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Introduction to the Literature of Historical Engineering to the Year 1640.

By E. Wyndham Hulme.

(Read on November 5th, 1920, at H.M. Patent Office, London.)

Inasmuch as Engineering and Technology are the mechanical foundations of all civilization, it is to the industrial history of primitive and prehistoric peoples that we must look for its first beginnings. The evidence of primitive industry is valuable because it gives us a picture of tribal life as a whole. That of prehistoric archaeology is much wider because it deals with past civilizations in all stages of their development. From it alone are we able to put together a connected history of man and his industries. But this reconstruction is necessarily a one-sided one—for it is based upon the survival of what our ancestors would have described as fossil remains, *i.e.*, a few unalterable substances such as pottery, glass, stone and the metals. Direct evidence of the perishable and immaterial things has been withheld from us.

The literature relating to primitive races I must dismiss by referring you to such works as Mason's *Origin of Industries amongst Primitive Tribes*, and Abbott's *Primitive Industries of North America*, while for prehistoric archaeology you cannot do better than consult the excellent British Museum Guides to the Stone, Bronze and Early Iron Ages respectively. Here I would draw your attention to the fact that while the Bronze Age shows a high degree of technical attainment in the casting of the more fusible metals, the early Iron Age remains the age of wrought iron from approximately 1500 B.C. to 1400 A.D., a period of nearly 3,000 years. When and where the first casting of iron took place, I leave to our experts in iron metallurgy to tell you. There can, however, be little doubt that it was the need for cast iron ordnance that led to the introduction of this process in Western Europe.

Of greater interest for the history of civil engineering are the results which archaeological research has yielded in Egypt, Asia Minor, Greece and Crete. Egyptological research owes a deep debt of gratitude to Napoleon for the magnificent survey of the history and antiquities of Egypt published between the years 1809-28 in 22 ponderous volumes of text and atlas under the title of "*Description de l'Égypte*." Interest for a time then shifted to the recovery of the buried cities of Pompeii and Herculaneum. But it was the discoveries of Schliemann be-

tween 1870 and 1880, first at Troy and then at Mycenæ, which gave the impetus to the scientific studies of classical archaeology which has recovered for us the history of the civilization of Crete which forms the connecting link between that of Egypt and Greece. The engineering problems of irrigation and water supply were, it is well known, solved at an early period by the engineers of Asia and North Africa, but in the great Palace of the Two Axes in Crete there has recently been discovered a system of water-carried sewerage and terra cotta socketed drain pipes which could not be paralleled in Europe prior to the end of the 18th century.

For a summary of these ancient civilizations, I can give you two excellent works by the American Egyptologist Breasted—the first entitled “Ancient Times”—a history of the early world, and the second which is just issued—“The Origins of Civilization.”

Coming to the classical and the late classical period, we find the first works of strictly technological importance. The names of Aristotle, Ctesibius, Hero of Alexandria, Archimedes and Vitruvius stand out pre-eminent, but unfortunately we do not possess in all cases that full and authentic evidence as to their inventions which we require. The fame, for instance, of the inventions of Archimedes rests upon tradition. Sir Thomas Heath says that Archimedes disdained to record them as being beneath the dignity of a philosopher. Ctesibius was the son of a barber who demonstrated his professional skill to clients by suspending a mirror from chains, to one end of which was attached a weight working in a tightly-fitting case. The weight as it descended compressed the air, which, as it escaped, made an audible sound, and this suggested to Ctesibius the hydraulic organ. His name is also associated with the double-acting manual fire-engine which was introduced into Europe in the 16th century. But of his writings, if such existed, not a line has come down to us—though his inventions are probably largely embodied in the works of his pupil Hero of Alexandria. The drawings in the latter's works are with two exceptions based upon originals—but those of Vitruvius are all modern reconstructions from the text—a fact which should be borne in mind when you consult his tenth book, which deals with machinery.

One of our members, Dr. Lones, has published a scholarly treatise on the teachings of Aristotle on natural science. We should welcome from him a paper on the teachings of Aristotle and his school in mechanics and applied science, for few of our members possess Dr. Lones's double qualification of classical scholarship and proficiency in modern technological processes. The great defect in our modern histories of inventors and engineers is that they have for the most part been written by men whose scholarship has not atoned for the lack of professional knowledge of the subjects with which they have elected to deal.

There are, however, some good modern works dealing with the engineering history of the classical period. Amongst my exhibits will be found a work by Mr. G. F. Zimmer, a Member of our Society, who describes himself in his preface

as "an Engineer by profession and an Archæologist by inclination." This description admirably defines the two-fold qualification for Membership in this Society.

The Middle Ages may be characterized as the period in which the artist rose superior to and dominated the engineer and scientist. Here we find bodies of workmen of mixed nationalities, moving from place to place and country to country working harmoniously in the service of Church or State, and instinctively solving the problems which the constant changes in architectural style and decoration demanded of them. Of them we may say they "builded better than they knew"; for throughout this period they never appear to have felt the need for analysing or reducing to system the principles upon which they worked. From the bibliographical standpoint we have to record a blank. Science, it is true, is represented by MSS. on Alchemy, Medicine, Mathematics, Geometry and Optics, but no great material progress is recorded. On the other hand, the Fine Arts are more worthily represented by various collections of receipts, of which the Treatise of the monk Theophilus and collections of Mrs. Merrifield are the most notable. But the only MS. which appears to recognise the needs of the time for some approach to methodical instruction in technology is the Sketch Book of Wilars de Honecourt, an Architect of the 13th century.

Honecourt's book, it is true, is little more than an architect's notebook, but it did contain, and its author attached special importance to, certain mechanical drawings, four of which, alas, have disappeared from the original MS. His preface runs—

"Wilars de Honecourt salutes you, and implores all who labour at the different kinds of work contained in this book to pray for his soul and hold him in remembrance. For in this book may be found good help to the knowledge of the great powers of masonry, and of devices in carpentry. It also shows the power of the art of delineation, the outlines being regulated in accordance with Geometry." This work is notable as the forerunner of a class of engineering sketch books which became popular in the 16th and 17th centuries.

In the absence of any systematic mediæval treatises on the subjects of mechanics and engineering construction, we are thrown back upon the incidental illustrations with which the MSS. of the Middle Ages are embellished. Fortunately this material, unsatisfactory as it is in its evidential quality is abundant in quantity, and has proved a rich storehouse of information which has been carefully sifted and classified by many writers. I will mention only Parmentier's "Album Historique," where the arrangement is chronological by countries; and Feldhaus's "Technik der Vorzeit," which is in dictionary order. There is a small guide to the illustrations in the British Museum MSS. by Birch and Jenner, and there is also a General Index of Names of Persons and Places and to some extent of Subjects in the entire literature of the Middle Ages by Chevalier in four vols.

The English works by Wright, Cutts and others you are probably familiar with.

In the 15th century the obscurantism of the Middle Ages begins to dissolve under the influence of the new arts of artillery and printing. The development of artillery brought about changes in military tactics, ballistics, fortification, metallurgy and the mechanics of lifting and transporting heavy weights. The result is to be seen in the German MSS. reproduced by Berthelot illustrating the methods of attack and defence employed in the Hussite War c. 1430, the illuminated MS. of Valturius, and the anonymous German "Hausbuch," c. 1480, with its remarkable drawings, some of which are of a mechanical nature. On the other hand, the invention of printing from movable types, coupled with the recovery of many classical MSS., led to the printing of editions of the classical writers on mechanics with whom we have already dealt. It is true that the professional instinct of secrecy died hard. Da Vinci, for instance, the greatest artist, engineer and inventor of all ages, published nothing in his lifetime and committed his text to writing in cypher—by writing in reverse. His sketch-books, here represented by the collotype edition of the Milanese MSS., have only recently been reproduced—other MSS. still await publication. The printing press in the 16th century at last broke down the professional reserve, with the result that the technological literature of this century is probably equal in bulk and superior in merit to that of the following one. Thus we have the works of Agricola "De re metallica," of Biringuccio on pyrotechny, or as we should call it to-day metallurgy, and of Ercker on assaying. There is no parallel in importance to these three works in the technical literature of the 17th century except in the works of Moxon, the first English publisher of a series of technical handbooks issued in parts. Ercker's work on assaying was translated by Pettus a century later. Agricola has recently been translated into English and edited by the Hoover Brothers in a style worthy of the great writer; while Biringuccio, whose work was reprinted several times in the 16th and 17th centuries, as well as translated into French, has not yet appeared in an English version.

Then we have a series of folio engineers' sketch-books issued between 1569 and 1620 by Besson, Ramelli (1588), Veranzio (1590), Zonca (1607), Zeising (1621) and Strada (1617-18). Note the predominance of the Italian genius and the absence of English talent, which was still bent more upon copying foreign models than originating new designs.

There is, however, one great, perhaps the greatest mechanical invention of the age, which is unquestionably of English origin, viz., the Stocking Frame of Lee. Unfortunately the inventor, unable to obtain protection here, sought and secured encouragement in France. Then we have another great invention by an Englishman, the water-closet of Sir John Harington. Here the inventor, being a literary humourist, published his invention in the form of a prose burlesque on an unsavoury subject which he called the Metamorphosis of Ajax (*i.e.* a jakes).

Bourne's *Inventions or Devises* (1578) and the works of Platt must not be overlooked, as affording evidence of the existence of a native inventive talent slowly coming to the front; and there is a folio work by Lucar Solis, a miscellany containing some original mechanical contrivances. Mr. Jenkins will show you a MS. collection of inventions by a military adventurer about the year 1590, which is, I think, worthy of reproduction by the Society if we adventure on such things. Finally, there are three classes of works to which I must briefly refer which became popular in the 16th century. (1) Histories of Inventions, (2) Books of Receipts and (3) Iconographies of the Arts and Trades. Of the first two classes, a careful bibliographical description exists in a series of papers by the late Prof. Ferguson of Glasgow. The histories of invention represented by the works of Polydore Vergil and his followers were popular snippets from early literature—they deal chiefly with the origin of human institutions and contain little of technical value. For the iconography of the arts and trades, the prototype is the well-known work of Jost Amman, which had many followers. The class of works he inaugurated degenerated into a form of chap-book literature in the early 19th century.

Finally, although this survey extends to the year 1640, I have deliberately abstained from dealing with writers on the subject of water-raising which, though they fall within my period, will be best treated by my successor in dealing with the forerunners of the steam engine.

In conclusion, I trust that this brief and imperfect survey has shown to students of historical engineering the need for research outside the narrow limits of technological literature. The field of historical engineering is as wide as that of history itself. All the auxiliary historical sciences must be pressed into your service. The study of coins, seals, heraldry, genealogy, inscriptions, the records of national and municipal administration—nay, even of literature itself may be necessary to complete the missing links in the chain of your historical investigations. For instance, the current number of the *Journal of Philology* contains under the form of a disquisition on the Latin word "*arcus*," a valuable contribution to the history of the drill and the origin of the lathe.

I hope, therefore, that this Society will collect and publish periodically references to the current literature of the subjects germane to it, with a view of widening the interests of its members and of enhancing the utility of the papers contributed to it. For bibliography is the corrective of old age. The constant supply of new ideas, gathered from all quarters, will prove the greatest incentive to new efforts on the part of our members and will tend to preserve the Society from premature decay.

Attention was directed by the author to the books that were there for inspection by the members; the books were some of those noted in the Appendix and had been drawn from the Patent Office Library for the occasion.

In the discussion that ensued, Sir George Greenhill, Mr. Jenkins, Mr. Pendred, Mr. Reid, Eng.-Comm. Robertson, Mr. Sieveking and Mr. W. A. Young took part.

The meeting terminated with a vote of thanks to the Comptroller for the use of the Court Room.

Appendix.

Primitive Industries and Prehistoric Archaeology.

- Mason** (Otis T.)
The origins of inventions: a study of industry amongst primitive peoples.
W. Scott, 1895. F'cap. 8vo.
- Abbott** (Charles C.)
Primitive industry . . . of the Northern Atlantic Seaboard of America.
Boston, 1881. 8vo.

British Museum Guides

- Stone Age.
Bronze Age. 1920.
Early Iron Age. 1905.

Early Civilizations.

- Description de l'Egypte**
Paris, 1809-28. 10 vols., text, and 12 vols., atlas.

British Museum Guides

- Egyptian Collections, 1909.

[Minoan Civilization]

- Papers by Sir Arthur Evans and others.
In Annual of the British School at Athens. Vols. VI. to XII., 1899-1906.
Vol. VIII., pp. 13 and 82-7, deals with the drainage system of the "Palace of the Two Axes" at Knossos.

Breasted (James H.)

- (1) Ancient Times, a history of the early world.
Ginn & Co., 1916.

- (2) Origins of Civilisation.
In Scientific Monthly, Dec., 1919, to March, 1920. 134 figs.

Wells (H. G.)

- Outlines of History. Illustrated edition.
Newnes, 1920. 2 vols.

Classical Civilization & Scholarship.

Veteres Mathematici

- i.e., the collected works of Athenaeus, Apollodorus, Bito, Hero, Philo and others in Greek and Latin.
Paris, 1693. Fol. illus.

Heath (Sir Thomas)

- Works of the Greek Mathematicians.
Cambridge, 1920. 2 vols.

Aristotle.

- Oxford translation. Vol. VI. [includes the "Mechanics"].
Oxford, 1913. 8vo.

- Aristotle's researches in natural science.
By T. E. Lones.

West, Newman, 1912. 8vo.

Hero of Alexandria, Pupil of Ctesibius

- Opera. Ed. Gul. Schmidt.
Leipzig, 1899, etc. *In progress.*

His Pneumatics, Automata and Mechanics are published.

Vitruvius

- Zehn Bücher über Architektur. Uebersetzt und erläutert von J. Prestel.
Strassburg, 1912, etc. *In progress.*
N.B.—For plates see French edition of Perrault, or the editions of Newton (1791) or Wilkins (1812).

Blümner (Hugo)

- Technologie und Terminologie der Gewerbe und Künste bei Griechen und Römern. 2te Aufl.
Leipzig, 1912. 4 vols., 8vo.
The standard work on the subject.

British Museum

- Greek and Roman Life. Guide to the exhibition. 2nd ed.
London, 1920. 8vo.

Leger (Alfred)

- Les travaux publics, les mines et la métallurgie aux temps des Romains.
Paris, 1875. Imp. 8vo, 12 folding plates.

Merckel (Curt)

- Die Ingenieurtechnik im Alterthum.
Berlin, 1899. Imp. 8vo.

Diels (Hermann)

- Antike Technik. Sechs Vorträge.
Teubner, 1914. F'cap. 8vo.
Deals with locks, steam engine, automata, alchemy, etc.

Zimmer (Geo. Fred.)

- Engineering of antiquity.
Frobsthain, 1913. Sm. 8vo.
Deals with the history of iron, conveyors, etc.

Middle Ages to 1400 A.D.

Honecourt (Wilars de) Architect, 13th Century

- Sketchbook. Ed. R. Willis.
London, 1859. Sm. 4to.

Parmentier (A.)
Album Historique. (Reproductions of
mediaeval drawings arranged in
periods.)
Paris, 1897-1905. 3 vols., 4to.

Saizmann (L. F.)
English industries of the Middle Ages.
London, 1913. 8vo.
Compiled from the national Records;
mostly new material.

Feldhaus (F. M.)
Technik der Vorzeit.
Leipzig, 1914. Large 8vo.
A dictionary of inventions, etc., from
the Stone Age.

Chevalier (Ulysse)
Répertoire des sources historiques du
Moyen Age. Bio- [and] Topo-biblio-
graphie.
Paris, etc., 1903-9. 4 vols., large 8vo.

Turner (Hudson)
Some account of domestic architecture
in England from the Conquest—Henry
VII.
Oxford, 1851-9. 3 vols. in 4.

Addy (S. O.)
The evolution of the English House.
Sonnenschein. Sm. 8vo.
Has gone through many editions.

Innocent (C. F.)
The development of English Building
Construction.
Cambridge, 1916. 8vo.

1400-1640. Engineers' Sketchbooks.

Vinci (Leonardo da)
Il Codice Atlantico.
Milan, 1884-1904. 3 vols., folio.
There is an extensive and growing
literature on Da Vinci, for which con-
sult the catalogues of the British
Museum and Patent Office Libraries.

Deutscher Verein für Kunstwissenschaft
(Berlin)
Mittelalterliches Hausbuch.
Leipzig, 1912. 4to.

Compiled about 1480. A book of
receipts with drawings in the style of
Durer. At the end are some valuable
designs of machinery for raising
weights, working bellows, etc.

Besson (Jac.)
Theatrum Instrumentorum et Machin-
arum.
Re-issued with explanatory text in
1578.

Ramelli (Ag.)
Le diverse et artificiose Machine del
capitano Ag. Ramelli.
Paris, 1588. Folio.

Veranzio (F.)
Machinae novæ.
c. 1590. Folio.

Zonca (V.)
Novo Teatro di Machine ed Edifici.
1607 [reprinted 1621 and 1656]. Folio.

Zeising (H.)
Theatrum Machinarum.
Leipzig, 1621. Folio.

Strada (J.)
Dessins artificiaux.
1617-18. 2 vols. 8vo.

Beck (Th.)
Beitraege zur Geschichte des Maschinen-
baues.
Berlin, 1900. 8vo.
Summarizes the work of the above
writers.

1400-1640. Military Sciences— Fortification and Gunnery.

Berthelot (Marcellin)
Pour l'histoire des arts mécaniques et
de l'artillerie vers la fin du moyen age
(Reproduction of Munich MSS.), c.
1430.

In *Annales de Chimie*, etc., 6 Sér.,
Tome 24, 1891, pp. 433-521, illus.

Valturius (R.)
De re militari. (15th Cent. illuminated
MS. in British Museum Library, prin-
ted in 1472 and often re-issued.)
Paris, 1534. Folio.

Cockle (Maurice J. D.)
Bibliography of English military books
up to 1642 and of contemporary for-
eign works.
London, 1900. 4to. xlii., 268 pp.,
portrs., facs.

The English works are arranged
chronologically; the foreign ones in
class order. The preface is of great
value.

Guttmann (Oscar)
Monumenta Pulveris Pyrii.
London, 1906. 4to.
Illustrated history of the develop-
ment of gunpowder and ordnance.

Mechanics.

Del Monte (Guido Ubaldo)
Mechanicorum liber.
Pisa, 1577. Folio.
Transl. into Italian in 1581.

Branca (Giovanni)
Le Macchine.
Rome [1629]. Sm. 4to.

Mine Engineering and Metallurgy.

Biringuccio (V.)
Pirotecnia (i.e., Metallurgy and allied in-
dustries, e.g., wire-drawing, ordnance,
etc.).
Venice, 1540. Sm. 4to.
Re-issued several times and transl.
into French.

Agricola (G.)
De Re Metallica. Translated and edited
by H. C. and L. H. Hoover.
London, 1912. Folio.
Original published at Basle in 1556.

Eroker (L.)
Beschreibung allerfürnemsten Mineralien, etc.
Prag, 1574. Folio.

Water Raising, including the precursors of the Steam Engine.

Ceredi (G.)
Tre discorsi sopra il modo di alzar acque da' luoghi bassi.
Parma, 1567. Sm. 4to.

Porta (G. B.)
Le tre libri de' spiritali.
Naples, 1606. Sm. 4to.

Caus (Salomon de)
Raisons des forces mouvantes.
Frankfort, 1615. Fol.

Land Irrigation.

Vaughan (Roland)
His book [on water meadows].
1610. Reprinted 1897.

Surveying and Mathematical Instruments.

Kobel (J.)
Jacob's Stab.
Frankfort, 1531. Sm. 4to.

Warachtige Const der Geometryen, etc.
Antwerp, 1547. Sm. 4to.

Fullene (A.)
Holometro [geometric square].
Venice, 1563. Sm. 4to.

Bartoli (C.)
Del mode di misurare, etc.
Venice, 1564. 4to.

Belli (S.)
Libro del misurar con la vista, etc.
Venice, 1570. Sm. 4to.

Cataneo (G.)
Opera del misurare.
Brescia, 1572. 2 vols. Sm. 4to.

Lupicini (A.)
Discorso sopra la fabrica e uso delle nuove verghe astronomiche [surveyor's square].
Florence, 1582. Sm. 4to.

Orsini (L.)
Trattato del radio latino, etc.
Rome, 1583. 4to.

Digges (Leonard)
Pantometria.
London, 1592. Sm. 4to.

Pifferi (F.)
Monicometro, etc.
Siena, 1595. 4to.

Romano (B.)
Proteo militare [surveying instrument].
Naples, 1595. Sm. 4to.

Danfrie (P.)
Déclaration de l'usage du graphomètre.
Paris, 1597. 8vo. Printed in script type.

Fabri (O.)
L'uso del la squadra mobile, etc.
Venice, 1598. Sm. 4to.

Suberville (H. de)
L' Henry-mètre.
Paris, 1598. 4to.

Zubler (L.)
Fabrica et usus instrumenti chorographici [plane table].
Basle, 1607. Sm. 4to.

Faulhaber (J.)
Neuerfundner Gebrauch eines Niderlandischen Instruments zum abmessen, etc.
Augsburg, 1610. Sm. 4to.

Hopton (A.)
Baculum geodeticum.
London, 1610. Sm. 4to.

Hulsius (L.)
Instrumenta mechanica [Planimetrum; Baculum; Circinus proportionalis].
Frankfort, 1605. 3 vols. Sm. 4to.

Flamand (C.)
La pratique et usage d'arpenter, etc.
Montbéliart [1611]. 8vo.

Hopton (A.)
Speculum topographicum.
London, 1611. Sm. 4to.

Bramer (B.)
Kurtzer Bericht eines Schreg-oder Winkel-Instruments [cross staff protractor].
Marburg, 1615. Sm. 4to.

Bramer (B.)
Beschreibung . . . eines neuen . . . Instruments zum Grundlegung und Theylung der Circle-Linien.
Marburg, 1616. Sm. 4to.

Rathborne (A.)
The Surveyor.
London, 1616. Fol.

Oddi (M.)
Dello Squadro.
Milan, 1625. Sm. 4to.

Faulhaber (J.)
Mathematischer Kunst-Spiegel [Perspective drawing instrument, etc.].
Ulm, 1626. Sm. 4to.

Arduser (J.)
Geometrica, etc. [on surveying].
Zurich, 1627. Sm. 4to.

Malombra (G.)
Practica . . . di misurare con la vista.
Florence, 1630. Sm. 4to.

Gunter (E.)
The description and use of the sector, crosse-staffe, etc.
London, 1636. Sm. 4to.

Roads.

Procter (T.)

Concerning the mending of all Highways, as also for Waters and Ironworkes [second edition].
London, 1610. Sm. 4to.

Miscellaneous Inventions—English.

Bourne (William)

Inventions or Devises.

London [1578]. Sm. 4to.

Contains anticipations of the submarine boat and telescope.

Lucar (C.)

A treatise named Lucarsolace [Miscellaneous inventions, surveying, etc.].
London, 1590. 4to.

Harington (Sir John)

The Metamorphosis of Ajax [water-closet system].
1596. Reprinted at the Chiswick Press, 1814. 8vo.

Platt (H.)

The Jewell House of Art and Nature.
London, 1594. Sm. 4to.

Bate. (J.)

Mysteries of Nature and Art.
London, 1634. Sm. 4to.
Reprinted in 1635 and 1654. Valuable for its section on pumps.

Histories of Inventions and Books of Receipts.

Ferguson (John)

Bibliographical notes on the histories of Inventions and Books of Secrets.

Glasgow, 1882-1916. Sm. 4to.

In Trans. Glasgow Archæol. Soc., with a parallel series in the Glasgow Lit. and Phil. Soc.

Illustrations of the Arts and Trades.

Schopperus (H.)

Omnibus illiberalibus sive mechanicis artibus, etc.

Frankfort, 1599. 8vo.

The engravings are by Jost Amman.

English Social & Industrial History.

Victoria County Histories (Constable)

The Section "Industries" has been issued in separate form for the counties of Bedford, Berks, Bucks, Hants, Herts, Surrey.

These are essential for English industrial history as they contain much new matter.

Traill (H. D.) and Mann (J. S.)

Social England.

Cassell. 6 vols. 8vo.

Green (J. R.)

Short History of the English People.
Illustrated edition.

Macmillan, 1892. 4 vols.