tained for calculating, if possible, a more exact formula. No adequate theoretical explanation has been found, as yet, of the observed variations, though it is suspected that the annual part of the variation is due to meteorological causes, and that the other part may be caused by changes in the relative positions of portions of the earth's mass, such as movements of great masses of water and depositions of ice and snow.

A number of important problems are involved in this question of latitude variation. All the determinations of astronomy have been made on the assumption that our latitudes do not change. When the astronomer is supplied with sufficiently exact data the determination of various constants used in astronomy must be recalculated. Dr. Chandler and others have already begun the reinvestigation.

The problems so far discussed belong to pure astronomy. In the past forty years there has grown up, with a vigorous growth, a new branch of astronomy styled by some The New Astronomy. This branch deals with the beautiful and interesting investigations of the heavenly bodies made by the aid of that wonderful instrument of modern research, the spectroscope. On this occasion I will not trespass on your patience by attempting to describe to you the achievements of the new astronomy in the examination of the sun and the planets, the stars, nebulæ and comets. By the investigations of this young science of spectroscopy applied to the heavenly bodies, we get our first and accurate ideas of their constitution. On the spectroscopist we must depend for our knowledge of the surroundings of the sun and planets—the materials entering into the make-up of the stars, comets and nebulæ. The study of the stellar spectra brings wonderful information in regard to variable stars and the motions of stars.

The discoveries of argon and helium have unlocked some doors to knowledge previously closed tightly. On astrophysics the astronomer of the 20th century must depend for solving many problems. It is likely that a study of planetary spectra will give us the means of determining the rotation times of the planets—Venus and Mercury.

We have thus briefly and inadequately mentioned some of the problems which the astronomer of the next century must deal with. When we consider the progress made during the past twenty-years only, we are led to believe that world-wide coöperation in astronomical work will be one of the great features of the coming century. Only by such coöperation, directed by the ablest astronomers, can the most effective work be done. With such coöperation many of the troublesome problems will undoubtedly be solved.

J. K. Rees.

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*A NEW FORM OF RADIATION.**

As my investigations will have to be interrupted for several weeks, I propose in the following paper to communicate a few new results.

§ 18. At the time of my first communication it was known to me that X-rays were able to discharge electrified bodies, and I suspected that it was X-rays, not the unaltered cathode rays, which got through his aluminum window, that Lenard had to do with in connection with distant electrified bodies. When I published my researches, however, I decided to wait until I could communicate unexceptionable results. Such are only obtainable when one makes the observation in a space which is not only completely protected against the electrostatic influences of the vacuum tube, leading-in wires, induction coil, etc., but which is also protected against the air coming from the

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vicinity of the discharge apparatus. To this end I made a box of soldered sheet zinc large enough to receive me and the necessary apparatus, and which, even to an opening which could be closed by a zinc door, was quite air-tight. The wall opposite the door was almost covered with lead. Near one of the discharge apparatus placed outside, the lead-covered zinc wall was provided with a slot 4 cm. wide, and the opening was then hermetically closed with a thin aluminum sheet. Through this window the X-rays could come into the observation box. I have observed the following phenomena:

(*a*) Positively or negatively electrified bodies in air are discharged when placed in the path of X-rays, and the more quickly the more powerful the rays. The intensity of the rays was estimated by their effect on a fluorescent screen or on a photographic plate. It is the same whether the electrified bodies are conductors or insulators. Up to the present I have discovered no specific difference in the behavior of different bodies with regard to the rate of discharge, and the same remark applies to the behavior of positive and negative electricity. Nevertheless, it is not impossible that small differences exist.

(*b*) If an electrical conductor is surrounded by a solid insulator, such as paraffin, instead of by air, the radiation acts as if the insulating envelope were swept by a flame connected to earth.

(*c*) If this insulating envelope is closely surrounded by a conductor connected to earth, which should like the insulator be transparent to X-rays, the radiation, with the means at my disposal, apparently no longer acts on the inner electrified conductor.

(*d*) The observations described in *a*, *b* and *c* tend to show that air traversed by X-rays possesses the property of discharging electrified bodies with which it comes in contact.

(*e*) If this be really the case, and if, further, the air retains this property for some time after the X-rays have been extinguished, it must be possible to discharge electrified bodies by such air, although the bodies themselves are not in the path of the rays.

It is possible to convince oneself in various ways that this actually happens. I will describe one arrangement, perhaps not the simplest possible. I employed a brass tube 3 cm. in diameter and 45 cm. long. A few centimeters from one end a portion of the tube was cut away and replaced by a thin sheet of aluminum. At the other end an insulated brass ball fastened to a metal rod was led into the tube through an air-tight gland. Between the ball and the closed end of the tube a side tube was soldered on, which could be placed in communication with an aspirator. When the aspirator was worked the brass ball was surrounded by air, which on its way through the tube went past the aluminum window. The distance from the window to the ball was over 20 cm. I arranged the tube in the zinc box in such a manner that the X-rays passed through the aluminum window at right angles to the axis of the tube, so that the insulated ball was beyond the reach of the rays in the shadow. The tube and the zinc box were connected together; the ball was connected to a Hankel electroscope. It was seen that a charge (positive or negative) communicated to the ball was not affected by the X-rays so long as the air in the tube was at rest, but that the charge immediately diminished considerably when the aspirator caused the air traversed by the rays to stream past the ball. If the ball by being connected to accumulators was kept at a constant potential, and if air which had been traversed by the rays was sucked through the tube, an electric current was started as if the ball had been connected with the wall of the tube by a bad conductor.

(*f*) It may be asked in what way the air loses this property communicated to it by the X-rays. Whether it loses it as time goes on, without coming into contact with other bodies, is still doubtful. It is quite certain, on the other hand, that a short disturbance of the air by a body of large surface, which need not be electrified, can render the air inoperative. If one pushes, for example, a sufficiently thick plug of cotton wool so far into the tube that the air which has been traversed by the rays must stream through the cotton wool before it reaches the ball, the charge of the ball remains unchanged when suction is commenced. If the plug is placed exactly in front of the aluminum window the result is the same as if there were no cotton wool, a proof that dust particles are not the cause of the observed discharge. Wire gauze acts in the same way as cotton wool, but the meshes must be very small and several layers must be placed one over the other if we want the air to be active. If the nets are not connected to earth, as heretofore, but connected to a constant-potential source of electricity, I have always observed what I expected ; however, these investigations are not concluded.

(*g*) If the electrified bodies are placed in dry hydrogen instead of air they are equally well discharged. The discharge in hydrogen seems to me somewhat slower. This observation is not, however, very reliable, on account of the difficulty of securing equally powerful X-rays in successive experiments. The method of filling the apparatus with hydrogen precluded the possibility of the thin layer of air which clings to the surface of the bodies at the commencement playing an appreciable part in connection with the discharge.

(*h*) In highly-exhausted vessels the discharge of a body in the path of the X-rays takes place far more slowly—in one case it was, for instance, 70 times more slowly—than in the same vessels when filled with air or hydrogen at atmospheric pressure.

(*i*) Experiments on the behavior of a mixture of chlorine and hydrogen, when under the influence of the X-rays, have been commenced.

(*j*) Finally, I should like to mention that the results of the investigations on the discharging property of the X-rays, in which the influence of the surrounding gases was not taken into account, should be for the most part accepted with reserve.

§ 19. In many cases it is of advantage to put in circuit between the X-ray producer and the Ruhmkorff coil a Tesla condenser and transformer. This arrangement has the following advantages: Firstly, the discharge apparatus gets less hot, and there is less probability of its being pierced; secondly, the vacuum lasts longer, at least this was the case with my apparatus; and thirdly, the apparatus produces stronger X-rays. In apparatus which was either not sufficiently or too highly exhausted to allow the Ruhmkorff coil alone to work well, the use of a Tesla transformer was of great advantage.

The question now arises—and I may be permitted to mention it here, though I am at present not in a position to give answer to it—whether it be possible to generate X-rays by means of a continuous discharge at a constant discharge potential, or whether oscillations of the potential are invariably necessary for their production.

§ 20. In § 13 of my first communication it was stated that X-rays not only originate in glass, but also in aluminum. Continuing my researches in this direction, I have found no solid bodies incapable of generating X-rays under the influence of cathode rays. I know of no reason why liquids and gases should not behave in the same way.

Quantitative differences in the behavior of different bodies have, however, revealed themselves. If, for example, we let the cathode rays fall on a plate, one-half consisting of a 0.3 mm. sheet of platinum and the other half of a 1 mm. sheet of aluminum, a pin-hole photograph of this double plate will show that the sheet of platinum emits a far greater number of X-rays than does the aluminum sheet, this remark applying in either case to the side upon which the cathode rays impinge. From the reverse side of the platinum, however, practically no X-rays are emitted, but from the reverse side of the aluminum a relatively large number are radiated. It is easy to construct an explanation of this observation; still it is to be recommended that before so doing we should learn a little more about the characteristics of X-rays.

It must be mentioned, however, that this fact has a practical bearing. Judging by my experience up to now, platinum is the best for generating the most powerful X-rays. I used a few weeks ago, with excellent results, a discharge apparatus in which a concave mirror of aluminum acted as cathode and a sheet of platinum as anode, the platinum being at an angle of 45 deg. to the axis of the mirror and at the center of curvature.

§ 21. The X-rays in this apparatus start from the anode. I conclude from experiments with variously-shaped apparatus that as regards the intensity of the X-rays it is a matter of indifference whether or not the spot at which these rays are generated be the anode. With a special view to researches with alternate currents from a Tesla transformer, a discharge apparatus is being made in which both electrodes are concave aluminum mirrors, their axes being at right angles; at the common center of curvature there is a 'cathode-ray catching' sheet of platinum. As to the utility of this apparatus I will report further at a later date.

W. K. RÖNTGEN.

BEHAVIOR OF SUGAR TOWARDS RÖNTGEN RAYS.

THE fact that sugar is transparent to X-rays was ascertained at an early date after Röntgen's announcement of his momentous discovery. It seemed, however, of interest to learn whether the structure of the sugar traversed by the rays might exercise any influence on the rays or modify their action on photographic plates.

Through the courtesy of Prof. M. I. Pupin, of Columbia University, who kindly extended the privileges of his laboratory to the writer, the following tests were made:

Two plates of sugar were selected. The one was a disk 16 mm. thick, sawed from a titlar; a titlar is made by pouring a magma of best white refined sugar into a cone-shaped mould, washing well with pure white sugar liquor, and then baking the mass perfectly dry and hard. This disk was, therefore, practically a solid agglomeration of pure sucrose crystals. The other disk was made by dissolving perfectly pure white sugar in water, evaporating to a certain consistency, and then casting the mass in a copper ring. This disk also measured 16 mm. in thickness; it was a perfectly clear and transparent solid of a yellow color, and consisted of amorphous sugar-candy—so-called barley sugar.

A few preliminary trials were made by photographing with X-rays through these plates of sugar—with and without fluorescent screens—varying the time of exposure, etc. Finally, the following experiment was carried out.

A photographic plate was placed in a box, on the outside of which six metal disks were arranged in two groups of three each. Each group consisted of a medal of aluminium, provided with figures and inscriptions in bas-relief, a plain disk of aluminium and a silver quarter dollar.

One of these groups was covered with the crystalline, the other with the amorphous