HISTORY OF ENCKE'S COMET.

HISTORICALLY, Encke's comet, which has recently come into view again, stands next in interest to Halley's. The history of the latter can be carried back much farther than that of any other comet. It was indeed conjectured that the one (the first telescopically discovered comet, by Kirch) which made so near an approach to the sun in 1680, and in reference to which Newton first applied his principle of universal gravitation to the motions of these bodies, was identical with comets seen at intervals of about 575 years before, and Gibbon (not exactly an astronomical authority, who recommends others to study Newton and Halley on the question) devotes a section of his forty-third chapter to the supposed history of these early appearances (two of them in mythical times), concluding with the remark that the calculations with regard to it might perhaps in the year 2355 "be verified by the astronomers of some future capital in the Siberian or American wilderness," little thinking how many splendid telescopes would be employed on the study of the heavens in the "far west," before a century had elapsed from his own death. There was then, in 1794, no observatory on any part of the American continent. But it is now known that the period of the comet of 1680 amounts not only to hundreds, but to thousands of years; and one of the supposed previous appearances, that in the reign of the Emperor Justinian, was in all probability a return of the smaller or less conspicuous comet which appeared in 1682, and at the next return in 1758–9 acquired the name of Halley's comet, because that eminent astronomer had confidently predicted its return at that date, calling upon posterity to notice that the prediction had been made by an Englishman. He recognised its identity with comets observed in 1531 and 1607, by a comparison of the orbits calculated for each, and considered from the similarity of period, that the fine comet of 1456 was also probably an earlier appearance of the same. Later investigations, and the accessibility of Chinese records, have shown since his time that successive appearances of this body can be traced with very great probability to a date before the Christian era, our distinguished countryman, Dr. Hind, having taken a leading part in these calculations.

Of the subsequent observations of this comet in 1835, this is not the place to speak, nor of the full expectation astronomers then living will entertain of seeing it again in 1910, and applying the new methods of analysis to it, thereby obtaining information respecting its constition, which was beyond the wildest flights of imagination at its last appearance. For our present subject is a comet which acquired the name by which it is now universally known as a fitting meed of honour to an astronomer who worthily presided over the then new observatory at Berlin within our own recollection. Many comets have since that time returned according to prediction; but when Encke announced that the small one discovered by Pons at Marseilles on November 26, 1818, was identical with the discovery of Méchain in 1786, of Miss Herschel in 1795, and of Thulis in 1805, no predicted return of any comet but Halley's had ever taken place, though two predictions had been made, by himself and by Bessel respectively, of the returns of comets observed in 1812 and 1815, which duly came to pass in 1883 and 1887, the periods of these being nearly as long as that of Halley's. The remarkable point about Encke's comet was the extreme shortness of its period, amounting only to 1212 days, or three years and about four months. It was therefore concluded that it would reappear in 1822; true to prediction it did then appear, but from its situation in the heavens was visible only in the southern hemisphere, which then possessed only *one* observatory, that established (but which has long ceased to exist) by Sir Thomas Brisbane at Paramatta, New South Wales, where the comet was rediscovered by Rümker on June 2. The next appearance took place in the autumn of 1825, when the comet was observed in this hemisphere, and since that time it has never failed to be observed at the calculated epochs. Encke did not desert it after he had determined its period in 1819, but, following up its motions with accuracy, was led to notice a remarkable continuous shortening of the period by a fraction of a day at each return. The question had before his time been started whether a medium might be diffused through the solar system which, though insufficient to affect the motions of the planets, would produce appreciable effects upon those of comets, composed as they must be of matter in a state of great rarity. Here was a case which seemed to settle the question in the affirmative. Encke's calculations showing that the diminution in the observed length of the period was such as might well be caused by the action of such a resisting medium checking the onward motion of the comet, which would bring it a little nearer to the sun at each return, and thus shorten both the orbit of revolution and the period of time in which it was accomplished. The difficulty remained how to explain the fact that no such effect was perceptible in the motions of any other comet; a difficulty which the lapse of time has not removed, for though in one other case (that of a comet known as Winnecke's) a similar effect was for a while thought to be noticed, further investigation showed that this view could not be sustained. Encke, however, to the end of his life (he died in 1865) was able to trace the above continuous effect in the motion of his own comet, the period of which was then 1210·2 days, or 1·6 days shorter than it had been in 1819. But, strangely enough, soon afterwards, the amount of retardation was reduced by about one half, at which it has remained from 1868 to the present time. Must the resisting-medium theory be modified, or must it be altogether abandoned and some other cause be sought for the retardation in question? Prof. Young suggests a regularly-recurring encounter with a cloud of meteoric matter.

When nearest the sun, Encke's comet is at very nearly the same distance from him as the planet Mercury. When farthest from him, it is in the zone of small planets (nearly four hundred of which are now known), revolving between the orbits of Mars and Jupiter. May the attraction of some of these have something to do with the effect above referred to? Small as is the mass of most of the tiny bodies in question, it is possible that at certain times some of them may act together and produce a cumulative and appreciable effect. Of great value to astronomy has been the position of Encke's comet at the other extremity of its orbit, in perihelion. Before its discovery, the mass of Mercury had been rather a matter of conjectural inference than of actual calculation, that planet having no satellite the motions of which would be affected by its attraction. But at certain returns, the comet of which we are treating, made very near approaches to the planet, and the effects produced on these occasions have enabled astronomers to obtain determinations of the mass of the planet as accurate, or nearly so, as those determined for the larger planets which have satellites. The first of these near approaches since the comet's discovery took place in 1835; the last at the most recent return, in 1891.

We now come to the physical appearance of Encke's comet. It has on some occasions, when nearest the Earth, been just visible to the naked eye, particularly in the autumns of 1828 and 1848. After Miss Herschel had detected it (supposed to be a new comet), at its return in 1795, her brother, Sir William Herschel, observed it on November 8, and noticed it the following day pass centrally over a star of the twelfth magnitude without obscuring it, whence he concluded that the comet "is evidently nothing but what may be called a collection of vapours" Maskelyne, who observed it at

Greenwich a few nights afterwards (Bode had in the meantime, in company with an amateur astronomical friend, detected it at Berlin on November 11, four days after Miss Herschel's discovery at Slough), contested this view on the ground that the nucleus might be situated not in the apparent centre of the comet. And this indeed would seem to be the case; the general appearance of the comet, when seen under the most favourable circumstances, being that of a slightly oval vaporous mass, with a small ill-defined nucleus eccentrically situated within the coma. In 1848, towards the end of September, a faint brush of light was noticed by Prof. Bode, extending from the more condensed part of this towards the sun; and a few weeks afterwards a tail, between one and two degrees in length, was seen on the other side, *i.e.* the normal position of a comet's tail. Late in the month of November in the same year, it may be remarked, the comet made one of its very near approaches to Mercury, coming within the distance 0·038 of the Earth's mean distance from the sun, or about three and a half millions of miles. The return of 1871 was a noteworthy one in several respects; and particularly for the remarkable fan-like appearance which the coma presented in November and December.

The apparent contraction of a comet's bulk as it approaches the sun, and dilatation of it again when receding from him, which has been manifested in several of these bodies, has been especially marked in the case of Encke's, the visible diameter at perihelion being not equal to the twentieth part of what it is about the time when the comet first comes into view. The most probable cause of this would seem to be that suggested by Sir John Herschel, which would make it rather apparent than real, namely, that near the sun a part of the cometary matter becomes invisible by evaporation, just as a cloud of fog might be.

In 1871 the spectrum of this comet was examined by Prof. Young, and found to consist of three bright bands, of which the central one was the most prominent; they were somewhat sharply defined on the least refrangible side, whilst on the other they were diffused. "Of a continuous spectrum there was no trace, and the spectrum was the same from every part of the comet." But in 1881 a faint continuous spectrum was detected by Prof. Tacchini, so that the result of spectrum analysis applied to this comet would seem to be essentially the same as that obtained from the great majority of comets of which the light has been examined in this way.

At the last appearance of Encke's comet, in 1891, it was first seen by Prof. Barnard at the Lick Observatory in California, at the beginning of August, and passed its perihelion on October 18. At the present return it was detected at the Nice Observatory on October 31, in the constellation Pegasus; and Dr. Max Wolf found it registered on a photographic plate taken by him the same evening at Heidelberg. As on several previous occasions, its ephemeris has been calculated by Dr. Backlund, of Pulkowa; and it is matter of regret to notice his accompanying announcement that this is the last occasion on which he will be able to undertake it. The earlier portion of this ephemeris was given in NATURE last week.

W. T. LYNN.

PROGRESS OF THE CATARACT CONSTRUCTION COMPANY'S WORKS AT NIAGARA.

THE general scheme of the Niagara Falls Power Company has already been described in these columns (NATURE, vol. xlix. p. 482). We understand that the great power house is now complete, and the foundations ready for the three great 5000-horse power dynamos which have been constructed by the Westinghouse Company. The turbines and vertical shafts up to the floor of the power house have long been in place, and the dynamos may now be shipped any day. They have already been revolved in the shops at full speed. Our readers will remember that there is no gearing. The dynamos are on a vertical shaft, and the revolving fields are external to the armature, forming a sort of bell-cover to it, with the poles pointing radially inwards. This was the only design which Prof. Forbes could make to fulfil the requirements of the turbine designers as to maximum weight and minimum fly-wheel effect to be allowed. It gives a splendid mechanical construction, as the revolving pole-pieces and coils are retained in place against the centrifugal forces by the nickel-steel ring which forms the yoke.

The first place to be supplied with current is the aluminium works of the Pittsburg Reduction Company. To convert the two-phase, 2000 volt alternating current into a continuous current of 160 volts at these works, 2500 feet from the power house, transformers are there used, and the low pressure alternating current in two phases is supplied to commutating machines. This is a new departure of great interest, as no machines of this class have been previously built except for experimental purposes. They are each of 500-horse power, and are continuous current machines with four rings attached to four bars of the commutator. The alternating current is supplied by brushes rubbing on these rings, and it drives the machine as a motor. The continuous current is taken from the commutator by brushes in the ordinary way. All this machinery was made for the Cataract Construction Company by the General Electric Company, which is far the largest electrical concern in the United States. The machinery was tried in September, and it seems to work admirably. Four of these machines, with eight transformers, equal to 2000-horse power, are being put down to begin with.

The next place to be supplied is the Carborundum Company, which makes a substitute for emery, much harder, being composed of carbon and silicon raised to a high temperature in an electric furnace. They begin with 1000-horse power, and their factory is making good progress.

After that the Buffalo transmission will go on, but the selling of power in the neighbourhood is more profitable than at a distance; and many of the manufacturers, who have been holding back for two years to see how the tariff was to be settled, will now start factories, and some of them will settle at Niagara Falls to get the cheap power.

The transformer house, for raising the electric pressure from 2000 to 10,000 or 20,000 volts, is on the side of the canal opposite the power house, and these are connected by a massive stone bridge, with a covered way for carrying the cables. The concrete subway starts from the transformer house, and is at present to be used for supplying the first customers on the Company's lands.

Everything looks most promising at present, and as to the electrical works, everything indicates that any other general scheme than the one adopted would have been vastly inferior. Especially is low frequency proving itself invaluable. The continuous current could not have been got for the aluminium works without it, the motors will be far more satisfactory, and the safety and economy of the line is far higher. It was once objected that transformers could not be cheap or efficient at the low frequency proposed. Prof. Forbes held, however, that large sizes could be got even with low frequency at half the cost and at higher efficiency than anything that had been done on a small scale. This statement was based upon his own designs; and now it is entirely supported by all the manufacturers who have made designs for the work.