Lightning Studies.

By Anna McNeil (*Scotia, N. Y.*).

SCIENTISTS turn their attention to the entire realm of Nature with the hope of harnessing mighty forces and making them subservient to man's use. Lightning in itself may not be tamed, but its cause is known, its action studied, its effects may be averted insofar as they disturb electrical transmission lines, and man has made artificial lightning in the great laboratories of industry and has caused it to strike and shatter objects that have been designated for the purpose.

It is estimated that an average of forty-four thousand thunderstorms takes place daily, the world over, and that the power of the lightning dissipated in these storms is equal to 1,200,000 kilowatts, or the glow of thirty million electric lamps of medium size.

Lightning over Milwankee, Wisconsin, U.S.A.

One of the great lightning investigators was a Hungarian named Lenard. The descending drops and rising spray of a waterfall gave him a clue to the nature of lightning. He found that small drops of water are blown upward just as thunderheads are piled high by the wind. The small drops in the spray carry negative charges of electricity and large drops carry positive charges. He reasoned from this that the small drops of water that rise upward in a thunderhead are negatively charged while the larger drops that remain in the lower part of the cloud carry positive charges. The earth is charged negatively.

When the difference between the charge of the upper and lower parts of the cloud; between the lower part of the cloud and the earth; or between parts of one cloud and another, become too great, there is a flash of lightning with the accompanying rumble or crash of thunder. On transmission lines the flash may cause a sudden rise to as high as four or five million volts.

Lightning may pass from the earth to a cloud as well as from a cloud to the earth. When a tree is struck by lightning a current of great intensity is gathered up from the earth. It passes up the tree through the air and charges the cloud to the same potential as the earth. This explains why it is extremely dangerous to stand under a tree for shelter during a thunderstorm and why so many cattle are killed through being struck by lightning.

Lightning Observatory, top of building 42, General Electric Co., Pittsfield Works. 102 ft. above ground, equipped with periscope, dark room, camera platform, and other devices. First building of its kind erected solely for observation of natural Lightning.

Until recently it was believed that lightning never strikes twice in the same place; in fact, there is a time honored proverb to that effect. But lightning not only strikes twice, but as many as ten times. This has been proved by a special type of camera in which the film is whirled past the lens at a faster speed than a mile a minute. There is a time scale along the length of the film so that readings in millionths of a second are possible. The ten re-current discharges from cloud to earth; earth to cloud; and so on,

alternately, occur in a fraction of a second, and at this inconceivable speed could not be detected by the human eye nor by an ordinary camera.

Farmers have observed that their crops grow better after an electrical storm and have attributed the fact to the rainfall which is apt to be heavy at such a time. Lightning is really the responsible factor. Scientists in the great fertilizer plants are lately uncovering one of Nature's age-long chemical secrets. Lightning produces one-hundred-million tons of nitrogen over the earth's surface every year, depositing it upon the soil to aid all growing things. A bolt of lightning coming down through the air which is composed of approximately four-fifths nitrogen and one-fifth oxygen, breaks down the chemical constituency of the air and bestows fixed nitrogen upon the land as a boon to the farmer, at no cost. Lightning thus serves a useful purpose and is a blessing in disguise, however terrifying its form.

For years the General Electric Company has experimented with artificial lightning and has produced ten million volts in the laboratory. Recently an outdoor lightning observatory believed to be the only one of its kind in the world, has been constructed 102 feet above ground, on the roof of the largest building of the Pittsfield, Massachusetts, General Electric plant.

The strange-looking structure is equipped with a periscope and a twelve-lens lightning recorder camera. Built largely of metal, it is grounded to the steel framework of the building on which it rests. It is coated with aluminum paint on the outside; with flat black on the inside. It is fourteen feet in diameter, topped by an eight-inch crystal sphere.

Lightning flashing in any direction within a radius of twenty miles is reflected on the silvery surface of the roof and thence in the crystal sphere and is made visible through the eyepiece of the periscope by a mirror set at an angle of 45 degrees, in its dark-walled tube.

The camera is directly beneath the periscope platform. It is exposed to the weather when in use but is protected with a curtain of compressed air. The compressed air is admitted into a perforated metal ring beneath which the camera is placed. The invisible curtain does not interfere with the taking of pictures and effectually keeps out all but the most severe downpour.

RESEARCH ITEMS.

Linear Diophantine Approximations.—Khintchine (*Math. Ann. B.*, **113,** 398–415) has contributed an interesting article about the solution of the non-homogeneous n-dimensional $[n > 1]$ diophantine approximation problem. The theorem of Kronecker, *viz.*, that given n irrational numbers $\theta_1, \theta_2, \ldots\ldots \theta_n$, then corresponding to every $t > 1$ we can find integers $x, y_1, \ldots\ldots y_n$ such that

$$(1) \quad x\theta_i - y_i \mid < \frac{1}{t}. \quad i = 1, 2, \cdots n$$

and $0 < \mid x \mid \leqslant t^n$. Khintchine considers the non-homogeneous case, *i.e.*, when (1) is replaced by (2) $\mid x\theta_i - a_i - y_i \mid < \frac{1}{t}$, where a_i's are given real numbers. It is well known even in case $n = 1$, this problem is not solvable if the restriction on x is the same as above (or even when t^n is replaced by Ct^n). It was recognised by the author long ago that the theorem would only be true with some restriction on the irrational number θ. Ten years ago he found out the condition in case $n = 1$. The condition expressed in terms of continued-fractions is that the quotients of the continued-fraction-development of θ were bounded. It should be observed that if the contrary is true then the homogeneous problem for θ is solvable with much less restriction on x. [*i.e.*, $x = o(t)$ instead of $x = O(t)$.] The theorem he proves is the generalisation of this to higher dimensions. It should also be noted that generalisations of diophantine approximations to higher dimensions is often impossible or extremely complicated. As the author observes that the inequalities $\mid x\theta - y - a \mid < \frac{1 + \epsilon}{\sqrt{5}\, x}$ is solvable for a sequence of values of x, and the analogue of this in the case of higher dimensions not being true. The extremely interesting result that he proves is the following :

Let $\theta_1, \theta_2, \ldots\ldots \theta_n$ be real numbers. The necessary and sufficient condition in order that a positive constant A exists satisfying the condition

$$o < x < At^n \mid x\theta_i - y_i - \alpha_i \mid < \frac{1}{t}. \quad i = 1, 2, \cdots n$$

for all $t \geqslant 1$, is that there should exist another constant a (both the constants depend on the θ's such that the inequalities

$o < x < At^n \quad \mid x\theta_i - y_i \mid < \frac{1}{t}$ *does not* possess a solution for any integral t.

The necessity of this follows easily by a method analogous to the one-dimensional case. The proof of sufficiency is extremely intricate.

K. V. I.

A Very Accurate Test of Coulomb's Law of Force between Charges.—Taking Coulomb's law of the force between two charges to be given by $F = \frac{\sigma\sigma'}{r^{2 \pm q}}$, Maxwell showed that $q < 1/21600$. This result quoted in all text-books gives the limit of accuracy of the inverse square law as determined by Maxwell and we have had to be satisfied with it till to-day. Now S. J. Plimpton and W. E. Lawton (*Phys. Rev.*, 1936, **50,** 1066) report experiments which prove that the exponent of r in the law of force differs from 2 by less than 1 part in 10^9. The electrostatic method of Maxwell and Cavendish was replaced by a quasi-static method in order to eliminate stray effects due to spontaneous ionization and contact potentials. The principle however is the same: A spherical air condenser consisting of two concentric insulated globes is employed. The upper globe has a small hole closed by a lid which has a projection making contact between the two globes. The outer globe is first charged to a high potential,