poison. Some salivas are more fatal than others—that of Dr. Sternberg being especially virulent. It will be noticed in our report that Dr. Sternberg attributes the poisonous element to the presence of Micrococci—having found this form of Bacteria both in the saliva employed and in the poisoned blood of the victims.

These facts may be considered in conjunction with experiments by M. Pasteur in the same direction.

SCIENTIFIC SOCIETIES IN WASHINGTON.

THE BIOLOGICAL SOCIETY.—At the last two meetings the Society has listened to four papers: A Fatal Form of *Septicæmia* in the Rabbit produced by Subcutaneous Injection of Human Saliva, by Dr. George M. Sternberg; On the Mortality of Marine Animals in the Gulf of Mexico, by Mr. Ernest Ingersoll; A Statistical View of the Flora of the District of Columbia, by Professor Lester F. Ward; and Notes on Scale Insects, by Professor J. H. Comstock. All of these papers were of the highest scientific value, prepared by specialists in connection with their own immediate investigations. Dr. Sternberg has been making experiments for the past two years under the patronage of the National Board of Health, concerning the causes and development of epidemic diseases. In the course of his labors he has made careful observations with reference to inoculation, and in the paper referred to above gave the Society the benefit of his experiments on saliva injected under the skin of the rabbit. As an elaborate report will appear in the proceedings of the Board of Health, it will be necessary to state only the conclusions arrived at, which are as follows: The rabbits impregnated died invariably in less than 48 hours. Other animals which did not succumb were afflicted with sores. Dogs resist the poison, guinea pigs yield less readily than rabbits, fowls escape entirely. Some salivas are more fatal than others; that of Dr. Sternberg is especially virulent. The presence of Micrococci in the saliva, in the blood of the poisoned animals, and in that of animals infected with this poisoned blood led the author to the conviction that the evil effect was owing to these minute bacteria.

Mr. Ernest Ingersoll, who has been studying the waters of the Gulf of Mexico in the interest of the U. S. Fish Commission, reported that in certain years there occurred a great mortality among the marine animals. In the years 1844, 1854 and 1878 such disasters had been noticed, but the one most injurious in its consequences was in the year 1880. Oysters, clams, fish, and even sponges, were involved in the universal ruin. The beaches were so thickly covered with the dead bodies that the inhabitants were driven from their homes. Various attempts were made to account for the phenomenon, but with indifferent success.

Professor Ward is preparing a work to be entitled "A Catalogue of the Flora of the District of Columbia." It will include all the phænogamous plants and the vascular cryptogams. The number of species enumerated is 1233, distributed among 526 genera, as follows:

Polypetalous	genera,	173	Species,	354
Gamopetalous	"	169	"	388
Monochlamydeous	"	47	"	122
Monocotyledonous	"	120	"	321
Coniferæ	"	4	"	7
Vascular Cryptogams	"	13	"	41
		526		1233

Professor Ward then proceeded to give the census of these species with reference to the orders, to the position of the district north and south, and east and west, as well as in comparison with local floras which have been described with sufficient accuracy.

Professor Comstock's paper on the *Coccidæ*, or scale insects, was a very entertaining treatment of a very dry subject. The group under discussion is usually regarded as the most uninteresting of all the animal kingdom as well as the most anomalous. It is true that the lac of commerce and that of Arizona is the product of these insects, but the most of them are worthless or pernicious. They infest greenhouse plants and most of our useful fruit and timber trees. A specimen was exhibited which had been taken from Europe to Los Angeles, Cal., and back to Washington, upon a lemon, and at the end of its nine-thousand-mile trip was as lively as ever. The method of hatching, of the deposit of the meal, or lac, and of moulting in the male and female, were described and illustrated with drawings and cabinet specimens. The method of classifying these animals into species has been a very uncertain one. Even the later used characteristic, namely, the series of pores or openings on the penultimate ring not being always invariable. Professor Comstock has found the fringe on the last segment of the abdomen to be the most constant specific characteristic. An interesting point in the paper was a discovery made by Mrs. Comstock, that the poisers behind the wings are furnished with a hooklike process which fits into a groove on the back of the wing and helps to sustain it in flight.

THE ANTHROPOLOGICAL SOCIETY.—The entire session of the Society at its last meeting was occupied with the reading and discussion of a paper read by the Rev. Clay McAuley upon the Seminole Indians still remaining in Florida. Of this once formidable but now humbled tribe there remain in the vicinity of Lake Okeechobee 208 individuals, 37 families, 22 camps, and 5 settlements. There are no half-breeds among them, the occurrence of such a birth would probably subject the author to torture or death. They are healthy, have an abundance of food, and are probably increasing. The men are tall, well proportioned, erect, lithe, and graceful. The women are shapely, agreeable, vigorous, and many of them handsome. Dr. McAuley singled out three, whom he characterized as the stately, the beautiful, and the handsome among all the Indians whom he had visited. A very minute description was given of the dress, ornament, customs, and language of these people. A full report will appear in the publication of Major J. W. Powell's Bureau of Ethnology.

THE ULTRA-GASEOUS OR RADIANT STATE OF MATTER.*

BY PROF. H. S. CARHART.

The announcement by Mr. William Crookes, F. R. S., some six years ago, that he had produced mechanical motion by the direct impact of waves of light created a profound impression in the scientific world. But when it was found that the Radiometer, which was supposed to exhibit this new action of light, carried a system of blackened vanes, delicately balanced in a very high vacuum, it impressed most physicists as being an interesting form of heat engine receiving its supply of heat by absorption of radiant energy.

Mr. Crookes subsequently adopted the same view, which was the only tenable one, and investigated the subject in a long series of exceedingly skilful and ingenious experiments. His researches on the Radiometer formed the introduction to a more extended series of investigations into the movement of the residual gas of very high vacua, under the influence of heat and the negative discharge of electricity. These investigations carry us to the very farthest boundary of matter thus far attained, and furnish an ocular demonstration of some of those molecular movements that have heretofore been merely imagined. In fact the phenomena observed are such that Mr. Crookes has felt himself justified in announcing a fourth, or ultra-gaseous state of matter. Such an an-

*Lecture delivered before the New York Electrical Society on May 5, 1881.

nouncement startles us by its boldness, and encounters the opposition of our conservatism. I shall have the pleasure of reproducing a part of Mr. Crooke's experiments before you with tubes made after his models, and recently imported; and at the close of the exhibition I hope you will be able to draw your own conclusions.

Let us first prepare the way from our study of the subject by a clear presentation to our minds of the exact differences between the solid, the liquid, and the gaseous states. We shall then be able the better to judge whether this new claimant is sufficiently differentiated from ordinary gases to warrant its being set aside by itself.

I. A solid is composed of distinct molecules separated from one another by spaces which are large compared with the diameter of molecules themselves. These molecules, which are the indivisible units so far as all *physical* changes are concerned, are held rigidly in a fixed relation to one another by cohesion, a force which acts only across these invisible inter-molecular spaces, and the intensity of which depends upon the chemical constitution of the body. The force of cohesion is counterbalanced by the motion of the individual molecules, the energy of this motion constituting the heat of the body. As the temperature rises, the amplitude of vibration increases, and the force of cohesion is diminished by an increase of distance between the molecules. When the temperature falls the reverse process takes place.

Molecules of matter, in the solid state, retain fixity of position about their centres of oscillation; and any attempt to change the relation of these centres, by distorting the body, calls into action resistances opposing the change of form.

II. When the temperature rises so high that the molecules lose their fixity of position, and are released from the rigid thraldom of cohesion, so that they can apparently roll round one another without changing the distances of their centres, then the solid becomes liquid. As the force of cohesion differs with each kind of matter, so the temperatures of liquefaction also differ. In liquids the cohesion is much diminished but not entirely overcome by the energy of molecular oscillations, which we call heat. A liquid is characterized by taking the form of the containing vessel, by its surface becoming horizontal, and by its equal transmission of applied pressure in all directions. The state of liquidity is due to intermolecular motions of much greater amplitude than those peculiar to the solid state.

III. The temperature still rising, the molecules are finally released entirely from the force of cohesion, and move about in every conceivable direction with enormous and constantly varying velocities. The mean distance between them is sufficiently great to render cohesion inoperative; but they come into constant collisions with one another, now colliding, and now rebounding, changing their direction of motion and perhaps their velocity with every impact. On account of this rapid molecular motion and the absence of cohesion in gases, they tend to expand indefinitely; and they transmit pressure by multitudinous collisions among the molecules, and exert pressure on the walls of the containing vessel by innumerable impacts against its interior. Place a small, closed balloon, partly filled with air, under the receiver of an airpump and exhaust. The balloon distends more and more as the exhaustion proceeds, because of this molecular bombardment against its inner surface, the external coun eracting pressure being withdrawn. In much the same way an impenetrable sheet of metal might be kept suspended horizontally in the air by bullets fired vertically against its under surface. The dynamical principles concerned in the two cases are identical. When a gas is heated, the velocity of the individual molecules increases, and they exert greater pressure on the walls of the containing vessel by their impact, or by expansion secure a longer free path for themselves between successive collisions with one another. This mean free path, or mean length of path, is known to be about $\frac{1}{250000}$ of an inch at the average or normal pressure of the air, while the mean distance between the molecules is about one seven-millionth of an inch, according to the late Prof. Clerk Maxwell. Accordingly a cubic inch of air at normal density must contain the cube of 7,000,000 or 343 quintillions of molecules. Each of these molecules, moreover has, perhaps, millions of encounters every second, the number varying with the kind of gas considered. The state of gaseity is therefore pre-eminently characterized by innumerable molecular collisions, from which proceed all the properties constituting the ordinary gaseous state of matter; and this state continues so long as the motions of the molecules are in every possible direction, and the collisions almost infinite in number. Under such conditions the mean length of path of the molecules, or the distance traversed between two successive collisions, is extremely small compared with the dimensions of the containing vessel, only $\frac{1}{250000}$ of an inch.

Such are the distinctions existing between the solid, the liquid, and the gaseous states, distinctions depending entirely upon molecular aggregation. In the snow or frost crystal, for instance, the molecules of water are grouped together in a definite structural relation; the application of heat destroys the structure, the molecules becoming more nearly individualized by a certain increase of independence or freedom of motion, and the solid becomes a liquid; a still further rise of temperature increases this molecular independence to such an extent that their only physical relationship depends upon innumerable collisions with one another. If now, by any means, molecular independence can be rendered so nearly complete that the hits may be disregarded in comparison with the misses, then the free path of the molecule between the hits may become comparable with the dimensions of the containing vessel, the properties which constitute gaseity are reduced to a minimum, and matter is exalted to an ultra-gaseous state. The residual gas is then in that peculiar state when it has ceased to have the power of adjusting its own pressure; and consequently the phenomenon of diverting the molecules by suitable means into any paths at desire will be possible. Such is the ultimate result of gaseous expansion. As the rarefaction proceeds the number of molecules in a given space becomes smaller and smaller, and the mean length of path greater and greater, the molecular collisions diminishing as the free path increases.

At an exhaustion of a millionth of an atmosphere the number of molecules in any given space is reduced to one millionth of the number at the ordinary pressure; each molecule has a million times more room to move about in, and its mean length of path becomes about four inches (1,000,000 times $\frac{1}{250000}$ in.) If now the rarefaction be carried to another millionth, the space appropriated to each molecule is then increased a million million times, but the distance between the molecules becomes only one seven-hundredth of an inch, and a cubic inch contain seven then not less than 340 millions of molecules, according to Prof. Clerk Maxwell. This rarefaction is about 50,000 times further than the best mercurial air-pump can attain. A *gas* transmits pressure instantaneously in all directions by innumerable molecular collisions; an *ultra gas*, or "radiant matter," has lost the power of adjusting its pressure because of the infrequency of collisions among the molecules.

If then a bulb about four inches in diameter is exhausted to a millionth of an atmosphere, the residual gas in it will have lost the power of rapid adjustment of pressure to equality at every point. Hence any extraneous force, like heat or electricity, may "infuse order into the apparently disorderly jostling of the molecules in every direction by coercing them into a methodical rectilinear movement. * * * * * And according to the extent to which this onward movement has replaced the irregular motions, which constitute the very essence of the gaseous condition, to that extent have the molecules assumed the condition of radiant matter."

Let us now see to what extent Mr. Crookes has reached these conditions in his Radiometer and radiant matter tubes.

In the Radiometer the blackened vanes become heated by absorbing radiant energy (both heat and light), and they project the contiguous gaseous molecules from their surfaces by communicating to them their molecular motion, much as a vibrating drum-head would project into air grains of sand strewn on it. An increase of pressure is thus produced between the heated lampblack and the gaseous residue; but this pressure is not transmitted throughout the whole bulb because of the relative infrequency of collisions among the molecules at this degree of exhaustion. Hence the molecules are projected forward against the cooler bulb in right lines, and the blackened vanes retreat because the repulsion between them and the gaseous residue is mutual. [A Radiometer projected on the screen by an oxyhydrogen lantern; also, a diagram showing the paths of the projected molecules].

Mr. Crookes investigated the Radiometer with an ingenuity and a variety of detail that left nothing to be desired. Moreover, his visualization of the molecular motions taking place in this little instrument prepared him for a further research into the motion of the residual gas in Geissler tubes. The dark space around the negative pole, which broadens as the exhaustion proceeds, and the brilliant stratification displayed by many Geissler tubes, were hints in the line of his special studies. I cannot forbear, at this point, to call your attention to the vibration of the air in a sounding pipe, made visible by very light, precipitated silica powder. The resemblance between the beautiful segmentation of the pipe by the thin, vertical planes of silica powder, and the stratification of a Geissler tube, is most marked and suggestive. [A finely stratified Geissler tube shown; and a glass pipe, containing silica powder, and vibrated by a whistle projected on the screen]. As the silica planes limit the free swing of the air particles in the pipe, so the bright portions of the vacuum tube show when the residual gases of contiguous segments encounter each other—the vibration being set up by the passage of electricity. And it may be observed here that as the transmission of sound is the onward transference of energy by motion, so the passage of electricity is the transference of energy from one point to another by means of another form of motion.

The exhaustion which answers best for a Geissler tube is comparatively low. I have frequently obtained beautiful stratification in a tube six feet long, exhausted by a good air-pump. Mr. Crookes carried the exhaustion much further and obtained entirely new results. The first noticeable feature was the gradual broadening of the dark space surrounding the negative pole as the exhaustion advanced [dark space tube, exhibited a transverse sheet of aluminum in the middle constituting the negative pole]. This dark space is regarded as the free path of the molecules at this degree of exhaustion. It increases as the exhaustion proceeds, and contracts when the exhaustion diminishes. The molecules of air are projected normally from the negative pole, and the illumination at the boundary of the dark space is due to the collision between the gas projected from the negative pole and the more slowly moving molecules advancing toward it. Here, then the lines of molecular pressure, caused by the excitement of the negative pole, are illuminated by the induction spark.

With still higher vacua the free path becomes equal to the dimensions of the containing vessel, and the projected molecules impinge directly against its walls. The molecules stream from the negative pole with enormous velocities and dart across the tube with comparatively few collisions. Their motion is then arrested by the solid matter of the tube. A noteworthy property of this radiant matter then appears. Luminosity is produced by the impact of the projected molecules against solid matter. Phosphorescence, as this luminosity is called, is thus excited, its color depending upon the kind of matter receiving the impact. [Three phosphorescent tubes shown; also a bulb partly filled with phosphorescing material.] English glass phosphoresces a light blue, uranium glass rather dark green, and soft German glass, light apple green. Rubies always shine with a deep red hue whatever the color of the gem itself. The artificial rubies made in Paris show no variation from the real stones in the color of their phosphorescent light. This phosphorescence takes place better at an exhaustion of about a millionth of an atmosphere than at any other. A tube designed to show the dependence of the phosphorescence upon exhaustion, is made by connecting to the main tube a small supplementary tube containing caustic potash, which holds captive a certain amount of aqueous vapor [the tube exhibited]. Turning on the coil, the tube now shows green phosphorescence, but upon heating the potash tube with a small lamp, aqueous vapor is released, the phosphorescence gradually disappears, and is replaced by the stratified discharge of a Geissler tube. Withdrawing the lamp, the vapor is re-absorbed by the caustic potash, the fine stratification widens out slowly and finally retreats towards the potash bulb, while a wave of green light sweeps from the negative pole, driving the last pale stratification into the potash tube. Radiant matter moves in straight lines and absolutely refuses to turn a corner. This peculiarity is shown by a V-shaped tube. [The tube exhibited.] The flood of green light proceeds from the negative pole at the top only as far as the bottom, refusing to turn the angle toward the positive in the other branch. Reversing the current, the illuminated branch follows the negative pole. A striking contrast is thus presented between a Geissler and a Crookes tube; but this contrast is brought out more clearly still by two bulbs exactly alike, except in the degree of their exhaustion. Both are fitted with one negative terminal and three positive ones. With the low vacuum tube the stratification follows the direction of the positive pole, changing its path as that pole is changed. Changing now to the high vacuum or Crookes tube, containing only about a millionth of an atmosphere, and turning on the coil the only light to be seen is the green phosphorescence of the glass. The negative pole is a very shallow cup, and the projected radiant matter crosses its focus and then strikes on the opposite side of the bulb where the impact excites strong phosphorescence. Changing the positive pole produces no change whatever in the path of the projected molecules or the luminosity of the glass. The positive pole exercises no influence whatever upon the direction of discharge of radiant matter from the negative pole. The residual gas is here exalted to the fourth or radiant State, and its free path, under the impulsion of the negative discharge, is entirely across the bulb. Moreover, not only is luminosity induced, but the glass bulb rapidly heats where it receives the cannonade of these invisible balls.

Another peculiarity of radiant matter, depending upon its projection in right lines, is that when intercepted by solid matter it casts a shadow. This large pear-shaped bulb has the negative pole at the small end. A cross cut out of sheet aluminum is placed across the bulb so as to intercept a part of the gaseous molecules streaming from the negative pole. Connecting with the induction coil, the dark shadow of the cross is seen plainly projected on the large end of the bulb. Here the projected molecules pass by the aluminum cross and bombard the walls of the bulb, producing the usual phosphorescence Nothing could show more distinctly than the projection of matter from the negative pole in straight lines.

This bombarding causes the surface of the glass to lose its sensitiveness to intense phosphorescence. The cross is hinged so as to turn down with a slight shake.

Again turning on the coil the rays from the negative pole fall uninterruptedly on the large end of the bulb; the dark cross is now replaced by one more intensely green than the adjacent portions of the glass. The fresh parts of the glass are more susceptible to luminous excitation than the areas previously bombarded. This stenciled image of the black cross, Mr. Crookes tells us, is so persistent that it remained in one case after the glass had been heated hot, so that the end of the bulb was bent in and then blown out again. After re-exhaustion the bright green cross came out plainly in the more intense phosphorescence produced by the electrically projected residual gas. Thus the molecules hammer away upon the glass with sufficient energy to produce a permanent impression.

Since the molecules of the residual gas are driven violently from the negative pole, there should be a recoil of the pole from the molecules. That such is the case is shown by this electrical radiometer. The connections are such that the aluminum vanes constitute the negative pole. The vanes are not blackened but are covered on one side with mica, a non-conductor. The uncovered sides constitute the radiating or projecting surfaces. Turning on the induction current the vanes are repelled and the system rotates rapidly. The phosphorescent spots on the glass, produced by the impact of the molecules projected from the vanes, rotate as the vanes do, giving us a visible image of the process going on in the heat radiometer. In this second form the negative pole consists of a ring of platinum wire. Above this is a fly, composed of mica vanes inclined like the fans of a wind-mill. Turning on the current the matter projected from the wire strikes against the sloping vanes and sets them in motion. But this is not all. I now connect a battery directly with the terminals of the platinum ring, and the passage of the current heats the ring red hot. Directly the fly begins to turn more rapidly than before. Radiant matter is thus projected by heat as well as electricity, and the ordinary heat radiometer is propelled by the recoil of projected radiant matter like the electrical radiometer.

The action of magnetism on this stream of electrified particles is, indeed, curious. When a straight Geissler tube of low vacuum is employed it gives a narrow line of violet light joining the two poles. [This tube placed over the poles of an electro-magnet.] On passing the battery current through the magnet underneath, the violet line is repelled or attracted according to the direction of the currents; but it recovers itself after passing the magnet and proceeds to the other pole. Not so with a tube of high vacuum. This tube contains a mica screen, covered with material which phosphoresces under molecular impact. The radiant matter from the negative pole passes through a narrow opening and impinges upon the screen along its entire length. You observe how the phosphorescence marks the path of the projected molecules. Bringing a strong magnet down over the stream or actuating the electro-magnet, and the luminous path curves toward the side of the tube like the path of a projectile; but in this case the stream does not recover its original direction after deflection, as in the case of the Geissler tube. This same tube is fitted to determine another question of much interest connected with these wonderful phenomena. It is provided with two negative projecting surfaces, and the stream of molecules from each of these may be made to trace its path on the mica screen in a luminous line. Observe the position of this line first from one pole and then the other. What now will be the result if streams issue from both poles at once? If they constitute two currents of electricity in the same direction then we know that they will attract each other; but if they consist of a train of similarly electrified molecules, then they must repel each other Put to the test of experiment we see plainly that the stream lines diverge by mutual repulsion.

We have seen that mechanical action is produced by the recoil from the radiant matter. It is equally true that strong mechanical effects may be produced by the impact of these swiftly moving molecules. This tube is ingeniously constructed with a pair of glass rails running from end to end. Along them rolls freely the axle of a small wheel with broad vanes as paddles. The poles are so situated that the radiating molecules may strike against the vanes. Turning on the induced current, the stream of swiftly moving molecules strikes against the vanes on one side of the wheel and sets it running along the rails. Reversing the current, the wheel stops and returns on its track. [Tube projected on a screen by oxy-hydrogen light.] Another tube has been devised to show both magnetic deflection and mechanical action on the screen. The negative pole is a large, shallow cup. A mica screen intercepts the converging streams of radiant matter.

Behind the screen is placed an easily-revolving mica wheel provided with vanes and making a sort of paddle wheel. So arranged the molecular rays from the pole are cut off from the wheel, and no movement is produced. Placing a magnet over the tube the rays are deflected so as to pass above the screen and the wheel begins to revolve. Reversing the magnetic poles, the deflection is in the other direction, and the wheel now rotates like an undershot water-wheel. Even at this high vacuum of about a millionth of an atmosphere, enough matter remains in the tube to produce a sort of molecular wind under the impulsion of the negative discharge. Radiant matter produces heat as well as mechanical motion when its motion is arrested. The negative pole in this tube is a cup or concave projector. The radiant matter comes to a focus near the cup and then passes on toward the other end of the tube. But on bringing a magnet near it the stream of radiant matter is deflected so as to strike the side of the tube, producing a green, phosphorescent spot. The nearer the magnet approaches the greater the deflection of the stream and the smaller the spot. Covering the side of the tube with wax and placing it in front of the lantern, a dark image of the tube is projected because of the opaque wax. But with the coil in action the approach of the magnet deflects the radiant stream, the tube is heated by the impact of the molecules, the wax melts and becomes transparent, and the light from the lantern passes through.

The heat generated by the arrest of radiant matter is further shown by a bulb of special device. It has a negative pole of aluminum in the form of a concave projector. In its focus is fixed a piece of platinum foil. Turning on the coil, the projected molecules impinging against the platinum at last raise it to a red heat. Indeed Mr. Crookes has actually melted iridio-platinum in such a focus. We are accustomed to see powerful heating effects produced by currents of electricity traversing rather poor conductors; but here red hot platinum glows with the invisible cannonade of innumerable molecules of the air we breathe.

These effects take place indifferently with hydrogen, carbonic acid gas, and air at this high vacuum. The only difference appears to be that the phosphorescence begins at different pressures with the different gases. The results obtained depend, therefore, not on chemical properties, but on the physical, molecular condition of the gaseous residues. These phenomena are so entirely different from those obtained at ordinary degrees of exhaustion, that Mr. Crookes appears to me to be justified in considering that he has at last verified Faraday's early hypothesis of matter in a radiant state. Mr. Crookes has well said that, "In studying this fourth state of matter we seem at length to have within our grasp and obedient to our control the little indivisible particles which, with good warrant, are supposed to constitute the physical basis of the universe. We have seen that in some of its properties radiant matter is as material as this table, while in other properties it almost assumes the character of radiant energy. We have actually touched the borderland where matter and force seem to merge into one another, the shadowy realm between the known and the unknown, which for me has always had peculiar temptations. I venture to think that the greatest scientific problems of the future will find their solution in this borderland, and even beyond; here, it seems to me, lie ultimate realities, subtle, far-reaching, wonderful."

GREAT ASTRONOMICAL TELESCOPE.

The greatest refracting telescope in the world—Lord Rosse's is a reflecting telescope—has been constructed for the Vienna Observatory by Mr. Howard Grubb, at his celebrated manufactory of astronomical instruments, at Rathmines, near Dublin. We give an illustration, from a sepia drawing of it by Mr. G. Browning, and abridge the following account of it from a description received at this office.

The idea of crowning the observatory at Vienna with a refracting telescope of surpassing power was conceived by the Austro-Hungarian Government about five years ago. Such a building was worthy of the best instrument that could be constructed. Every visitor to the Austrian capital must be struck by it, standing upon a site of between fourteen and fifteen acres at a height of 200 feet above the city, and extending 330 feet in length and 240 feet in width. Desiring to possess the finest telescope which could be procured, the Government commissioned Dr. Edward Weiss, now Director-General of the Observatory at Vienna, to visit all the principal observatories and workshops in the world. He recommended that the task should be confided to Mr. Grubb, of Dublin, who was ordered to construct a refracting telescope of at least 26 inches aperture. A commission was appointed by the Austro-Hungarian Government to superintend the work. It was composed of the following gentlemen: The Earl of Crawford and Balcarres, Dr. Higgins, the Earl of Rosse, Professor Stokes, of Cambridge, Professor Ball, Astronomer Royal for Ireland, Dr. Stoney, Secretary of the Queen's University in Ireland, many years connected with Lord Rosse's observatory, Dr. E. Reynolds, professor of chemistry, Trinity College, Dublin, and Mr. Walsh, Austro-Hungarian Consul in Dublin. On the 16th ult. the Commissioners reported their unanimous approval of the finished instrument.

The general form of the telescope is that known as Grubb's modified Gramme, and is similar to the well-known standard equatorial which he constructed for the Earl of Crawford and Balcarres, Dr. Huggins, Oxford University, Berlin, Cork, and other places. It possesses all the modern improvements and special arrangements of an ingenious character, which are rendered desirable by its great size. The length of the tube is 33 feet 6 inches, and the aperture is 27 inches. The tube is entirely of steel, 3½ feet in diameter in the centre, and tapering to each end. The entire moving parts, including the tube, polar, and declination axis, counterpoise and various adjustments weigh between six and seven tons; yet the whole apparatus is under such control that one person can move it about and manipulate it with the utmost ease. The mechanism is remarkable for its solidity and strength, as well as for its exquisite delicacy.

In order to render the motion of such ponderous instruments sufficiently easy, the makers are generally obliged to reduce the diameter of the axes, particularly that known as the declination axis, to an extent that makes one almost alarmed for their safety, to say nothing of their stability. Mr. Grubb, however, has mastered the difficulties of the position by a peculiar and most interesting system of equipoise, by which he is enabled to make his axes so large and solid as to ensure stability and give perfect confidence without sacrificing the ease of motion. The application of antifriction apparatus to the polar axis has been already successfully effected, and was a simple problem, but Mr. Grubb has the exclusive merit of applying it to the declination axis, which is a task of great and complicated difficulty, demanding the highest scientific skill.

Another remarkable feature in the work is the ingenious arrangement by which the circle can be read with the utmost ease and certainty. It is usually a very troublesome operation with large telescopes to read the circle, and when the circles are about 20 feet or more from the ground the labor and delay which it involves are very formidable. In Mr. Grubb's instrument, the circles are carefully and accurately divided on a band of gold, and by a system of reflectors, at once beautifully simple and ingenious, the observer can without stirring from his chair read all the circles of the instruments through one little reader telescope attached to the side of the main telescope tube.

The setting of the telescope is massive and graceful. The frame on which it rests down to the ground level is of cast iron, and there are chambers of considerable size at the base. In the lower one, which is entered by a door at the end, is a clock for driving the instrument in order to follow the paths of the heavenly bodies. The castings of which the frame is formed are of about ten tons weight, and are of simple but not inelegant design. The clock-work is controlled by Mr. Grubb's novel frictional governor, and is also furnished with his new electric control apparatus. There are two right ascension circles, each 2 feet in diameter, one read from the eye end of the telescope and the other from the ground floor. The declination circle is 5 feet in diameter, and is read from the eye end of the telescope. All the circles are divided on an alloy of half pure gold and half pure silver, which is found to be very white and not liable to corrode or tarnish.

The material for the object glasses was procured from M. Feil, of Paris. The protracted delay in procuring this material for the work was a subject of great anxiety to Mr. Grubb, and occasioned heavy additional outlay on his part. In October, 1879, however, discs were obtained, which in working gave good promise, and in December last he was able to report the work finished—his part of it being, in fact, accomplished in less than half the time stipulated by the agreement with the Austro-Hungarian Government. His task was practically trebled by the difficulty experienced in obtaining pure discs. The success of his undertaking is regarded with great satisfaction and with national pride. He has supplied equipments to most of the modern observatories, but this telescope is his greatest achievement.

THE *Athenæum* prints an interesting extract from a letter from Prof. Draper, giving a description of the progress he has made in photographing the nebula in Orion:—"I have succeeded," he says, "in taking stars in it of the 14.1, 14.2, and 14.7 magnitudes of Pogson's scale. Prof. Pickering has made a series of measures on these magnitudes especially for me at the Harvard College Observatory. You will perceive that we have photographed stars which approach the *minimum visible* of my 11 in. telescope, and we may, therefore hope shortly to photograph stars actually too faint to be seen with the eye in the same instrument. The nebula, which was exposed 104 minutes, extends over an area of about 15′ in diameter, though, as it becomes fainter toward the exterior parts, it is difficult to determine its precise limits." This is a great advance; no star of less than the ninth and a half magnitude has hitherto been photographed.

A CURIOUS magnetic property of the meteoric iron of Santa Cattarina (Brazil), has been lately observed by Professor Lawrence Smith. Small detached fragments, not weighing more than 0.1 to 0.2 gr., were very weakly affected by a magnet; but on being flattened on a piece of steel, with a steel hammer, they become very sensitive to it. By heating red-hot, the particles were made to be still more easily attracted than by flattening. The meteoric iron in question contains 66 iron, 34 nickel.