completely unfounded is the popular impression that radio reception is universally poor in summer and good in winter," said Dr. Stetson. "Generally speaking, reception should be better in the winter months on account of the shortened days and decreased daylight. On the other hand, the sun spots and radio curves of 1926-28 show that the increased solar activity actually gave much poorer reception in the winter months of both 1926 and 1927 than during the summers of the same years."

While this work shows undoubtedly the relation between the sun spots and radio reception, the experimenters are both of the opinion that the relation is probably not one of cause and effect.

"It seems far more plausible that changes in solar activity are more directly responsible for variations in the signal strengths received than that such should be dependent upon any absolute values in atmospheric temperature," they say.

But the knowledge thus gained of the nature of the gravity of the sun itself may prove to be the most important outcome of these researches.

"That the earth is in the midst of an immense electric field emanating from the sun and varying with the solar cycle may prove to be the outcome of our investigations," said Dr. Stetson. "For many generations scientists have recognized a recurrent cycle in solar activity, but never before now has it been possible to study the changing degree of the electrification of the earth's atmosphere with the coming and going of sun spots across the solar disk. All this has come about by the development of radio."

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