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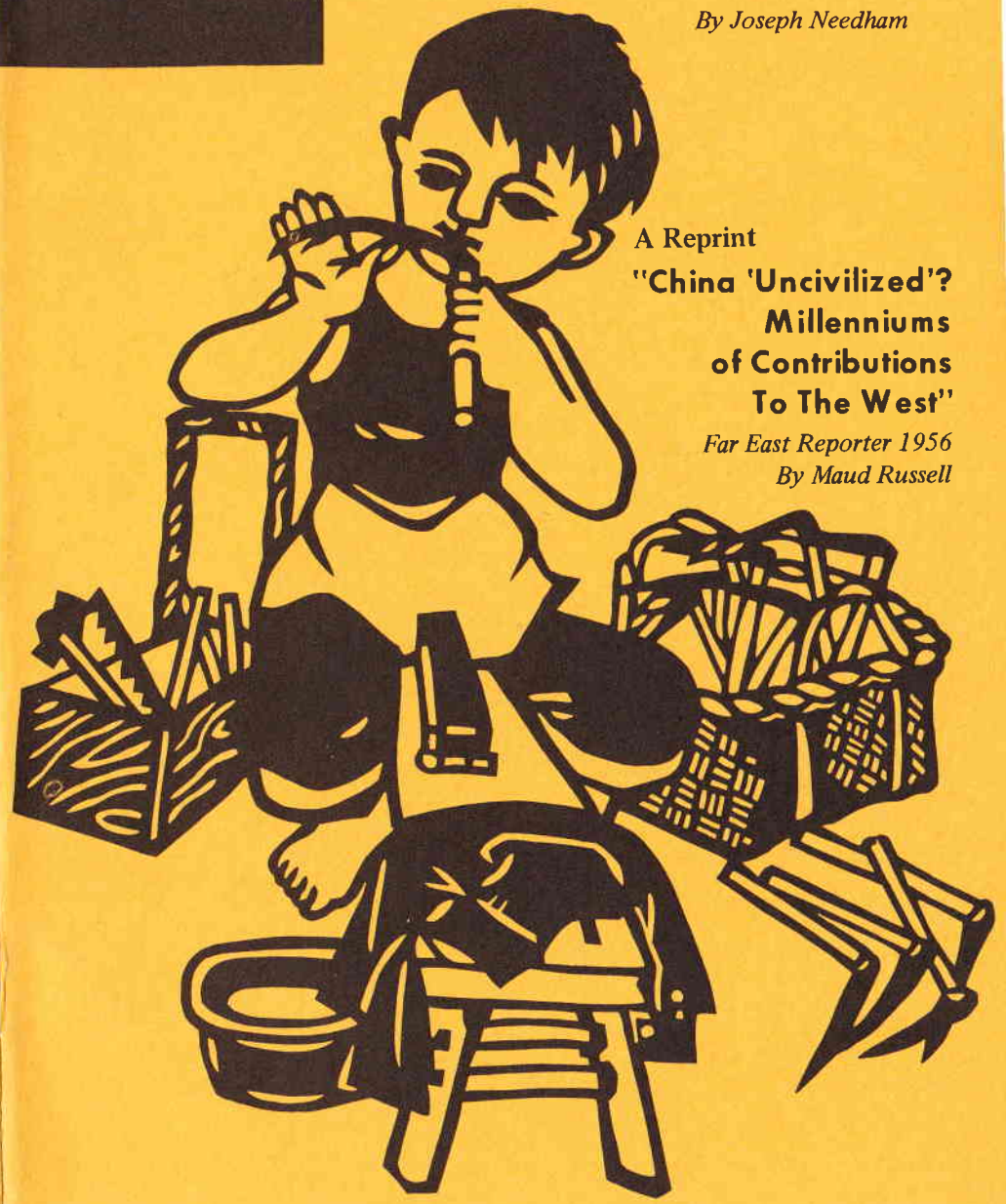
"The Grand Titration - Science and Society in East and West"

By Joseph Needham



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Far East Reporter 1956

By Maud Russell

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CHINA'S CENTURIES OF CONTRIBUTIONS TO WORLD SCIENCE AND TECHNOLOGY

In this issue FAR EAST REPORTER brings to the attention of its readers the long role of China as a contributor to world civilization. Here is a people who were civilized and strong long before the Christian era and who today are in the forefront of modern civilization, still strong and creative.

The first part of this issue is a review of Dr Joseph Needham's "THE GRAND TITRATION: SCIENCE AND SOCIETY IN EAST AND WEST". The title of the book will cause many to look in their dictionaries. Dr Needham writes, "1864 saw the first use of the word"(titration) "derived undoubtedly from the French 'titre', an assayist's term used much earlier for the degree of purity of gold in alloys." (page 12)

But let no one be held off from reading this excitingly informative book by its difficult title. (Dr Needham, in all his writings, seems always to have a side-interest in educating his readers by his use of rich but unfamiliar words!). He clarifies the meaning of the word: "We are always trying to fix dates.....In such a way one can 'titrate' the great civilizations, against one another, to find out and give credit where credit is due; and so also, it seems, one must analyze the various constituents, social or intellectual, of the great civilizations, to see why one combination could far excel in medieval times while another could catch up later on and bring modern science itself into existence. ....Hence the title of this book of papers, lectures and essays", from 1951 to 1966. (page 12)

Also included in this issue is a reprint of a 1956 issue of FAR EAST REPORTER: "China 'Uncivilized'?-Millenniums of Achievement and Contribution to the West" by Maud Russell.

THE GRAND TITRATION
SCIENCE AND SOCIETY IN EAST AND WEST

By

Joseph Needham

A Review

Dr Needham's presentation focuses on two questions: 1) "Why did modern science take its meteoric rise only in the West at the time of Galileo?" and 2)"Why was it that between the second century B C and the sixteenth A D East Asian culture was much more efficient than the European in applying human knowledge of Nature to useful purposes"?

FAR EAST REPORTER quotes some of the exciting and revealing facts Dr Needham gives about Chinese discoveries, inventions and techniques- fascinating facts about China's contributions to the flow of science and technology that eventuated in modern science.

Some Quotes About Chinese Discoveries, Inventions And Techniques

Writes Dr Needham, "There is nothing in China which corresponds to the period of the Dark Ages in Europe". (page 18) Indeed, as one reads these essays in "The Grand Titration", what was going on in China in the millenniums preceding the modern age seems, by contrast, like one long age of enlightenment - in thinking, in social patterns, in technology and in science ("ancient" as it must be called as compared with modern science).

"Modern science has indeed created a universal and international culture, that of the airman, the engineer and the biologist, but although modern science originated in Europe, and in Europe only, it was built upon a foundation of medieval science and technology much of which was non-European...The 'testator'" (the one who gave this legacy) "is a civilization with a longer continuous living tradition than any other, with the possible exception of Israel, and one which is in no danger of

decay". (page 56) "In fact, Chinese civilization has never been living more vigorously than it is today". (page 55) "The 'legatee' is the international world of which every country now inevitably forms a part.....The metaphor of inheritance is unsatisfactory....One would rather prefer the image of the great rivers of past science and technology flowing into the ocean of modern natural knowledge, so that all peoples have been testators and all are now inheritors..." (Page 56)

"What the Chinese did do was to classify natural phenomena, to develop scientific instruments of great refinement for their respective ages, to observe and record with a persistence hardly paralleled elsewhere; and if they failed (like all medieval men, including Europeans) to apply hypotheses of modern type, they experimented century after century obtaining results which they could repeat at will. When one recites this list of the forms of scientific activity it becomes difficult to see how any one could deny them their status as essential components of fully developed world science, biological and chemical as well as astrononomical and physical".(Page 56)

"It would be fairer to admit that throughout the first fifteen centuries of our era Chinese instrument making was generally ahead, and (as in such instances as the seismograph and the mechanical clock) often much ahead, of anything that Europe could show". (Page 47)

"In technological influences before and during the Renaissance China occupies a quite dominating position. In the body of this contribution we shall mention among other things the efficient equine harness, the technology of iron and steel, the invention of gunpowder and paper, the mechanical clock, and basic engineering devices such as the driving-belt, the chain-drive, and the standard method of converting rotary to rectilinear motion, together with segmental arch bridges and nautical techniques such as the stern-post rudder". (Page 58)

"The introduction of the water-powered metallurgical blowing-engine is attributed to Tu Shih who was Prefect of Nanyang in A D 31....Tshai Lun was made Director of the Imperial Workshops in A D 97 and announced the invention of paper in A D 105". (Pages 26-27)

"Observation, accurate and untiring, is one of the foundation stones of science. What records from an antique culture are of vital interest to radio-astronomers today? Nothing from Greece, only the nova, comet and meteor lists of China's star-clerks. They it was who first established (by the seventh century A D at least) the constant rule that the tails of comets point away from the sun. Renaissance astronomers who quarrelled so much among themselves about the priority of the study of sun-spots might have been somewhat abashed if they had known that these had been observed since the first century B C in China, and not only observed but recorded in documents reliably handed down".(Pages 47 and 48)

"There are three ways of measuring the position of any star in the heavens, and modern astronomy uses not the ecliptic coordinates of the Greeks, nor the alta-zimuth measurements of the Arabs, but the equatorial system of the Chinese". (Page 77)

"Of the dial-and-pointer readings which make up so much of modern science, a search throughout the medieval world between the eighth and fourteenth centuries A D would reveal instruments capable of giving them only in China - I refer to the needles of the magnetic compasses used first by geomancers, then (at least a century before Europe) by the sea-captains. For it is a remarkable fact that the Chinese were worrying about the cause of magnetic declination for a considerable time before Europeans knew even of magnetic directivity". (Pages 48 and 49)

"The early study of magnetism was purely Chinese, a point of immense importance. If we go into any place today where nature is under accurate observation or control - into the atomic power-station, the engine-room of an ocean liner, or any scientific laboratory - the walls are covered with dials and pointers, and people are making dial-and-pointer readings. But the first of all dial-and-pointer devices was the magnetic compass, and in the development of this Europe had no part". (Page 71)

"The Chinese were also very early in the field with advanced survey methods and the making of relief maps. ....In the geological sciences and in meteorology the same pattern presents itself". (Page 18)

"Mechanical engineering and indeed engineering in general was a field in which classical Chinese culture scored special triumphs....also water power was first used for industry about the same time as in the West (first century A D); not however so much for grinding cereals as for the operation of metallurgical bellows. The development of iron and steel technology in China constitutes a veritable epic, with the mastery of iron-casting some fifteen centuries before its achievement in Europe...Civil engineering also shows extraordinary achievements, notably iron-chain suspension bridges and the first of all segmental arch structures".(Page 18)

"In martial technology the Chinese also showed notable inventiveness. The first appearance of gun-powder occurs among them in the ninth century A D and from A D 1000 onwards there was a vigorous development of explosive weapons some three centuries before they appeared in Europe. Probably the key invention was that of the fire-lance at the beginning of the twelfth century A D in which a rocket composition enclosed in a bamboo tube was used as a close-combat weapon. From this derived, I have little doubt, all subsequent barrel guns and cannon of whatever material constructed. Other aspects of technology also have their importance ...silk...the driving-belt and the chain-drive...paper, block-printing and movable type printing...porcelain". (Pages 18 and 20)

Dr Needham quotes Francis Bacon: "Printing, gun-powder and the magnet...these three have changed the whole face and state of things throughout the world, the first in literature, the second in warfare, and the third in navigation, whence have followed innumerable changes; in so much that no empire, no sect, no star, seem to have exerted greater power and influence in human affairs than these mechanical discoveries", from the Novum Organum. (Page 62)

The Chinese achieved "the recognition of the hex-

agonal system of snowflake crystals many centuries before this was noticed in the West". (Page 22)

"Decimal place-value and a blank space for the zero had begun in the land of the Yellow River earlier than anywhere else, and decimal metrology had gone along with it. By the first century B C Chinese artisans were checking their work with calipers decimally graduated. Chinese mathematical thought was always profoundly algebraic, not geometrical, and in the Sung and the Yuan (12th to 14th centuries A D) the Chinese school led the world in the solution of equations, so that the triangle called by Pascal's name was already old in China in 1300 A D...The system of linked and pivoted rings which we know as the Cardan suspension was commonly used in China a thousand years before Cardan's time". (Pages 16 and 17)

"The Chinese were in fact the first, as early as the fourteenth century B C to be able to express any desired number, however large, with no more than nine signs....Very accurate values of π were computed. The Han mathematicians anticipated Horner's methods for obtaining the roots of higher powers. The triangle of binomial coefficients was already considered old by AD 1303...The influence of Asian ways of computation on European mathematicians of the later Middle Ages and the Renaissance is well established. And when the transmissions are examined the balance shows that between 250 B C and 1250 A D.. a great deal more mathematical influence came out of that culture than went in". (Pages 44 and 45)

"Chinese society in the Middle Ages was able to mount much greater expeditions and pieces of organized scientific field work than was the case in any other medieval society. A good example of this would be the meridian arc surveyed in the early eighth century A D. ...This geodetic survey covered a line no less than 2500 kilometers long reaching from Indo-China to the borders of Mongolia. About the same time an expedition was sent down to the East Indies for the purpose of surveying the constellations of the Southern Hemisphere within 20 degrees of the south celestial pole. It is doubtful whether any other state in the world at

that time could have engaged successfully in such activities". (Pages 32 and 33)

"Chinese technical skill tended to wander far and wide; there were Chinese metallurgists and well-diggers in second century A D Parthia and Ferghana; while eighth century A D Samarkand knew Chinese weavers and paper-makers. People were always asking for Chinese technicians...As late as A D 1675 a Russian diplomatic mission officially requested that Chinese bridge-builders should be sent to Russia". (Page 25)

"Very careful experimentation was practised in classical Chinese culture. For example, the discovery of magnetic declination would not have occurred unless the geomancers had been attending most carefully to the positions of their needles; and the triumphs of the ceramics industry could never have been achieved without fairly accurate temperature measurement and the means of repitition at will of oxidizing or reducing conditions within the kilns". (Page 23)

"As for astronomy, I need only say that the Chinese were the most persistent and accurate observers of celestial phenomena anywhere before the Renaissance.....A brilliant development of astronomical instruments also occurred, including the invention of the equatorial mounting and the clock-drive...Their skill affected also other sciences, such as seismology, for it was a Chinese man of science, Chang Heng, who built the first practical seismograph about A D 130. Three branches of physics were particularly well developed in ancient and medieval China - optics, acoustics and magnetics.. In the West magnetic phenomenon were almost unknown". (Page 17)

"There was no backwardness in the biological fields either....including the earliest known use of biological control of insect pests. They were also the greatest pioneers in the techniques of inoculation". (Page 20). "Perhaps the most outstanding Chinese discovery related to post-Renaissance modern science was that of the first successful immunization technique.

Variolation, the forerunner of Jennerian vaccination, had been in use in China since the beginning of the sixteenth century...The origins of the whole science of immunology lie in a practice based on medieval Chinese medical thought". (Pages 58 and 59) "Let us remember the brilliant empirical discovery of deficiency diseases clearly stated by the physician Hu Ssu-Hui in the fourteenth century A D". (Page 48)

The use the Chinese made of their great practical inventiveness contrasts sharply with the fear-of-unemployment attitude toward new inventions in modern capitalist society. "We have never so far come across any important instance of the refusal of an invention in Chinese society due to fear of technological unemployment". (Page 206) "Chinese labour conditions were no bar to a long series of 'labour-saving' inventions. Whether one thinks of the efficient trace-harness for horses (from the fourth century B C onwards) or of the appearance of the still better collar-harness of the fifth century A D, or of the simple wheelbarrow of the third century A D (though not in Europe till a thousand years later), one constantly finds that in spite of the seemingly inexhautible massses of man-power in China, lugging and hauling was avoided wherever possible. How striking it is that in all Chinese history there is no parallel for the slave-manned oared war galley of the Mediterranean...When the water-mill appeared in the first century A D for blowing matallurgical bellows, the records concerning Tu Shih distinctly say that he considered it important as being both more humane and cheaper than man-power or animal-power.....All this is in considerable contrast to the position in Europe where we do know of classical examples of refusal of innovation for fear of technological unemployment". (Pages 33 and 34)

****

Dr Joseph Needham, F R S, Master of Caius College, Cambridge is foremost among historians. He has been studying the history of Chinese science for more than thirty years. His "Science and Civilization in China" (seven volumnes in twelve parts) is a monument to his knowledge and his humanism.

THE GRAND TITRATION
SCIENCE AND SOCIETY IN EAST AND WEST
By
JOSEPH NEEDHAM

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The book may be ordered through
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TRADE ROUTES BETWEEN CHINA AND THE WEST
(From Joseph Needham, "Science and Civilization in China," Vol. I, p. 171)

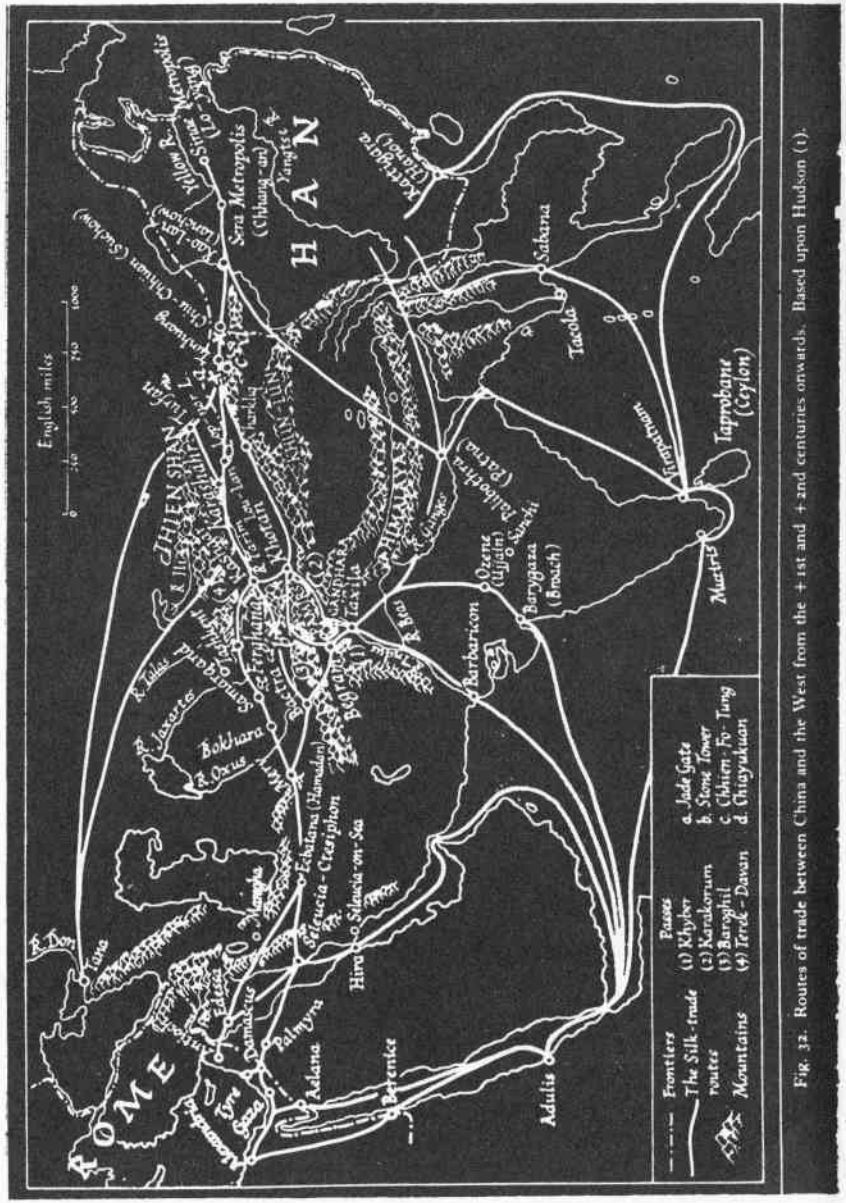

Fig. 32. Routes of trade between China and the West from the 1st and 2nd centuries onwards. Based upon Hudson (1).

A Reprint (Revised)
Of a 1956 issue of Far East Reporter

CHINA "UNCIVILIZED"? MILLENNIUMS OF ACHIEVEMENT AND CONTRIBUTION TO THE WEST

By
Maud Russell

Introduction

Certain American political leaders, pontifficating on foreign policy, and some teachers purporting to teach their students about China, seem to delight in presenting the Chinese as "uncivilized" or even as "barbaric". Their ignorance, feigned or otherwise, if unchecked by correct knowledge of historical facts can contribute to a serious undervaluation of that great sector of mankind which is China. One quarter of the human race resides in China.

The Chinese people are no new-comers on the world scene. The Chinese not only constitute the world's longest continuous civilization - having a history recorded in writing for over 3500 years - but this great people have been for well over 2000 years one of the most voluminous contributors to the technical, economic, cultural and political thought and activities of the West. Indeed, our Western civilization is in deep debt as the recipient of the practical and theoretical achievements of the Chinese people.

The following brief presentation is intended to be suggestive of the immense body of China's historical relations with and contribution to the world. Volumes of scholarly work document, enlarge upon and add to the information here presented. Every fact mentioned herein is documented in one or more of the following works:

Joseph Needham
"Science & Civilization in China" Vol I
Cambridge University Press 1954
"Science Outpost"
Pilot Press, Ltd London 1948

Locke and Stern
"When Peoples Meet"
Progressive Education Ass'n New York 1953
Rudolf Hommel
"China At Work"
John Day Co 1937

China Has Long Been In Contact With The West

"The process of exchange between Europe and China" Locke and Stern tell us "passed through elaborate relays of interconnecting civilizations. These relays of culture were world movements in their day, much more impressive on their cultural and economic sides than in their military exploits and political combinations. Throughout the rise and fall of dynasties and military leaders, these constructive processes went on, extending in geographical scope from farthest China to beyond Italy on both shores of the Mediterranean. The time span too is impressive for it runs at least back to the 4th millennium B C. Chinese civilization during much of that long period was flourishing and richly creative, and furnished Europe not only with basic materials, but time and again with technological skills, scientific inventions and occasionally even with institutional ideals and modes." At the time of the Tang Dynasty (618-907 AD) China was considered the most civilized country in the world.

Some Inventions That Appeared Historically First In China

The Chinese preceded the Greeks in many important scientific and technical discoveries; they kept pace with the Arabs who had access to all the treasures of the ancient Western world; they maintained between the third and thirteenth centuries a level of scientific knowledge unapproached in the West. The weakness of China in theory and geometrical systemization "did not prevent the emergence of technological discoveries and inventions often far in advance of contemporary Europe especially up to the 15th century", says Needham. And he points out that these technological inventions poured into Europe in a continuous strean during the first 13 centuries of the Christian era.

Some of the basic, every-day things that have come to us in the West from China are rice, tea, porcelain, silk, the umbrella, eye-glasses, the printing press, the mariner's compass, paper, paper money, the finger print system of identification, water-tight compartments in ships, kites, etc.

Paper and Printing

Paper was invented in the first century A D by Tsai Lun, but it was at least six hundred years before it passed to the West. And in China colored paper began to be used in the seventh century.

Printing had begun in China at least by the eighth century. The earliest block printing known is that of a Buddhist charm of 770. The Chinese had long used ink and paper and they knew how to make seals of metals, stone and clay; the time was ripe for such an invention as printing. Text books were needed by the thousands for the civil service system, and charms for warding off evil spirits and diseases were desired by the Buddhists and Taoists. In the tenth century Confucian classics were printed from wooden blocks in 130 volumes and were widely distributed throughout the Country. By the end of the century Taoist books had become fairly common in the far western province of Szechuan.

China gets the credit for inventing gunpowder. "Cracking and exploding staves", say the chroniclers, were used in the Wei Dynasty (220-265 AD) and fire-works were used in the Sui Dynasty (605-617 AD). Their use for war is not proven, though experiments along those lines were carried out. In 1161 "thunderbolt projectives" were made of paper filled with lime and sulphur were used in battle; when they touched the water the fire leapt from them and the dense fumes that arouse confused the enemy. And there were "fire-stones" thrown a considerable distance by a "fire-drug" made of nitre, sulphur and willow charcoal. Arab traders brought the secret of this combination to the West and it was adopted for warfare.

Iron Refinement and Bridges

The appearance of iron among the Chinese about 600 BC was indeed the last appearance of iron among any of the great cultures of the world - but the Chinese rapidly surpassed all other parts of the world in iron technology. Pliny represents the Chinese as sending to Rome the most highly prized kind of iron. There was a highly skilled iron industry in North China in Han (202 BC-220 AD) times - "fine cast iron, otherwise unknown to the ancients" (Locke and Stern). China's achieving the mastery of cast iron may well have been due to the nature of the ores employed, permitting fusion at temperatures lower than those possible elsewhere.

The first great segemental bridge was constructed by Li Chun in China shortly after 600 AD, but no such structure was built elsewhere until Italy followed with several of the kind shortly after 1300. The first suspension bridges with iron chains were constructed in China at least as early as the sixth century AD; yet though they had many successors in that part of the world, especially among the Tibetans and other Himalayan peoples, the principle was not suggested in Europe until the end of the 16th century; and the first such bridge was not built there until the end of the eighteenth century.

The Sowing Plow, Brick Making, Well Boring, Metal Coinage

Chinese records of the Han time relate that the prefect of the Tun Huang District taught the people to make a sowing plow which saved half their labor. In Europe the earliest mention is in the 16th century.

In China the art of brick making and the utilization of bricks seems to go back as far as the Hsia Dynasty (22nd-18th century BC). A Chinese account of that period says that brick enclosures were built over coffins; by the Han times the art was fully developed.

Needham tells us that "the art of drilling wells or bore-holes, such as are used today for exploiting fields

of petroleum is specifically Chinese, for we have much evidence of it going back to the Han period. Furthermore, the method used for so long was essentially the same as that employed in California and Pennsylvania before the application of steam power. No trace of the radiation of the technique into other cultures appears for a millennium."(The Grand Titration-pages 106-107)

The classical statement is that the making of small pieces of precious or standard metal with specific dies or with designs produced in casting first developed in Lydia in the 7th century BC. It appears, however, that the earliest coined money in China goes back almost to the Shang period.(1530-1030 BC)

Silk, Porcelain, The Mariner's Compass, Navigation

Chinese embassies made presents of Chinese silk to the Parthians in the first century, and it was they who introduced silk into Western Asia (though caravans from China to Iran date from 106 BC) and it was then that the trans-Asian silk trade was regularized. The event whereby the Roman Empire and thus ultimately Europe as a whole was rendered independent of China for a supply of raw silk took place in 552: someone guilefully smuggled silk moth-eggs in a hollow stick from Kashgaria. Domestication of the silk worm and the development of the silk industry had taken place at least as early as the Shang period, in the 14th century BC.

True porcelain was not only made as early as the Tang Dynasty (618-907 AD) but had already become articles of overseas trade by that time. Proto-porcelain which is pottery with elements of porcelain had been made in Han times, just before the dawn of the Christian era. It was the 18th century before Europe was producing true porcelain.

Still extant writings (of Han Fei who died in 238 BC) tell of a "south pointer" which fixed the position of morning and evening; legend in China even puts the use of a guiding "south pointing contrivance" as far back as the 12th century BC. The eastern deviation of the magnetic needle was already noted by a writer, Shen Kua, about 1068. The first mention in Europe of the

deviation of the needle (by Pierre de Maricourt) in 1269 comes therefore two centuries later than the Chinese record.

The gimbels of the navigator (rings for suspending his compass so as to keep it always horizontal) and the mounting of the gyroscope of the automatic navigator go back, not to the charcoal stoves which warmed the hands of medieval prelates in chilly cathedrals, but to the self-righting perfume burners with which a 2nd century AD Chinese mechanic furnished the beds of princes and officials, Dr Needham assures us.

The Automatic Clock Drive and The Mechanical Clock

It was not in 19th century Europe but in second century AD China that the automatic clock-drive of the astronomical telescope first appears; its equatorial mounting was made in Mongol Khanbaliq, not in the workshops of Uraniborg or Vienna. Fraunhofer invented his clock drive in 1824 and he certainly did not know that the Chinese had for many centures caused their equatorial armillary sphere to rotate by water power. But Dr Needham tells us that "One of the finest Chinese instruments was the armillary sphere of Su Sung, set up in 1088..This was the first observational instrument in astronomical history to be provided with a clock-drive." (The Grand Titration page 78)

It was China, not Europe, that was responsible for the development of the mechanical clock. "Indeed", writes Dr Needham, "the mechanical clocks of China built between A D 700 and 1300 have revealed at last the missing link between the very ancient water-receiving and water-giving vessels (clepsydras) of Babylonia and ancient Egypt and the purely mechanical clocks and watches of later ages". (The Grand Titration, page 81)

Eatables and Household Things

Our potato, with its claim of American ancestry was known and eaten by the people of China in the Liang Dynasty (907-923). Sugar was already mentioned in records dating back to the 2nd century BC. The Book of History (24th-8th century BC) mentions a fermented bev-

erage of millet or rice; the straining of liquor from lees is mentioned in the Book of Odes (23rd-6th century BC). The first reference to coal in China was made about 100 BC called "ice charcoal", and was probably discovered about the same time in Europe, though Marco Polo (13th century AD) noticed its use in China and described it in such a manner that it seems it was utterly unknown to him or his contemporaries. The Chinese had perfectly developed cooking stoves by the time of the Han Dynasty and were also acquainted with the principle of the chimney. And it was the Chinese who introduced the washboard to the United States.

Chemistry Botany Zoology Horticulture

A line developed in China which led to great improvement in agriculture and kindred sciences was that of chemistry. The origin of chemistry is alchemy.The earliest alchemy is to be found in China - at least 400 years before there are evidences of it in the West; in Greece and Egypt it is not known until about the 2nd century AD. There was reference to alchemy in China in the 2nd century BC and the earliest book on alchemy in any language is that of Wei Po-yang in 142 AD. This pre-science was developed by the Taoists; searching for immortality by means of drugs and gold, they developed chemical technology and the ways of handling materials, and so were the fathers of modern chemistry. The Chinese helped to "lay the foundations of knowledge of chemical affinity, as was done in some of the alchemical tractates of the Thang, Sung and Yuan".* "Taoist scholars'..alchemy penetrating to the west was the foundation of all modern chemistry".** "It is now well recognized that alchemy - which we may call the search for the philosopher's stone, and the drug or pill of immortality - goes well back into, and even beyond, the earliest imperial period in China....In the second century A D there is on record the earliest book known in the history of science on alchemy, the work of Wei Po-Yang, in A D 140....That is a date earlier than alchemy in Europe by about six hundred years".***

Needham The Grand Titration *p 22 **p 142 *** p 158

The books of pharmaceutical botany reached an unprecedentedly high standard; the illustrations in certain editions of the 12th and 13th centuries were better than those of the European botanical books of the 15th and early 16th centuries. Particularly characteristic of the period are numerous botanical and zoological monographs of which The Orange Record, in 1178 (by Yen Chih) is a type specimen -it deals with aspects of citrus horticulture and was the first book on the subject in any language. Besides, there were numerous monographs on bamboo, lichis, aromatic plants, cucurbits and flowering trees, as well as crustacca, birds and fishes.

Simultaneous Appearances In East And West

In Chinese and Hellenistic civilizations toothed wheels appeared almost simultaneously (2nd century BC-1st century AD). The hodometer appears in Europe between the 1st century BC and the 1st century AD and in China sometime between the 2nd century BC and the 2nd century AD. The water-wheel appeared on the north coast of Asia Minor about 60 BC and in China about 20 AD, and since in China it was not used to grind grain, but to operate metallurgical bellows, the pre-existence by at least several decades of trial and use must be admitted. The camera-obscura appears both among the Arabs and the Chinese about the 10th century AD. The dependence of sea tides upon the moon was distinctly stated in China (by Wang Chung) about 80 AD; it is possible that some word of Seleucus, the Chaldeen who explained tides by the resistance opposed by the moon about 140 AD, may have reached Wang Chung, but in China the idea had been in the air earlier, Needham assures us.

Just about the time eclipses began to be regularly recorded in Babylonia (8th century BC) we find them carefully recorded in Chinese writings. The Babylonian records are all lost, but the Chinese records are still preserved. The soli-lunar cycles of Meton and Callippos appear in China under different names at the same time, where they may indeed have been much older. The cycles of Plato and Berossos have their anologues in China from 300 BC onwards at least. The Chinese had been observing sun spots since the first century BC.

China's Intellectual Life

By the fifth century BC the Chinese were "entering the greatest period of intellectual flowering of ancient China". (Needham) The "Hundred Flowers" School philosophers were at their height between 500 and 200 BC. Increasing population pressure, increasing conflicts with barbarians and among the feudal states themselves, growing unrest among the people and the technological revolution caused by the coming of iron all led to a demand for advisors on the part of the feudal lords, who often felt themselves at a loss in unfamiliar situations. Such, at any rate, are the only explanations which are available for the great rise at this time of philosophers traveling from capital to capital with their disciplies, prepared to take up positions as advisors and diplomats upon request. From this time date the earliest Chinese books to which names of individual authors are attached. Confucius (551-479BC) spent most of his time imparting his social teachings to his disciples. Besides Confucius there were other schools - the Taoists, the Mohists, the Logicians, the Legalists.

The beginnings of academies of scholars go back to this very early time in China. The most famous of them was the Academy of the Gate, founded in 318 BC, uniting together many of the most brilliant scholars of the age, toward the end of the 4th century and the first half of the 3rd. (The Academy was founded in 348 BC by Plato and the Stoic Academy originated soon after 300 BC)

The first assembly of scientific experts in the history of China was called together in 4 AD. One thousand of them assembled at the capital - - persons learned in the lost classics and ancient records, in astronomy and calendrical science, in mathematics and the acoustics of standard musical tones, in philology and history, in magical and medical techniques, in the botany of woody plants and herbs, and in the Five Classics including the Confucian Analects, the Filial Piety Classic, the Literary Expositor.

In 124 BC the Imperial University was set up with

a chair for each of the classical books. This supplied candidates for the government official posts for many years. From Han times on there were oral and unorganized examinations for official positions; by the Sui period (581-618 AD) there were systematic written examinations; and during the Tang period (618---907 AD) the examinations became stabilized and definitive.

This system of examinations led to the reorganization of the university which about 650 AD had some 5000 students, as many as Cambridge today. An Imperial Academy was founded in 754 and continued to the end of the Empire in 1911 AD. If we may consider it the forerunner of the Academia Sinica today, the latter is older than any existing European Academy by nearly a millennium, according to Needham, of Cambridge.

China's Ancient Economic Ideas Ring a Modern Bell

China long ago grappled with our "modern" economic problems. "Confucian officialdom was always in fear of a ruiniation of the agricultural basis of production by the speculative activities of the merchants" - this was in China five hundred years before the Christ-era but how modern American it reads! In the Tang period (618-907 AD) China returned to the Han(206 BC-220 AD) expedient of "compensation offices" or "ever normal granaries". Government buying during gluts prevented prices falling, and conversely, release of seed grain at the right time of year prevented scarcity. The Government store-houses were also, at any rate, partially effective against famines. Han Ti-wu (140-87 BC) tried to bring the economic system into some kind of order. The merchants, goaded and bewildered by erratic anti-mercantile edicts, had speculated heavily and driven prices so high that the coinage no longer sufficed. Then, to remedy this, the right of private minting was given to certain families, leading to an extremely localized capital accumulation. Now the Emperor took the most capable of these merchants and financiers into the civil service, especially in relation to the salt and iron monopoly; experiments in currency were made, including the first attempt at paper money. But throughout the period taxation was

heavy and constantly increased, largely for the financing of the wars against the Huns.

In the Sung period (918-1260 AD) Wang An Shih, the second of two great reformers in Chinese history (the first was Wang Man of Han) introduced a long series of reforms. First, by reorganizing the finance ministry, he managed to save as much as 40% on the national budget. Then he proposed to abolish the ancient system of transporting tax grain to the capital, substituting a system of local ware-houses from which grains could be sold on the spot and the taxes remitted to the Central Government in money. At the same time money-lending arrangements were made - another attack on the merchants as source of credit - so that farmers could obtain advances on the security of growing crops, at rates of interest lower than those commercially obtaining. Then land surveys were carried out and taxes based on them. Further anti-mercantile laws bore heavily by taxation on hoarding of commodities and restricted production of luxury goods.

The bureaucrats of that day, the official and scholarly gentry, resisted on the same basis as the bourgeoisie today. They felt an abyss opening beneath their feet. If the peasants were no longer to be commanded, if what seened a dangerous reliance on unstable money (paper money) were to take the place of the good old long haul of grain in kind, and worst of all, if quantitative accounting were to restrict or close the field for peripheral "squeeze", and the modest enrichment of functionnaries which every one expected - the end of the world had come! A thousand years ago - but how timely it now sounds! *

Classical China's Influence on European Culture, Economy, and Political Thought

Periodically in the art and literature of medieval and Renaissance Europe interest in China makes its appearance, reflecting cultural relations. Such interest

*To see why China's economic procedures did not lead to capitalism read Needham's "The Grand Titration"

continued as late as the 18th century - a sustained Chinese cultural vogue affecting influentially the art, literature and philosophy of that period. Artists were charmed with the beautiful Chinese paintings on silks, perfumes, sedan chairs, and new fashions of dress and ceremony.

The building of canals, roads and dykes had already begun in Europe, but was greatly stimulated by the Chinese example Statesmen interested in taxation, public education, civil service and prison reform found that China was worth studying.

Not only economic but also other field of thought and action felt the influence of China. In philosophy, Roger Bacon, Leibnitz and Voltaire were interested in and influenced by China. Two Physiocrats, Quesnay and Mercier de la Riviere, found Chinese works on economic and political thought useful in their own writings and helpful in preparing proposals regarding the proper economic and political organization for Europe. Works by Dominican and Jesuit missionaries to China, relating to Chinese agriculture, government support of agriculture in China, the Chinese attitude toward domestic and foreign trade, the system of taxes - all these definitely influences the Physiocrats.

Locke and Stern affirm that "our 20th century heritage from these Physiocrats has retained deposits from the Orient" even going so far as to state that the Chinese influence became the base of the classical economic theory as well as being the stimulant of much of the rationalistic and utopian thought of the period."

Table Manners: Chopsticks Fingers Knives and Forks

The most popularly known fact about the Chinese is that they use chopsticks. Westerners are often apt to look down on this as a crude method of eating; they should remember that the general use of the fork in Europe dates back no farther than the late 16th century, before which time our ancestors used only knives and their fingers.

European table-manners rules at the end of the 15th century indicate clearly that table forks were not then in general use in Europe. It was "manners" to reach for a piece of meat with only three fingers and not to leave the hand unduly long in the bowl. Another point of good behavious was not to wipe the nose with the same hand you used in taking a piece of meat. The Chinese, on the other hand, had been using chopsticks for one thousand years - delicaly and hygienically moving the food from the central bowls to their individual bowls, and easily and neatly "cutting" fish and fowl, not with knives or daggers, but with chopsticks. The Chinese people long antedate Europeans in refinement in eating!

Conclusion

So we see that China produced a profusion of developments which reached Europe and other regions at times varying between the 1st and 18th centuries. The feature common to all examples is that firm evidence for their use in China antedates, and sometimes long antedates, the best evidence for their appearance in any other part of the world. This is summarized below in historical tables, from Needham.

TRANSMISSION OF MECHANICAL AND OTHER TECHNIQUES FROM CHINA TO THE WEST

[*Up to about* 1750]

Item		*Approximate Lag in Centuries*
a)	Square-pallet chain-pump	15
b)	Edge-runner mill	13
	Edge-runner mill with application of water power	9
c)	Metallurgical blowing-engines, water power	11
d)	Rotary fan and rotary winnowing machine	14
e)	Piston bellows	c 14
f)	Draw loom	4
g)	Silk-handling machinery (a form of flyer for laying thread evenly on reels appears in the 11th century AD and water power is applied to spinning mills in the 14th)	3-13
h)	Wheelbarrow	9-10

i)	Sailing-carriage [a type of boat]	11
j)	Wagon-mill	12
k)	Efficient harness for draught animals: Breast strap (postillion)	8
	collar	6
l)	Cross-bow (as an individual arm)	13
m)	Kite	c 12
n)	Helicopter top (spun by cord)	14
	Zoetrope (moved by ascending hot air current)	c 10
o)	Deep drilling	11
p)	Cast iron	10-12
q)	"Cardan" suspension [a type of suspension bridge]	8-9
r)	Segmental arch bridge	7
s)	Iron-chain suspension bridge	10-13
t)	Canal lock-gates	7-17
u)	Nautical construction principles	10
v)	Stern-post rudder	c 4
w)	Gunpowder	5-6
	Gunpowder used as a war technique	4
x)	Magnetic compass (lodestone spoon)	11
	Magnetic compass with needle	4
	Magnetic compass used for navigation	2
y)	Paper	10
	Printing (block)	6
	Printing (movable type)	4
	Printing (metal movable type)	1
z)	Porcelain	11-13

TRANSMISSION OF MECHANICAL TECHNIQUES FROM THE WEST TO CHINA

[*Up to about* 1750]

a)	Screw	14
b)	Force-pump for liquids	18
c)	Crankshaft	3
d)	Clock-work	3