that Donny, Dufour, and others made important contributions to the subject. I can find no vestige of a novel idea on the subject of continuity in the essay of Van der Waals. If he has succeeded in extending thermodynamic formulas to fit in with Andrews's discoveries, so far the work is praiseworthy and valuable; but an essay "On Continuity" ought certainly to contain a suitable acknowledgment to the author of the discovery.

J. T. Bottomley.

Rainbows on Scum.

I have several times noticed "rainbows" on the black scum upon the pond in a park in this town, and have imagined all of them to have been formed on *dew* deposited upon a film of soot. It is out of the question, however, that yesterday there can have been any *dew* to produce the phenomenon, as there had been a thick hoar frost on the grass, all melted by the warm sun by 10.30 a.m., at which time there was a very vivid double "rainbow," which seemed exactly like an ordinary bow upon rain, except that there were none of the supernumerary arcs due to diffraction, and that the outer bow was fainter than usual in proportion to the inner one. The pond was thinly frozen over, but, it being a cloudless day, the surface of the ice was by that time covered with water. On closely examining the scum, I found it was composed of floating black particles, I presume of soot (the weather being rather foggy), and to many of these, minute drops were adhering, which varied much in size, the largest being probably $\frac{1}{50}$ of an inch in diameter. It was surprising to find distinct drops upon water, but I suppose it must have been the particles of soot that kept them separate. It seems probable they were a portion of the melted hoar frost; but it is rather curious that in such a situation this can produce a rainbow, seeing that usually melted hoar frost does not do so at all, or at most gives a very slight one; so decidedly is this the case, that one may distinguish in the morning between dew and melted hoar frost by noticing whether a "rainbow" and white anthelion are formed; dew being capable of producing bright ones owing to the roundness of the drops composing it, while hoar frost when it melts usually turns into irregular drops. I may say, however, that this "rainbow" on the pond was far more brilliant than any ordinary dew bow, and therefore it would appear that there is some property in the particles of soot to perfect the roundness of drops adhering to them, and so produce a striking phenomenon even from melted hoar frost.

At 0.30 p.m. I noticed the bow was fainter, but still fairly bright, and I estimated there were about 100 drops to each square inch of the surface of the water; it seems this number of drops, averaging probably not more than 0·003 to 0·005 inch in diameter, is sufficient to produce a pretty bright "rainbow." When I placed my eye close to individual drops I found that supernumerary arcs were visible.

T. W. Backhouse.

Sunderland, February 20.

Wild Swine of Palawan and the Philippines.

Dr. A. Nehring has recently (*Abhandl. Mus. Dresden*, 1889, No. 2, p. 14 *et seq.*) characterized the wild pig of Luzon under the title of *Sus celebensis* var. *philippensis*, and the animal found in the island of Palawan (Paragua) as *Sus barbatus* var. *palavensis*. It would seem that both these local races or species have been already characterized and figured by M. Huet from specimens collected by M. Alfred Marche—the first-named as *Sus marchei* (*Le Naturaliste*, 1888, p. 6), and the second as *Sus ahenobarbus* (*op. cit.*, p. 5).

It is interesting to note that the wild pig of Palawan is a representative of the well-marked *Sus barbatus* of Borneo, and not of the wart-faced animal of the Philippines proper.

No specimens of wild pig from the large island of Mindanao appear to have been examined as yet. The following note of the external characteristics of a boar's head brought to me at Zamboanga may therefore be worth being transcribed:—"It was black with a white bar across the snout half-way between the eyes and the nose, with a black spot at the inner corner of the eyes; two tufts of coarse white bristles on the fleshy protuberances on the cheeks on either side, and two singular fleshy black knobs (warts) on the sides of the snout just below the white band."

A. H. Everett.

41 York Terrace, Regent's Park.

A Beautiful Meteor.

On February 25, about 7.30 p.m., I chanced to see, at Coombe, near Woodstock, Oxfordshire, a globular meteor start from the Pointers, and fall with a slightly northerly inclination. When it was near the horizon, my garden wall hid from my sight the close of its brilliant career. Big as Venus at her brightest, it was substantially of a yellow colour, but shot over with flashes of glowing scarlet.

John Hoskyns-Abrahall.

Coombe, near Woodstock, Oxfordshire.

INFECTIOUS DISEASES, THEIR NATURE, CAUSE, AND MODE OF SPREAD.[1]

I.

We read in Homer that "Phœbus Apollo, offended by mortals, sent a pernicious plague into the camp of the Greeks; the wrathful god with his arrows hit first mules, then dogs, and then also the Greeks themselves, and the funeral pyres burned without end." If we expressed this in less poetical language, but more in conformity with our modern realistic notions, we would say, that the deity of health and cleanliness, having been offended by mortals, sent his poisonous but imperceptible darts or bacilli into them, and caused an epidemic of a fatal disease, communicable to man and animals.

In whatever form we meet with this simile—whether an epidemic be ascribed to a wrathful providence, or to a sorcerer or a witch that put their spells on man or on cattle, thereby causing numbers of them to sicken and to die; whether this happened amongst the nations of old, or amongst the modern Zúlus, whether amongst the peasants of Spain or in Italy—we now know that it always means that the offended deity of cleanliness, and the outraged laws of health, avenge themselves on mortals by the invasion of armies of imperceptible enemies, which we do not call arrows, nor sorcerers' or witches' spells or incantations, but microbes.

From Homer's Trojan epidemic among the Greeks to the epidemic in the camp of Cambyses, from the plagues carried and spread by the Crusaders of old to the plagues carried and spread in modern times by pilgrims to and from Mecca, the plagues following the ancient armies and those of more recent times, the plagues attacking a country debilitated by famine or by superstition have been in the past, and will be in the future, due in a great measure to neglect and ignorance, on the part either of individuals or of a whole population, of the principles of the laws of health: and it is chiefly to this neglect, ignorance, and indolence that the spread and visitations of epidemic infectious disorders must be ascribed. It is, therefore, with justice, that these disorders are called preventable diseases, and one cannot imagine a greater contrast than that between the knowledge we possess at the present time of communicable diseases, as to their cause, mode of spread and prevention, and the views of former generations, as to their spontaneous origin.

Although the notion that all epidemic diseases are communicable, *i.e.* spread from one individual to another, is not a new one, since many writers of former generations have had clear ideas about them, yet the actual demonstration of the fact that the different infectious or communicable diseases are due to definite species of microbes, which, having invaded a human or animal organism, are capable therein of multiplying and of causing a particular infectious illness; further, the identification of these living germs in the blood and tissues of an invaded individual, and the recognition of their many and intricate migrations outside the animal body; the study of the microbes in artificial cultures, *i.e.* out-

[1] Lecture delivered at the Royal Institution on Friday, February 20, 1891, by E. Klein, M.D., F.R.S., Lecturer on Physiology at St. Bartholomew's Hospital Medical School.

side the human or animal body; further, the best means to do battle with them, to neutralize them, to prevent their growth and to destroy them; then the *modus operandi* of the different species, each appertaining to, and causing, a definite kind of disorder—in short, all that is exact and precise in the knowledge of the causation, nature, and prevention of infectious diseases, is an outcome of investigations carried on during the last twenty-five years. Modern research has not only definitely demonstrated these microbes, it has also shown that a number of diseases not previously suspected as communicable have a similar cause to the above, and are therefore now classed amongst them. It need hardly be emphasized that a knowledge of the causes must lead, and as a matter of fact has led, to a clearer and better understanding of the recognition, prevention, and treatment of these disorders, an understanding obviously directed towards, and followed by, the alleviation and diminution of disease and death in man and animals. I may point to a few special examples to illustrate these propositions. The disease known as splenic apoplexy or malignant anthrax is a disease affecting man and brutes. In some countries the losses to agriculturists and farmers owing to the fatal character of the disease in sheep and cattle is enormous. In man it is chiefly known amongst wool sorters and those engaged in the handling of hides. This disease has been definitely proved to be due to a bacillus, the *Bacillus anthracis*, which, after its entry into the system of an animal or human being, multiplies very rapidly in the blood and spleen, and, as a rule, produces a fatal result, at any rate in sheep and cattle. Now, the bacillus having been proved to be always associated with this disease, anthrax, it was then shown that this bacillus can grow and multiply also outside the animal body: its characters in artificial media have been carefully studied and noted, so that it can be easily recognized; and by the pure cultures of the bacillus the disease can be again reproduced in a suitable animal. Such cultures have been subjected to a number of experiments with heat, chemicals, or antiseptics; the chemical function of the *Bacillus anthracis* has been and is being accurately studied in order to give us an insight into the mode in which it is capable of producing the disease; it has been further shown by Koch that the bacilli are capable of forming seeds or spores which possess a very high degree of resistance to various inimical conditions, such as heat, cold, chemicals, &c., and that it is precisely these spores, entering the system by the alimentary canal, through food or water, or by the respiratory organs through the air, to which the disease in most instances is due. Further, it has been shown that a trace of the blood of an animal affected with or dead from the disease, when introduced into an abrasion of the skin of man or animal, produces at first a local effect (carbuncle) followed by a general and often fatal infection. But the most important result of the cultivation of the bacillus outside the body, in artificial media, was the discovery that if subjected to or grown at abnormally high temperatures, 42°·5 C., *i.e.* above the temperature of the animal body, its power to produce fatal disease—that is, its virulence—becomes attenuated, so much so that, while the so-altered bacilli on inoculation into sheep or cattle produce a mild and transitory illness, they nevertheless furnish these animals with immunity against a fatal infection.

The recognition and identification of the *Bacillus anthracis* as the true cause of the disease, splenic fever or splenic apoplexy, the knowledge of its characters in the blood and spleen of man and animals, and of its peculiarities in artificial cultures, have enabled us to make a precise diagnosis of the disease, which previously was not always easy or even possible. The knowledge of its forming spores when grown under certain conditions, and of the manner in which experimentally the disease can be reproduced in animals by the bacilli and its spores, has led to a complete understanding of the means and ways in which the disease spreads both in animals and from them on to man; and last, but not least, the methods of the protective inoculations first indicated and practised by Pasteur have been solely the result of the studies in the laboratory of the cultures of the *Bacillus anthracis*, and of experiments with them on living animals. I could add here a number of other diseases, such as glanders, fowl cholera and fowl enteritis, erysipelas, scarlet fever and diphtheria in man, actinomycosis in man and cattle, swine fever and swine erysipelas, grouse disease, symptomatic charbon in cattle, and other diseases of animals—we have been brought to a fairly advanced understanding of one and all of these by methods such as those indicated above; and hereby not only in the diagnosis and recognition, but also in the treatment and prevention of these disorders, an immense amount of valuable progress has been achieved.

[1. Demonstration: lantern slides of anthrax, fowl cholera, fowl enteritis, grouse disease, typhoid, cholera, pneumonia, diphtheria, actinomycosis, scarlatina, and glanders.]

As examples of the second proposition, viz. that the modern methods of study of disease germs, of their nature and action on living animals have led to the recognition as communicable diseases of some disorders which previously were not known or even suspected to be of this character, I may mention amongst several the disease known as tuberculosis or consumption, tetanus or lock-jaw, and acute pneumonia. Not until Klencke and Villemin had shown by direct experiment on animals that tuberculosis is inoculable was it grouped amongst the infectious diseases. Since these experiments were first published a large amount of work has been done, proving conclusively that tuberculous material—that is, portions of the organs containing the tubercular deposits (*e.g.* lung, lymph gland, spleen, &c.)—by inoculation, by feeding or by introducing it into the respiratory tract, can set up typical tuberculosis in the experimental animals; the tubercular deposits in these experimental animals again are endowed with the power to propagate the disease in other animals. Further, it was shown that the disease in cattle called "Perlsucht" was in all respects comparable to tuberculosis in man, and it is accordingly now always called tuberculosis.

A further, and perhaps the greatest, step was then made by Koch's discovery in 1882 of the tubercle bacillus, and his furnishing the absolute proof of its being the true cause of the disease. The demonstration and identification of this microbe is now practised, I might almost say, by every tyro, and it is of immense help to diagnosis. In former years, and before 1882, the diagnosis of tuberculosis was not by any means an easy matter in many cases of chronic lung disease; since that year every physician in such cases examines the expectoration of the patient, and the demonstration of the tubercle bacilli makes the diagnosis of tuberculosis absolutely certain. Not only in medical, but also in many surgical cases, *e.g.* certain forms of chronic disease of bones and joints, particularly in children, the demonstration of the tubercle bacilli is of essential importance, and by these means diseases like lupus of the skin, scrofula and certain diseases of bones and joints not previously known as tuberculosis, are now proved to be so. The same applies to animals; wherever in a diseased organ of man or animal the tubercle bacilli can be demonstrated, the disease must be pronounced as tuberculosis.

The proof that the tubercle bacillus is the actual cause of the tubercular disease was established by Koch beyond possibility of doubt. Cultures in artificial media were made from a particle of a tubercular tissue either of a human being, or of cattle affected with tuberculosis, or of an experimental animal tubercular by ingestion, or by injection with tuberculous matter, and in all cases crops of the tubercle bacilli were obtained. Such cultures were then carried on from subculture to subculture, through many generations, outside the animal body; with a mere trace of any of these subcultures, however far removed from the original source, susceptible animals were infected, and all without fail developed tuberculosis, with the tubercle bacilli in the morbid deposits of their organs. The discovery of the tubercle bacilli and the demonstration that they are constantly present in the tubercular deposits of the typical tuberculosis, and the proof by experiment on living animals that they are the actual cause of the disease, are not all that we have learned, for it has also been shown that certain diseases, like the dreaded and disfiguring disease known as lupus—at any rate some forms of it—and further the disease scrofula, so often present in children, are really of the nature of tuberculosis, the former in the skin, the latter in the lymph glands.

Now see what an enormous step in advance this constitutes:--

(1) We can now diagnose tuberculosis with much greater accuracy in man and animals, even in cases in which this was formerly difficult or impossible.

(2) We have accepted rightly that all forms of tuberculosis are infectious or communicable diseases, communicable by inoculation, by ingestion, *i.e.* by food, or by respiration, *i.e.* by air.

(3) We have learned to recognize that, as in other infectious disorders, there exists a risk to those susceptible to tuberculosis, of contracting the disease from a tubercular source, and it is the recognition of these facts which ought to regulate all efforts to prevent its spread.

Tetanus or lockjaw, not previously known to be so, has likewise been fully demonstrated to be an infectious disease: we now know that it is due to a bacillus having its natural habitat in certain garden earth; that this bacillus forms spores, that these spores gaining access to an abrasion or wound of the skin in man or animals are capable of germinating there and multiplying, and of producing a chemical poison which is absorbed into the system, and sets up the acute complex nervous disorder called lockjaw. The recognition of the disease as an infectious disease and caused by a specific microbe has taught us at the same time the manner in which the disease is contracted, and thereby the way in which the disease is preventable.

[2. Demonstration: lantern slides of tubercle and tetanus.]

The study of disease germs by the new and accurate methods of bacteriology has also led to a clearer and better understanding of the manner in which at any rate some of the infectious diseases spread. While it was understood previous to the identification of their precise cause that some spread directly from individual to individual (*e.g.* small-pox, scarlet fever, diphtheria), others were known to be capable of being conveyed from one individual to another indirectly, *i.e.* through adhering to dust, or being conveyed by water, milk, or by food-stuffs (*e.g.* cholera, typhoid fever). But we are now in a position to define and demonstrate more accurately the mode in which infection can and does take place in many of the infectious diseases. By these means we have learned to recognize that the popular distinction between strictly contagious and strictly infectious diseases—the former comprising those diseases which spread as it were only by contact with a diseased individual, while in the latter diseases no direct contact is required in order to produce infection, the disease being conveyed to distant points by the instrumentality of air, water, or food—is only to a very small extent correct. Take, for instance, a disease like diphtheria, which was formerly considered a good example of a strictly contagious disorder; we know now that diphtheria, like typhoid fever or scarlet fever, can be, and, as a matter of fact, is, often conveyed from an infected source to great distances by the instrumentality of milk. In malignant anthrax, another disease in which the contagium is conveyable by direct contact, *e.g.* in the case of an abrasion or wound on the skin coming in contact with the blood of an animal dead of anthrax, we know that the spores of the anthrax bacilli can be, and, as a matter of fact, in many instances, are, conveyed to an animal or a human being by the air, water, or food. The bacilli of tubercle, finding entrance through a superficial wound in the skin or mucous membrane, or through ingestion of food, or through the air, can in a susceptible human being or an animal produce tuberculosis either locally or generally. The difference as regards mode of spread between different diseases resolves itself merely into the question, Which is, under natural conditions, the most common mode of entry of the disease germ into the new host? In one set of cases, *e.g.* typhoid fever, cholera, the portal by which the disease germ generally enters is the alimentary canal; in another set an abrasion or wound of the skin is the portal, as in hydrophobia, tetanus, and septicæmia; in another set the respiratory organs, or perhaps the alimentary canal, or both, are the paths of entrance of the disease germ, as in small-pox, relapsing fever, malarial fever; and in a still further set the portal is just as often the respiratory tract as the alimentary canal, or a wound of the skin, as in anthrax, tuberculosis. But this does not mean that the virus is necessarily limited to one particular portal, or that it must be directly conveyed from its source to the individual that it is to invade. All this depends on the fact whether or not the microbe has the power to retain its vitality and virulence outside the animal or human body.

Anthrax bacilli are killed by drying: they gradually die off if they do not find sufficient nutriment in the medium into which they happen to be transferred; they are killed by exposure to heat far below boiling-point; they are killed by weak carbolic acid. But if these anthrax bacilli have been able to form spores, these latter retain their vitality and virulence when dried, when no nutriment is offered to them, and even when they are exposed for a few seconds to the heat of boiling water, or when they are exposed to the action of strong solutions of carbolic acid. Similarly, the bacillus of diphtheria when dried is killed also by weak solutions of carbolic acid; it is killed when kept for a few days in pure water on account of not finding sufficient nutriment; fortunately the diphtheria bacillus is killed in a few minutes at temperatures above 60° or 65° C., for this bacillus does not form spores. The same is the case with the microbe of scarlet fever.

The tubercle bacillus forms spores; these are not killed by drying, they are killed by the heat of boiling water of sufficiently long duration, two or more minutes; they are not killed by strong carbolic acid.

While, therefore, we know in these cases on what the conditions of infection depend, we have also learned to understand the conditions which favour or prevent the infection.

Not all infectious diseases which have been studied are due to Bacteria: in some the microbe has not been discovered, *e.g.* hydrophobia, small-pox, yellow fever, typhus fever, measles, whooping-cough; in others it has been shown that the disease is due to a microbe which belongs, not to the Bacteria, but to the group of those simplest animal organisms known as Protozoa. Dysentery and tropical abscess of the liver are due to Amœbæ; intermittent fever or ague is due to a protozoon called Hæmoplasmodium; a chronic infectious disease prevalent amongst rodents, and characterized by deposits in the intestine, liver, and muscular tissue, is due to certain forms known as Coccidia, or Psorospermia. A chronic infectious disease in cattle and man known as actinomycosis is due to a fungus. the morphology of which indicates that it probably belongs to the higher fungi; certain species of moulds (*e.g.* certain species of Aspergillus and Mucor) are also known to be capable of producing definite infectious chronic disorders, and so also is thrush of the tongue of infants; ringworm and certain other diseases of the hair and skin are known to be due to microbes allied to the higher fungi.

The microbes causing disease which have been studied best, are those belonging to the groups of Bacteria or Schizomycetes or fission fungi (they multiply by simple division or fission); most species of these have been cultivated in pure cultures, and the new crops have been utilized for further experiments on animals under conditions variable at the will of the experimenter.

[3. Demonstration: cultures of Bacteria in plates and in tubes.]

(*To be continued.*)

RECENT PHOTOGRAPHS OF THE ANNULAR NEBULA IN LYRA.

ANNULAR nebulæ can no longer be regarded as a class completely apart. They should rather be described as planetaries in which one special feature predominates over the rest. The progressive improvement of telescopes has tended to assimilate the two varieties by bringing into view peculiarities common to both. It is only when they are ill seen that planetary nebulæ appear really such. The uniformity of aspect at first supposed to characterize them disappears before the searching scrutiny of a powerful and perfect instrument. The usually oval surfaces which they present are then perceived to be full of suggestive detail. They are broken up by irregular condensations, or furrowed by the operation of antagonistic forces; betray here the action of repulsive, there of attractive, influences; and bear as yet undeciphered inscriptions of prophetic no less than of commemorative import. Among the various modes of diversification visible in them, however, two are especially conspicuous—first, the presence of a nucleus; next, the emergence of a ring, or even of a system of rings.

Now the nebula in Lyra, when distinguished by Sir William Herschel in the annular form, of which it is the most perfect exemplar, seemed completely perforated by a dark opening; but interior nebulosity, constituting the object essentially a disk with annular condensation, was noticed by Schröter in 1797, and is depicted as strongly luminous in the drawings of Lassell (reproduced in *Knowledge*, November 1890), Trouvelot (*Harvard Annals*, vol. viii., Plate 34, 1876), and Holden.[1] Moreover, a minute central star, visually discerned at intervals, has lately been photographed in unmistakably nuclear shape. The entire formation, then, consists of a disk, nucleus, and ring, and differs from many planetaries only in the proportionate lustre of its parts.

The records concerning the central star include some curious anomalies. They go back to the year 1800, when Von Hahn was struck with its disappearance. The change was in his opinion due, not to loss of light in the star, but to the veiling with delicate nebulous clouds of the dark background upon which, in former years, it had been seen projected (*Astr. Jahrbuch*, 1803, p. 106). His observations were made at Remplin, in Mecklenburg, with a 12-inch Herschelian speculum, somewhat impaired in brilliancy (Lisch, "Gesch. des Geschlechts Hahn," Bd. iv. p. 282). "Hahn's star" was next seen by Lord Rosse 1848 to 1851 (Trans. R. Dublin Society, vol. ii. p. 152), and drew the notice of Father Secchi in 1855 (*Astr. Nach.*, No. 1018). Twice observed by M. Hermann Schultz at Upsala in 1865 and 1867 ("Observations of 500 Nebulæ," p. 99), it unaccountably, ten years later, evaded the deliberate scrutiny with the Washington 26-inch of Prof. Asaph Hall, who nevertheless perceived the nebula as exteriorly surrounded by a "ring" of nine faint stars (*Astr. Nach.*, No. 2186). The same great instrument, however, displayed the missing star to Mr. A. C. Ranyard, August 23, 1878 (*Astr. Journal*, No. 200), while to Dr. Vogel, equally in 1875 with the Newall refractor, and on several nights in 1883 with the Vienna 27-inch, it remained imperceptible (*Potsdam Publicationen*, No. 14, p. 35). Very remarkable, too, is its non-appearance to Dr. Spitaler at Vienna in 1885, when he carefully delineated the nebula, as well as in 1886, during repeated verifying observations. The interior seemed then to contain only dimly luminous floccules; yet the star thus persistently invisible caught his eye at the first glance, July 25, 1887 (*Astr. Nach.*, No. 2800). It had in the meantime, September 1, 1886, been photographed by Von Gothard; and having committed itself to this *adsum qui feci* avowal, has, now for four years past, abstained from capricious disappearances.

[1] Executed in 1875, with a power of 400 on the 26-inch Washington refractor (*Wash. Observations* for 1874, Pl. vi.).

Its variability, then, is still unproved; since observational anomalies, even of a very striking kind, may be explained in more ways than one; and it is very easy *not* to see a fifteenth-magnitude star. More especially when the sky behind it is—perhaps intermittently—nebulous. Luminous fluctuations in the diffused contents of the ring certainly suggest themselves to the student of its history. At times a bare trace of nebulosity is recorded; at others, the whole interior is represented as filled to the brim with light—mist, coagulated, as it were, into a cirrous or striated arrangement. Under such conditions, the effacement of quasi-stellar rays, feebly seen at the best, is not surprising.

The "gauzy" stuff within the ring possesses very slight actinic power. The best drawings of the nebula represent what might be described as an oval disk with a brighter border, while in all photographs hitherto taken it comes out strongly annular. The interior does not fill up even with such abnormally long exposures as might be expected to abolish gradations by giving faint beams time to *overtake* the chemical effect more promptly produced by brighter rays.

The photographic record of the Lyra nebula goes back a very few years. It opens in 1886, with some Paris impressions showing a small, nearly circular ring, starless, and perfectly black within. A decided advance was marked by Von Gothard's picture of a pair of nebular parentheses—thus, ( )—inclosing a very definite, though probably non-stellar, nucleus. The failure of light at each extremity of the major axis, which makes one of the most significant features of this object, was already in 1785 noticed by the elder Herschel (*Astr. Jahrbuch*, 1788, p. 242; Phil. Trans., 1785, p. 263); and Lord Rosse in 1863, and Schultz in 1865, were struck with its accompaniment, *on the north-eastern side*, by "nebulous radiations in the direction of the longer axis, which seemed momentarily almost to destroy the annular form." This appearance of an equatorial outflow, however, had shifted to the opposite or *south-westerly side* of the nebula when Holden observed it at Washington in 1875;[1] while a photograph taken by Mr. Roberts, with twenty minutes' exposure in July 1887, showed a very decided protrusion in the place indicated by Schultz, but only an abortive attempt at Holden's appendage. The suggestion of real changes of an alternating character, affecting luminosity perhaps, rather than figure, meets some confirmation in Prof. Holden's remark upon a further incompatibility between his own and Lord Rosse's observations on a different part of the same object. "It is a little curious," he wrote in 1876, "that that end of the minor axis which Lord Rosse has represented as the best terminated, viz. the *south*, is precisely that one which to-day, and with the Washington telescope, is least so" (*Monthly Notices*, vol. xxxvi. p. 63). And the Lick 36-inch similarly disclosed the whole of the bright southern edge as filamentous (*Monthly Notices*, vol. xlviii. p. 387) in opposite correspondence with the views obtained at Parsonstown of the northern edge.

[1] *Monthly Notices*, vol. xxxvi. p. 66: and pastel drawing in *Wash. Obs.*, 1874.