ANCIENT ENGINEERING, ITS METHOD AND APPLIANCES.

No. I.

The word architecture in our day is principally applied to those constructions in which ornamental art is super-added to utility; but in remote times much of what we now call engineering, even including the construction of various machines, was expressed in that word. Thus Vitruvius' work, "De Architectura," contains chapters on machines for raising and transporting great weights, and even on the construction of looms, and that author himself held the post at Rome of inspector of war machines. Indeed, up to the middle of the fifteenth century, architecture and engineering mingle at many points, and the civil engineer of the future will be better educated, and have to pay more attention to the æsthetic element in his art, than has been often exemplified in the past. The history of architecture, viewed in its technical side—or as the builder's art—has, until within a comparatively recent period, almost no history, except that which has been derived from the observation of its monuments. These, while they have sufficed to hand down to our admiration and imitation the forms of beauty which were slowly elaborated by the ancient masters of the art, afford but little information as to the methods and contrivances employed in their construction; and in most instances even less information as to the technical methods employed by early architects or engineers has been obtained from the observations made in modern times of their monumental works, because architects and archæologists, who have been the chief observers and recorders of these works, have been themselves very generally more bent upon the æsthetic than the constructive element, of the latter of which they were very commonly ignorant, and hence have not known how and where to look for such indications in the buildings they have examined and measured as might, if carefully reasoned upon, have afforded more or less information upon technical methods and appliances by which they were erected, and as to which nothing else now remains for our instruction. In many instances, indeed, nothing is presented by the monuments of ancient art, however carefully examined, to give us any clue to the methods employed in their construction. We may create in imagination, with more or less of probability, the apparatus and methods by which the huge blocks of stone of the Egyptian Pyramids were raised and put in place; but the imagination receives little aid in such creation from anything now presented by the Pyramids themselves. On the other hand, the architect or engineer, well versed in the technical conditions of their art, can readily discover for himself the reason of the curious fact that the joints of the masonry of the Pyramids were laid in mortar, whereas many of the great monolithic structures of the same epoch were laid dry, or without mortar, as were also the enormous blocks of stone which, centuries after, were bedded into the walls of Pelasgic or Etruscan cities. Architecture, though transcending in antiquity the history or even traditions of the human race, of which the use of mortar 5000 years ago, as above cited, is an illustration, has in fact little or no written technical history that goes back more than three or four hundred years. Thus we know much historically about the Parthenon, and even the names of the sculptors employed upon its ornaments have reached us, but we know almost nothing as to the technical methods employed in the chiseling and putting in place of its fluted columns and their entablatures, and it is even matter of vague speculation whether the steps of the peristyle were laid perfectly level, or whether, for some mysterious reason, the surfaces were slightly curved, and lowest at the corners of the edifice, as they now are said to be. We know next to nothing as to what was the social status of the architects who designed and constructed the vast edifices, domes, aqueducts, and bridges of imperial Rome in its wealthiest days, and almost nothing of the same class of men who completed like works in distant parts of the empire; and of the constructive methods which they employed, we know scarcely anything beyond what may be gathered or inferred from a skilful examination of their works which still remain.

The introduction of arched structures gave rise to the most complicated forms of stone cutting, as seen in the amphitheatres which remain, where every complex form of archwork—skewed, conical, or twisted, as well as the close-fitting joints of the spectators' seats, the stairways, and the accurate elliptic lines of the plan—all prove how precise must have been the instruments and methods by which the designs of the master builder were carried into effect by the stonecutter or mason. But we know nothing as to what these methods were, what was the nature of their moulds or templates, by what means were the everchanging angles required in the separate blocks of stone transferred from the designs for the guidance of the stone-cutter: we do not even know with any certainty upon what sort of material, whether parchment, papyrus, wood panels, or waxen tablets, the designs themselves were drawn. At a still later period, after pointed architecture and cathedral building had evolved themselves all over Europe, still more complex forms of stone cutting became necessary, and the stonecutter's art reached a perfection in the complicated groins and vaulting of such buildings, which has never been exceeded. Yet even here, when we approach nearer to architectural written history, our information is of the most imperfect character as to what were the constructive methods employed. In this dearth of information, therefore, there is the greater reason for noting well any structural peculiarities in ancient architectural monuments which may enable us by a process of reasoning to infer from the work itself more or less as to the methods employed in its design and construction, and ultimately from these to infer more or less what was the extent of scientific knowledge and practical skill of the designers. In the following articles it is proposed to point out two examples of ancient structural methods as thus inferentially derived from examination of the structures themselves, both being instances of great technical interest, and which appear hitherto to have escaped the notice of engineering and architectural authors. The first of the examples about to be dwelt upon is that of the Pont du Gard, in France; the second that of the so-called Mole of Caligula, in the Bay of Pozzuoli, near Naples.

(To be continued.)

THE CIRCULAR RIP-SAW.

Prominent amongst the vast array of tools which inventive genius has placed in our furniture factories is the circular rip saw; it is, at the same time the most efficient, and the most delicate tool in use, and the success of its operation depends entirely upon the skill of the workman who handles it; ordinarily, it is placed in the hands of men practically unable, and totally unfit, to have charge of it. The trade of a sawyer is only acquired by years of experience, but not more than five per cent. of the professed sawyers in the land approach any high degree of perfection; the majority of them work hard and accomplish little. Wherein is the fault? Is it the man or the tool? oftener it is the tool; provided with a geometrically-true table constructed upon scientific principles and a perfect saw, other things being equal, the labour of running a saw ceases to be a source of physical and mental discomfort, and the sawyer views his work at eventide with evident satisfaction.

In this connection I will note down a few points of practical interest to the sawyer. In the first place it is indispensable that the frame should be heavy and well constructed; the table should be hinged at the tail end to allow it to be adjusted for thick or thin stuff, *ad libitum.* This may be accomplished by means of a rack and pinion, or a screw at the head end. Care must be exercised to prevent any lateral motion of the top; this in itself is a very important matter and should receive daily attention; the top should be very rigid, especially in front of and close to the saw to prevent any spring down of table or stock; the fence should be the full length of the table, easily adjustable, geometrically true, and in perfect line with the slide-board and saw. The mandrels should be of steel, not less than 1 1-2in. diameter; should be turned perfectly true of a standard gauge from end to end, and devoid of collars, in lieu of which 3 or 4 V-shaped grooves should be turned in the journal remotest from the saw. Just here let me state in parenthesis that the average mandrel is a magnificent mistake, excelled only by Allen, Thurman, and Co.'s "rag baby" finance plank; better have a mandrel made to order and pay two prices for it.

The mandrel should be turned on *drilled centres,* and the best lathe hand invariably employed on the job; the pulley should be straight on the face, and emery-dressed, to make it perfectly smooth, and always placed between journals. The flanges should be of the same diameter as the pulley, and free from all sand-holes and other imperfections, the faces should be turned straight 3-16ths of an inch deep, and from that point recessed or rebated to the centre, for scientific reasons. By no means whatever introduce a pin to prevent the saw from turning between the flanges; it is not only a detriment to the saw, but any applied force sufficient to stop the saw would cut the pin off; rather use a left hand nut on the end of your mandrel.

The saw should *fit the mandrel,* not hang on it, neither should it be driven on with a sledge. It, as well as the flanges, should be kept scrupulously clean and should not be allowed to become defaced or battered; the saw should be filed as often as it becomes