The President's Address.

The End of the World—a Collision in Space.

Standing as we do in the shadow of the greatest war the world has seen, a calamity that came upon us with startling suddenness, we may be pardoned if our thought should dwell for a few moments on the chances of cosmic catastrophe, one for example that would destroy the world. There have been several prophecies dealing with the end of the world. One of the best known is that contained in the second Epistle of St. Peter, in which he says :—

"But the heavens and the earth, which are now, by the same word are kept in store, reserved unto fire against the day of judgment and perdition of ungodly men. But the day of the Lord will come as a thief in the night, in which the heavens shall pass away with a great noise, and the elements shall melt with fervent heat, the earth also and the works that are therein shall be burned up."

The authenticity of the second Epistle of St. Peter has been widely questioned. Origen remarked that one Epistle was left by Peter, but with respect to the second he said that "There is some doubt." Irenaeus only mentions one Epistle of Peter, and Eusebius reckoned the second Epistle among the books of the New Testament of disputed authority. Perhaps it does not matter to us whether it was written by St. Peter or not; for centuries it has been attributed to him, and is believed to be an inspired prophecy.

Another prophecy is that of Isaiah who said: "Moreover the light of the Moon shall be as the light of the Sun, and the light of the Sun shall be sevenfold, as the light of seven days."

In the Mahabharata there is a prophetic passage which deals with the end of the world as follows :—

"O King, towards the end of those thousands of years constituting the four *yugas*, and when the lives of men become very short, a drought occurs extending for many years, and then, O Lord of the Earth, men and creatures, endued with small strength and vitality, becoming hungry, die by thousands. And then, O Lord of men, seven blazing suns, appearing in the firmament, drink up all the waters of the earth that are in the rivers or seas. And, O Bull of the *Bharata* race, then also everything of the nature of wood and grass that is wet or dry is consumed and reduced to ashes.

And then, O Bharata, the fire called *Samvartaka*, impelled by the winds, appeareth on the earth that hath already been dried to cinders by the seven suns. And then that fire, penetrating through the earth, and making its appearance in the nether regions also, begetteth great terror in the hearts of the gods, the *Danavas* and *Yakshas*. And, O Lord of the Earth, consuming the nether regions, as also everything upon this earth that fire destroyeth all things in a moment."

There is no need to labour over the similarity between the seven suns mentioned in this passage and Isaiah's prophecy that the light of the sun shall be sevenfold. The number seven was peculiarly sacred from the earliest historical times, and would be not unlikely to appear in this way in a prophecy claiming credence, but the point in which all these prophecies are in agreement is that the world will be destroyed by fire, and it will, then, be interesting to us to consider how the destruction of the world by fire might come about.

The Earth's Internal Heat.

It occurs to us at once that the interior of the earth is hot, and that perhaps the internal heat might in some way come to the surface. In all deep mines the heat increases with the depth, and the temperature of the rock has been carefully observed in the deepest mines in order to find out at what rate the temperature increases with the depth. Observations in mines and boreholes exceeding 3,000 feet in depth, situated at places as far apart as Virginia, Lancashire, and Leipsic, the latter being 5,600 feet from the surface, showed that the heat increased by every 74 feet, 66 feet and 67 feet of depth, respectively. We have no idea whether this rate of increase continues, neither do we know how far in from the surface the maximum temperature is reached, but the increase appears to be uniform as far as our deepest observations go, and that is about a mile and a quarter, and we are therefore bound to assume that the same rate of increase continues for a further considerable distance. The increase in temperature, to the observed depths, amounts, we may say, to about 75 degrees or more for a mile of depth, and at this rate of increase we should reach the melting point of lead at a depth of 7½ miles, of iron at 15 miles and of platinum at 23 miles, and the temperature at which coke is transformed into graphite 4,000. Fahrenheit would be reached at 53 miles.

If the circle which I have drawn on the black board, two feet in diameter, represents the earth, the thickness of the chalk line represents a depth of about 100 miles, so that a

depth of 53 miles is only a very little way into the interior of the earth, and it is very probable that the temperature continues to rise to a greater depth than 50 miles or even 100 miles. Whatever the temperature may be in the interior of the earth there can be no reasonable doubt that it is very high, quite sufficient to destroy everything on the globe if only it could reach the surface.

The weight or the rocks forming the crust of the earth with which we are acquainted is such that a cubic foot weighs from 150 to 180 lbs. Taking 170 lbs., as on average, one mile of thickness will give a pressure of $2\frac{3}{4}$ tons per square inch, and at a depth of 50 miles, the pressure is therefore over 130 tons per square inch and at 100 miles it must be 275 tons per square inch. At such pressures as these, rocks become plastic and even cold steel would flow, and the interior of the earth must consequently be fluid even if it were cold. But it is not cold, and the evidence of heat suggests that the temperature is so high that the ordinary substances we know are liquefied.

The combined effects, therefore, of pressure and heat must be such that under the crust the earth is fluid, and consequently, its structure must be in a condition of equilibrium, except for the comparatively small disturbances that take place in the crust. This explains how it is that earthquakes originate in the crust of the earth, and not at great depth, the greatest depth of origin of any earthquake is believed to be not more but probably less than 20 miles.

The question then arises as to whether any alternation in the existing conditions is likely, leading to a condition of unsuitable equilibrium, so that the interior hot materials could over flow the surface. The stresses set up in the crust of the earth by cooling are only likely to cause wrinkles, and there is nothing to suggest that the crust could ever break up, indeed its very weighty, and the plasticity of all but the surface of it, indicate that whenever any part of the crust reaches a condition of unstable equilibrium a settlement soon occurs, as is manifested in earthquakes. For anything more than this to appen the shape of the earth would have to be altered and the alteration would have to take place with some rapidity or the crust would settle down to suit the altering shape, the settlings being probably punctured by series of earthquakes. We may therefore be satisfied that there is nothing in the condition of the earth nor in the constitution of the solar system which gives any support to the idea that the world is likely to be destroyed by fire.

The Dark Stars.

Let us look beyond the solar system for a moment, and consider the stars, as they are called, which have appeared in various parts of the heavens from time to time.

On February 19th, 1901, a certain part of the constellation Perseus was photographed at Harvard, and the photograph showed all the Stars down to the eleventh magnitude. On the night of the 21st a new star was noticed in Edinburgh as between the second and third magnitude. In the next two days it became brighter than Capella. Its brightness therefore increased in about three days from less than the eleventh to the first magnitude, an increase in light of more than ten thousand times. In the case of this star we had clear evidence of the extraordinary rapidity with which a new star can blaze up, a rapidity that had always been suspected but in only one other case had been observed, and now that it was clear the change was sudden, explanations of the increase in light which otherwise seemed plausible had to be put aside, and the theory that it must have been due to a collision between the Star and another body has gradually gained ground.

Nova Persei, as the new star is called, was so bright that its light could be examined spectroscopically with ease and every detail of the character of the lines and bands was closely watched, and the changes in the constitution of the star and the movements of its gases were observed and noted. These appear to have been in agreement with what would have been expected if there had been a collision with another body, and as the proofs have accumulated it is now generally held that this is the most probable explanation of the apparitions of bright stars which have suddenly appeared in the sky.

We naturally at once ask ourselves what dark bodies there are in space and what are the chances of a collision. We know small dark bodies, which come into collision with the earth and appear as meteors when friction with the upper atmosphere causes heating. We are also well acquainted with larger dark bodies; all the planets are dark, and are only seen by the light they reflect from the Sun. There may be a very large number of dark bodies in space, bodies which having radiated their store of heat are now too cold to shine by their own lights. As far as we know, our Sun and all the stars are cooling in proportion as they are radiating their heat away into space, and as the stock of energy with which they commenced their career is gradually dissipated, the light and heat they radiate must be diminished until at length the heat is so much reduced that light is given off, and the star will be dark.

Among the stars we see many which seem to us to be waning, and to be in an older stage of radiation, indicating that they are further advanced in the process of cooling, and nearer to the time when they will be cold and dark. How many stars, large or small, have cooled down so far that they now emit no light, we have no means of knowing, but the number may be large, may be greater than the number of visible stars.

The Sun with his attendant planets is sweeping through space, and all the Stars are also each travelling through space with a considerable velocity and it is, therefore, possible that we may some day meet a dark body. If this dark body strikes the Sun or grazes the Sun, and if it is sufficiently large, the quantity of heat that would be generated would be so large that the hot envelope of the sun would be extended to an enormous extent, perhaps even engulfing the world, so that the inner planets would be absorbed into the blazing Sun.

If the force of the collision were somewhat less, so that the hot atmosphere of the Sun is only expanded to a comparatively small extent, the increase of the solar radiation would still be sufficient to vaporise all the water in the seas and to burn up every thing on the surface of the earth. It appears therefore that what has happened in the case of the new stars might happen to our sun as a result of a collision with a dark body and in that case the prophecy of St. James would be immediately fulfilled. If an approaching large body were to collide with the earth there would be the same evolution of heat and vaporising of all water and many of the less refractory substances, and the destruction of the earth would be practically instantaneous.

If a large body approached the Sun closely without actually touching it or touching any of the planets it would swing round the Sun and pass on into space in an orbit probably hyperbolic. In passing it would so disturb the Sun by its attraction that the deformation of the Sun would cause the evolution of a good deal of heat, perhaps enough to destroy the world, and if this body passed near the earth the deformation of the earth by its attraction of the rotating earth set up such stresses that the earth's crust would split and crumble and the tides would sweep round the earth over all the land.

How the Cataclysm would come.

It is evident that a celestial catastrophe is quite possible, and it may be interesting to inquire how long beforehand we should have any

knowledge of the coming disaster. Suppose that we were to meet a body of the same mass as the Sun. Being cold and dark it would have become consolidated by shrinking as it cooled and it may be assumed to be a smaller dimension than the Sun, say about 550,000 miles in diameter about five-eighths of the Sun's diameter.

Such an object would appear as soon as it came near enough for the reflected Sun's light to illuminate its surface. It would seem to be about the 10th or 11th magnitude at a distance of 22,000 million miles and might then be photographed, and might be recognised as a near body as it would have a disc about twice the apparent diameter of Neptune, and rather more than that of Uranus.

Let us suppose that this object was approaching the Sun with an initial velocity the same as the velocity with which the Sun is travelling through space, say 10 miles a second. The approach of the dark Star would at first be almost limited to its own initial velocity of 10 miles a second, the attraction of the Sun would be very little felt.

For the next twenty years the dark Star would be coming nearer, always with slightly increasing speed, and at the end of that time it would appear as a star between the 5th and 6th magnitude, about as bright as Uranus, and plainly visible to the unaided vision. Being so much larger than Uranus it would be a very conspicuous object in the telescope, as it would be half as large again as Saturn. Long before this it would certainly have been discovered by the telescope, its large diameter noted, year after year its parallax and its increasing diameter, would have been measured, and the size of the body would be known, also the fact that it was approaching the Sun and by the time it became visible to the naked eye the date when it would reach the Sun's surface would have been calculated with some accuracy, and all the world would know of the coming disaster.

In another 4 years it would be about as distant as Neptune and would shine as a first magnitude star, but its apparent diameter would be about the same as that of Jupiter at his nearest.

In another year it would reach the distance of Uranus and would be brighter than any star except Sirius and Canopus, but its apparent diameter would then be half as large again as that of Jupiter so that in a telescope it would be a very fine object indeed. In one year more it would reach the same distance as Jupiter, and would shine with 100 times the light

of Sirius, 5 magnitudes brighter. Its apparent diameter would be about six times that of Jupiter, about an eighth that of the diameter of the Moon. Then its progress being continuously more and more rapid, its speed would become so great that in a couple of months it would strike the Sun. In the last month, as it came near the Sun it would be a brilliant object in the sky. Approaching the Sun itself in brilliancy it would eventually be visible in broad daylight. Owing to the vaporisation of water and other substances its atmosphere would expand, and heavy clouds would form. Its apparent diameter would therefore considerably increase, as the clouds would reflect the sunlight and would hide its surface from view.

The Collision.

If the earth chanced to be in that part of its orbit at right angles to the line joining the centres of the sun and the dark star the sight at the moment of contact can be faintly imagined. Each sphere would bulge out to meet the other and their adjacent surfaces would fall together and mingle. In fifteen minutes after they touched, the smaller globe would have been completely engulfed in the larger whose substance would be splashed out. Some portions would probably leave the combined mass at such speeds that they would not return. The whole mass would be vapourised with an enormous evolution of heat. I have assumed that the dark star was approaching with the same initial velocity as that at which the Sun is travelling through space. If the velocity of the dark star were less the approach would be slower, and we should have longer warning.

The direction assumed, that in which the Sun is moving, would not bring the dark star near the earth, but if we suppose a dark body approaching from some other direction it might pass near the earth. The first result of this would be to deflect the earth from its normal path and its orbit might be reduced so that the earth would revolve round the Sun at a much less average distance, the distance at perihelion would be likely to be so small that the fierceness of the Sun's heat would destroy life, even if no collision of the dark star with the Sun or disturbance of the Sun's equilibrium caused an increase in the Sun's heat.

An approaching dark body might be very much smaller than we have assumed. Suppose that the dark body were the size of Jupiter. I twould then only become visible telescopically at 6,000 million miles, and to the naked eye at 3,000 million miles. From the time it became visible we should

have about five years before it actually fell into the Sun. If it was only as large as Uranus, it would only become visible to the naked eye as Uranus is now visible, and would reach the Sun in three years from that time.

We are therefore bound, you see, to have some warning of a collision of a dark body with the Sun causing such an outburst as would destroy the world. The larger the dark body, the greater the collision, and the more extensive the final catastrophy, the longer our warning would be, extending to perhaps twenty or thirty years. On the other hand if the dark body were of the smallest size that by its direct collision with the sun could cause the evolution of enough heat to destroy the earth we might only have a couple of years of warning.

Dynamical Theory and Tidal Friction.

Questions regarding the tides have been recognised as being of the very first importance by great sea-faring nations like the English from the remotest antiquity. The ancients must have early discovered that there was a connection between the ebb and flow of the tides and the diurnal motion of the Moon. Cæsar shows us in his De bello Gallico that he possessed a rough and ready idea of that connection. He must have noticed that the intervals between the times of high water were equal to half those between the Moon's meridian passage. Of course he did not know that the Moon could cause high tides when on the meridian below the horizon. For high water is not produced merely under the Moon, but equally (or to be more accurate, almost equally) on the side of the Earth furthest removed from the Moon. These great tidal waves are separated from each other by $\frac{1}{2}$ circumference of the Earth. As the Earth rotates, every part of its surface that is roughly in the same plane with the Moon, passes successively under these tidal waves. And then it is high tide at these particular places. But if the Moon's absolute attraction caused the tides, there would be only one high tide, whereas there are two tides daily. Again if the Moon's tidal force were equal on all the component parts of the Earth, there would be no tides at all. Why then are these two lunar tides (we are, for simplicity's sake at present neglecting the solar tides) daily? If the solid part of the Earth were fixed in space, and if the Moon were also fixed then there would be but one high-tide