handspikes placed in holes in the large and solid axles. These towers were of immense size. In the works of Vitruvius, one of the great architects of Rome, we find that they were never less than 90 feet high and 25 feet square. One was constructed one hundred and eighty feet high, and of thirty-four stories. In the lower part of this tower was placed the battering ram, to be described presently, and attached to the side next the enemy was a draw-bridge, proportioned to the breadth of the city ditch, and so constructed that when the tower reached the edge, the bridge was suddenly let fall, to the top of the rampart, and the besiegers passed over it to the assault.

It was always thought that if one of these towers could be brought thus, safely, up to the ditches' edge, the fortress was sure to be captured. The Greeks called it the "taker of cities."

The besieged party defended themselves vigorously. They replied to the fire of the besiegers by the discharge of similar missiles—they poured boiling water, seething pitch, scalding oil, and hot sand, on their heads; they hurled down great stones, and beams of timber, and one of their most horrid devices was to wind a quantity of tow soaked in pitch round an iron hoop, set it on fire, and drop it from the wall—the fiery circle often enclosed two or three men in its deadly embrace, when they perished miserably. This mode of annoyance was used by the Knights of St. John against the Turks at the siege of Malta in 1556.

Against the mines of the besiegers they made counter-mines, the hostile miners meeting in the subterranean galleries, in the most savage conflicts; they sometimes undermined the great mound itself, and penetrated beneath the great tower, which, when the props were fired, fell in with a horrid crash. If a breach was made in their wall, they raised a new wall behind it. In fact, considering the difference of the engines employed, the defence was conducted much on the same principle with that on which towns are defended at the present day.

We come now to the engines themselves, the Artillery of the olden time.

The most terrible and prominent of all these was the Aries or Ram. This was, simply speaking, a large and long beam of timber, like the mast of a ship; the end was armed with a huge head of iron, fashioned like that of a ram, whence its name. To give a familiar illustration, which an Ottawa man will readily understand; if you suppose one of our largest red pine spars, 100 feet long, and two feet in diameter, headed at its thickest extremity with a solid mass of wrought iron, for the ancients knew not cast iron—and fancy this huge piece of timber slung by several strong chains to a large beam that lay across a frame work of upright posts, and then further fancy this piece of timber with its iron head, furnished with ropes, at stated distances, drawn back, and then forcibly driven against the wall by the united force of two or three hundred men, continually relieved, you can begin to appreciate the power of the ram.

The ram, therefore, though not properly speaking a projectile weapon like the cannon ball, answered the same purpose.

Anciently it was a beam of much smaller size, carried in men's hands. But as walls began to be more strongly constructed the ram was made of far larger size, and suspended by mechanical contrivances. Instances are mentioned in which it was mounted on wheels, and so driven against the wall.

It is said that the first use of the ram, in its simplest form, that is, borne in men's arms, was by the Carthaginians at the siege of Cadiz in Spain; and that the mode of suspending it by ropes or chains was invented soon after by a Tyrian mechanic, Pephasmenos. Wheels were added by a Macedonian engineer, Polydus, at the siege of Byzantium, in the time of the great Philip, and a Chalcedonian engineer first formed the idea of placing it under a proof covering to defend the men who worked it.

Some of these rams according to Vitruvius were a hundred and twenty feet long.

I wish you now to understand how the ram produced its effect upon a high and thick wall, so as to throw it down. The effect of the ram was due to vibration, or in other words, shaking. The continued strokes of the heavy weight made the wall tremble—this trembling of the whole structure, gradually loosened the connection, or adhesion between the stones and the cement, untill the alteration in structure was so great that the wall finally tottered and fell. The action of the ram depended on precisely the same principle by which the strength of a suspension bridge is tried. If you march a regiment of soldiers across a suspension bridge, in the usual cadenced march, the bridge commences to rise and fall, responsively to their measured steps, and this motion continues to increase in violence, until the bridge gives way. A shocking accident of this kind took place in France a few years ago, by which a whole battalion in heavy marching order, was precipitated into a deep and rapid river, and an immense number of lives lost. It is for this reason that soldiers in passing over bridges are always ordered to break their step.

A curious calculation was made by Dr. Desaguliers, an eminent professor of mathemetical science, that the power of a ram, 180 feet long, with a head of one ton and a half, the whole weighing 41,112 pounds and driven by the united force of 1000 men is only equal to that of a 32-pound cannon ball, fired at point blank range, or 330 yards. But in this calculation it is apparent that the learned Doctor has forgotten one very important thing, that is the size of the head of the ram; the cannon shot penetrates the wall, and so by repeated battering beats the stones to pieces, as will be explained in a future lecture, when we shall see how modern artillery makes a breach. The ram does not penetrate, it shakes; its head having a larger size its power in the blow is spread over a larger surface. Thus while its penetrating power is diminished its shattering power would be increased. Most of you have seen a leaden bullet discharged from a common gun cut a clean round hole through a pane of glass, but all of you know that a stone the size of the fist would shatter it into fragments. This is the best example I can give you of the difference between the effect of the ram and the cannon ball.

In the earlier periods the ram was advanced to the assault, under the protection of a shed, called a 'vinea,' formed of hurdles, covered with earth, or raw hides. In latter times it was worked from the lowest story of the great wooden tower, the ram head projecting towards the side of the enemy from a narrow opening, merely wide enough to admit the passage of its head, while the rear of the tower was open for the convenience of the men who manned it.

We have no precise record of the time which was occupied in making a breach by the use of the ram. That must have depended on the height and thickness of the wall. It is quite evident that the higher the wall the more easily was it shaken.

The great object of the besieged was to prevent its approach. Hence the first effort was to destroy the shed, or tower which protected it, as I explained before. If the ram commenced its work upon the wall, great stones were dropped upon its head, in the hope to break it off. Nooses of rope or chain were let down to entangle it—bags of wool, wicker hurdles, or masses of any yielding material were lowered from the wall by ropes to interpose between the ram and the masonry, thereby to deaden the violence of the shock.

I believe that the last well known and authenticated instance of the use of the ram, was in London, in the reign of Charles the Second, when the great architect, Sir Christopher Wren, employed it to shake down the walls of old St. Pauls' Cathedral, burnt in the great fire of London, previous to the erection of the present structure, as it was thought dangerous to employ powder in the very heart of the great city.

I come now to the machines for casting projectiles. These were of various kinds and known by many names. Many of these engines were of Greek origin, and their use continued down to and after the invention of powder, just as we know, that even in the civil war waged by the Parliament of England against Charles the first, the bow and arrow had not been entirely superseded by the musket of the period.

These machines are correctly described by several ancient writers, and drawings of them may be continually found. The two principal ones were the Balista and the Catapulta. The Balista threw stones, the Catapulta large arrows tipped with iron. Down to the time of the invention of powder these identical engines were used under other names; in the Chronicles of Froissart, Monstrelet and De Comines we find them mentioned as Mangonels, Trebuchets, and War-wolfs. There are many other names of engines, both among the Romans and Greeks, and in more modern times, but they seem to have been applied to smaller engines. I shall not trouble myself with them, as the principle on which they were constructed was invariably the same.

The best description to give of them is that they were gigantic cross-bows, and that the most powerful of them did not consist of a single bow or spring, but of two, the end of each elastic arm being inserted in the centre of a coil of rope strongly twisted, so that when the two ends of the arms were brought together a most violent recoil was produced, when the trigger was pulled. Some of these engines were so contrived that they threw a whole shower of heavy darts, in what we should call a volley, or baskets of great stones. Their use was to clear the wall of the enemy who defended it.

We find in Vitruvius all the calculations for the size of these engines, according to the