

# Kennelly-Heaviside Ionized Layer -A Classic of Science

Physics

ON THE ELEVATION OF THE ELECTRICALLY-CONDUCTING STRATA OF THE EARTH'S ATMOSPHERE. By A. E. Kennelly. In the *Electrical World and Engineer*, New York, March 15, 1902.

ACCORDING to the measurements of Professor J. J. Thomson (Recent Researches in Electricity and Magnetism, p. 101) air at a pressure of 1-100 mm. of mercury has a conductivity for alternating currents approximately equal to that of a 25 per cent. aqueous solution of sulphuric acid. The latter is known to be roughly 1 ohm-per-centimeter, so that a centimeter cube would have a resistance of about one ohm. Consequently, air at ordinary temperatures, and at a rarefaction 76,000 times greater than that at sea level, has a conductivity some 20 times greater than that of ocean water, although about 600,000 times less than that of copper.

If we apply the ordinary formula for finding the elevation corresponding to a given air-refraction, we find that if the air had a uniform temperature of 0 deg. C., the height of this stratum of air with a rarefaction of 76,000, would be

18.39 log 76,000 kilometers above the sea,  
or 89.77 kilometers,  
or 55.77 miles.

If the air had a uniform temperature of -50 degs. C., this elevation would be reduced 18.3 per cent., or to 73.3 kilometers (45.5 miles). The temperature of the earth's atmosphere has only been measured within a range of a very few kilometers above the surface of the sea, and consequently the materials are not at hand for any precise calculation of the height of electrically conducting strata. It may be safe to infer, however, that at an elevation of about 80 kilometers, or 50 miles, a rarefaction exists which, at ordinary temperatures, accompanies a conductivity to low-frequency alternating currents about 20 times as great as that of ocean water.

There is well-known evidence that the waves of wireless telegraphy, propagated through the ether and atmosphere over the surface of the ocean, are reflected by that electrically-conducting surface. On waves that are transmitted but a few miles the upper

When Marconi, in Newfoundland, received the three dots of the letter S by means of an antenna held aloft a la Franklin, by a kite, he furnished Prof. Kennelly with data for his inference as to the existence of an ionized layer or layers in the earth's atmosphere. For the . . . were sent from a pioneer transatlantic radio station in Cornwall, England, and computation showed that the amount of energy radiated from England was too small to operate the receiver across the ocean, if the waves travelled directly over the water, or through the air, according to the ordinary three-dimensional expansion hypothesis of electromagnetic distribution. That was in the fall of 1901. Prof. Kennelly's explanation was published early in 1902.

At first the ionized layer of the earth's atmosphere was called the "Heaviside layer" due to fact that the English gave credit to Dr. Oliver Heaviside, English physicist, for the origin of the theory. In fact, Prof. Kennelly himself presumed that Dr. Heaviside's *Encyclopedia Britannica* article, reprinted in part on this page, was published earlier than his own explanation, but in 1923 he was prompted to look into the matter of priority, through a hint in a French comment that his was the prior publication.

The result was the rechristening of the ionized layer as the "Kennelly-Heaviside layer."

conducting strata of the atmosphere may have but little influence. On waves that are transmitted, however, to distances that are large by comparison with 50 miles, it seems likely that the waves may also find an upper reflecting surface in the conducting rarefied strata of the air. It seems reasonable to infer that electro-magnetic disturbances emitted from a wireless sending antenna spread horizontally outwards, and also upwards, until the conducting strata of the atmosphere are encountered, after which the waves will move horizontally outwards in a 50-mile layer between the electrically-reflecting surface of the ocean beneath, and an electrically-reflecting surface, or successive series of surfaces, in the rarefied air above.

If this reasoning is correct, the curvature of the earth plays no significant part in the phenomena, and beyond a radius of, say, 100 miles from the transmitter, the waves are propagated with uniform attenuation cylindrically, as though in two-dimensional space. The problem of long-distance wireless wave transmission would then

be reduced to the relatively simple condition of propagation in a plane, beyond a certain radius from the transmitting station. Outside this radius the voluminal energy of the waves would diminish in simple proportion to the distance, neglecting absorption losses at the upper and lower reflecting surfaces, so that at twice the distance the energy per square meter of wave front would be halved. In the absence of such an upper reflecting surface, the attenuation would be considerably greater. As soon as long-distance wireless waves come under the sway of accurate measurement, we may hope to find, from the observed attenuations, data for computing the electrical conditions of the upper atmosphere. If the attenuation is found to be nearly in simple proportion to the distance, it would seem that the existence of the upper reflecting surface could be regarded as demonstrated.

TELEGRAPHY. By Oliver Heaviside. In *Encyclopedia Britannica*, Vol. XXXIII, 1902 (Published Dec. 19, 1902, written June, 1902).

THERE is something similar in "wireless" telegraphy. Sea water, though transparent to light, has quite enough conductivity to make it behave as a conductor for Hertzian waves, and the same is true in a more imperfect manner of the earth. Hence the waves accommodate themselves to the surface of the sea, in the same way as waves follow wires. The irregularities make confusion, no doubt, but the main waves are pulled round by the curvature of the earth, and do not jump off. There is another consideration. There may possibly be a sufficiently conducting layer in the upper air. If so, the waves, so to speak, catch on to it more or less. Then the guidance will be by the sea on one side and the upper layer on the other. But obstructions, on land especially, may not be conducting enough to make waves go round them fairly. Then waves will go partly through them.

THE KENNELLY-HEAVISIDE LAYER. A letter by Alexander Russell to *Nature*, October 24, 1925.

EVERY radio engineer is familiar with what is called the "Heaviside Layer" and (Turn to next page)

# Crime Wave Spreads to Wild Animals

Zoology

The much-talked-of crime wave seems to have spread even to some of the wild animals of Yosemite National Park, and it has been necessary to provide a patrol wagon especially adapted to the peculiar need to take care of recalcitrant bears.

The patrol wagon is unique, consisting of a piece of corrugated pipe large enough to contain a bear, sealed at one end and equipped with a trap door at the other. It is mounted on pneumatic wheels to make the riding

## Adults Need Vitamin D

Physiology

That the present-day craving for sun-tan safeguards health as well as social standing has been further demonstrated by two Chicago scientists, Dr. Katharine Blunt and Miss Ruth Cowan, who are about to publish a book on the subject of ultraviolet light and vitamin D.

If adults are deprived seriously of these two factors, they run the risk of osteomalacia, a famine disease in which the bones lose calcium, soften, and change in shape. Bow legs, carious teeth and peculiar gait develop in these people. If they played golf, swam outdoors, or even walked to work the condition could be averted. But in these days of scientific wonders other methods of prevention and cure have been discovered, such as ultraviolet light therapy, cod-liver oil, and irradiated foods. It is this light which is so important, and a person can either irradiate himself or purchase irradiated food.

In certain sections of India, among the women of the better class, osteomalacia is common because they are kept indoors most of the time and are heavily veiled when they do go out. The ultraviolet light never reaches them. Women of the lower class who are out all day in the open air are entirely free from the disease.

Ultraviolet light is the key to the situation in the prevention or relief of this condition among adults, but it cannot accomplish prevention or relief entirely by itself, because other factors enter in. While vitamin D is important, a supply of calcium is also necessary for bones to grow properly and to remain strong and healthy throughout life. Sunshine and cod-liver oil are good sources of vitamin D and calcium is to be found in milk, primarily, and also in fresh fruits and vegetables.

*Science News-Letter, January 18, 1930*

easy and attached to an automobile truck.

When word is received at headquarters that a bear is disturbing the peace anywhere in the park, the patrol is quickly sent to the scene of trouble. Since bears live solitary lives, each holding sway over certain areas, the disturber is likely to be the only bear in his particular neighborhood. The pipe bear trap on wheels is then detached and a piece of meat placed inside.

This guilty bear, smelling the meat, usually crowds into the pipe in search of it. The trap door slams shut and the bruin is a prisoner.

Bears so caught in the inhabited portion of Yosemite Valley are sentenced to banishment. They are marked

## Kennelly-Heaviside—Cont.

its supposed functions. I find, however, that the hypothesis of an electrically conducting stratum in the upper air was clearly enunciated in an article by Prof. A. E. Kennelly, of Harvard University, published in the *Electrical World and Engineer* of New York on March 15, 1902. The official date of Heaviside's disclosure of his hypothesis is December 19, 1902. About the same date H. Poincaré, A. Blondel, and C. E. Guillaume made similar hypotheses. If names are to be attached to this hypothetical layer it should be called, in equity, the "Kennelly-Heaviside" layer, a name which is beginning to be used in America.

*Science News-Letter, January 18, 1930*

## Parrot Fever—Cont'd

break. A special study of the parrot fever epidemic in this country is now being made by Dr. Charles Armstrong, of the U. S. Hygienic Laboratory in cooperation with the health officers of the various states and cities where cases have been reported.

Dr. Armstrong was detailed to this special work as a result of a meeting of the staff of the U. S. Public Health Service, called especially to consider the present situation in regard to psittacosis.

*Science News-Letter, January 18, 1930*

One Cincinnati court has been equipped with a microphone and loudspeaker, so that jurors may be sure to catch all that is said by the witnesses.

with a daub of paint for purposes of later identification, taken to the lower end of the park and released. If they "repeat" they are identified by the paint mark.

Yellowstone Park's "holdup bears" have developed a new branch of the desperado business. One of them recently robbed the United States mails. Park Naturalist Dorr Yeager tells of the occurrence, which befell one of his colleagues, Dick White:

"It seems that some time ago Dick stopped at the West Thumb road camp for lunch. The season being closed, and the regular mail delivery having ceased, Dick was obligingly carrying a bundle of mail with him for the members of the different road crews around the loop. He left the mail in the car and, after enjoying a good meal, returned to continue his journey to Lake.

"Imagine his surprise, however, to find the package of mail not in the car but between the paws of a black bear in a nearby tree. Bruin was examining the packet intently, sniffing and turning it over in an inquisitive manner."

*Science News-Letter, January 18, 1930*

## Bibliography of the Writings of Edwin E. Slosson

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