50 GENERAL CONCLUSIONS AND REFLECTIONS

(*a*) SCIENCE AND SOCIETY IN EAST AND WEST[1]

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When I first formed the idea, about 1938, of writing a systematic, objective and authoritative treatise on the history of science, scientific thought, technology and medicine in the Chinese culture-area, I regarded the essential problem as that of why modern science[2] had not developed in Chinese civilisation (or Indian or Islamic) but only in that of Europe. Nevertheless, as they say in sunny France, 'Attention! Un train peut cacher un autre!' As the years went by, and as I began to find out something at last about Chinese science and society, I came to realise that there is a second question at least equally important, namely, why, between the –1st century and the 15th century, was Chinese civilisation much *more* efficient than occidental in gaining natural knowledge and in applying it to practical human needs?

The answer to all such questions lies, I now believe, primarily in the social, intellectual and economic structures of the different civilisations. The comparison between China and Europe is particularly instructive, almost a bench-test experiment one might say, because the complicating factor of climatic conditions does not enter in. Broadly speaking, the range of climate in the Chinese culture-area is not unlike that in Europe. It is therefore not possible for anyone to say of China (as has been maintained in the Indian case) that the environment of an exceptionally hot climate inhibited the rise of modern natural science.[3] Although the natural, geographical and climatic settings of the different civilisations undoubtedly played a part in the development of their specific characteristics, I am in any case not inclined to regard this suggestion as valid even for Indian culture. The point is that it cannot even be asserted of China. Nonetheless here again we see the enormous importance of geography in relation to the civilisations and the way they developed.[4] Europe, as I have often said, is like an archipelago. There is the Baltic, the North Sea, the Irish Channel, the Mediterranean, the Aegean, the Black Sea and then the great Atlantic outside the Pillars of Hercules – all inviting maritime commerce and the

[1] First published in the J. D. Bernal Presentation Volume (London, 1964), and then in *Science and Society* (1964), **28**, 385, and *Centaurus* (1964), **10**, 174; collected in *The Grand Titration* (Allen & Unwin, London, 1969), and further revised for publication here.

[2] If I were asked to define modern science, I would say that it was the combination of mathematised hypotheses about natural phenomena with relentless experimentation. On reflection, I am not sure that experimentation was not the greatest Chinese stimulus to European alchemy and so indirectly to the European Renaissance, for the Greeks did not experiment, but the Chinese did; otherwise they would never have made their fundamental discoveries such as porcelain and the magnetic compass.

[3] Cf. the writings of Huntington (1907), (1924) and especially (1945).

[4] For which see Dorn (1991).

activities of sea-captains. In contrast to all this, China is a vast land-mass, well suited for the activities of peasant-farmers in their millions. It is hardly surprising that the civilisations turned out to be so different.

From the beginning I was deeply sceptical of the validity of any of those 'physical-anthropological' or 'racial-spiritual' factors in explaining China's development. Everything I have experienced during the fifty years since I first came into close personal contact with Chinese friends and colleagues, has only confirmed me in this scepticism. They proved to be entirely, as Andreas Corsalis wrote home in a letter to Lorenzo di Medici so many centuries ago, 'di nostra qualità'. I believe that the vast historical differences between the cultures can be explained by sociological studies, and that some day they will be. The further I penetrate into the detailed history of the achievements of Chinese science and technology before the time when, like all other ethnic cultural rivers, they flowed into the ocean of modern science, the more convinced I become that the cause for the breakthrough (occurring only in Europe) was connected with the special social, intellectual and economic conditions prevailing there at the Renaissance, and can never be explained by any deficiencies either of the Chinese mind or of the Chinese intellectual and philosophical tradition. In many ways this tradition was much more congruent with modern science than was the world-outlook of Christendom. Such a point of view may or may not be a Marxist one – for me it is based on study and personal experience of life.

For the purposes of the historian of science, therefore, we have to be on the watch for some essential differences between the aristocratic-military feudalism of Europe, out of the womb of which mercantile and then industrial capitalism, together with the Renaissance and the Reformation, could be born; and those other kinds of 'feudalism' (if that was really what it was) which were characteristic of medieval Asia. From the point of view of the history of science we must have something at any rate sufficiently different from what existed in Europe to help us solve our problem. This is why I have never been sympathetic to that trend in Marxist thinking which has sought for a rigid and unitary formula of the stages of social development which all civilisations 'must have passed through'.

Primitive communalism, the earliest of these, is a concept which has evoked much debate. Though such a phase is commonly rejected by the majority of Western anthropologists and archaeologists (with, of course, some notable exceptions such as V. Gordon Childe), it has always seemed to me eminently sensible to conceive of a state of society before the differentiation of social classes, and in my studies of ancient Chinese society I have found it appearing through the mists clearly enough, time after time. Nor at the other end of the story is there any essential difficulty in the transition from feudalism to capitalism, though of course this was enormously complex in detail, and much has still to be worked out.[5] In particular the exact connections between the social and economic changes and the rise of modern science, that is to say, the successful application of mathematical hypotheses to the systematic

[5] On different aspects of feudalism see Wallerstein (1992).

experimental investigation of natural phenomena, remain elusive. All historians, no matter what their theoretical inclinations and prejudices, are necessarily constrained to admit that the rise of modern science occurred *pari passu* with the Renaissance, the Reformation and the rise of capitalism.[6] It is the intimate connections between the social and economic changes on the one hand and the success of the 'new, or experimental' science on the other which are the most difficult to pin down. A great deal can be said about this, for example the vitally important role of the 'higher artisanate' and its acceptance into the company of educated scholars at this time;[7] but the present writing is not the place for it because we are in pursuit of something else. For us the essential point is that the development of modern science occurred in Europe and nowhere else.

In comparing the position of Europe with China, one of the problems of interpretation we face is whether China ever passed through a 'slave society' analogous to that of classical Greece and Rome. The question is, of course, not merely whether the institution of slavery existed – that is quite a different matter – but whether the society was ever based on it.[8] According to my own experiences with Chinese archaeology and literature, for what they are worth, I am not very inclined to believe that Chinese society, even during the Shang and early Chou periods, was ever a slave-based society in the same sense as the Mediterranean cultures with their slave-manned galleys plying the Mediterranean and their *latifundia* spread over the fields of Italy. Here I diverge, with deep humility, from some contemporary Chinese scholars, who have been extremely impressed by the 'single-track' system of developmental stages of society prominent in Marxist thinking during the past seventy years. The subject is still under intensive debate and we cannot yet say that certainty has been achieved in any aspect of it. In the years 1956–7 at Cambridge we had a series of lectures on slavery in the different civilisations, in the course of which the participants all had to agree that the actual forms of slavery were very different in Chinese society from anything known elsewhere.[9] Owing to the dominance of clan and family obligations it was rather doubtful whether anyone in that civilisation could have been called 'free' in some of the Western senses, while on the other hand (contrary to what many believe) chattel-slavery was distinctly rare.[10] The fact is that no one fully knows what was the status of servile and semi-servile groups in the different periods in China (and there were many different kinds of such groups): neither Western sinologists

[6] The great stumbling-block here for the internalist school of historiography of science is the question of historical causation. Scenting economic determinism under every formulation, they insist that the scientific revolution, as primarily a revolution in scientific ideas, cannot have been 'derivative from' some other social movement such as the Reformation or the rise of capitalism. Perhaps for the moment we could settle for some such phrase as 'indissolubly associated with . . .'. The internalists always seem to me essentially Manichaean; they do not like to admit that scientists have bodies, eat and drink and live social lives among their fellow-men, whose practical problems cannot remain unknown to them; nor are the internalists willing to credit their scientific subjects with subconscious minds.

[7] This factor was much emphasised and elaborated by the late Edgar Zilsel (see Bibliography C). Its importance has recently been recognised by the well-known medievalist, A. C. Crombie (1963). See also his (1961), p. 13.

[8] See Wallerstein (1992) and Needham (1969a), p. 167.

[9] This symposium was organised and presided over by Professor E. G. Pulleyblank.

[10] See Pulleyblank (1958b).

nor even the Chinese scholars themselves.[11] A great amount of research remains to be done, but I think it seems already clear that neither in the economic nor in the political field was chattel-slavery ever a basis for the whole of society in China in the same way as it was at some times in the West.

Although the question of the slave basis of society has a certain importance in so far as it affects the position of science and technology among the Greeks and Romans,[12] it is of course less germane to what was originally my central point of interest, namely the origin and development of modern science in the late Renaissance in the West. It could, however, have a very important bearing on the greater success of Chinese society in the application of the sciences of Nature to human benefit during the earlier period, the first fourteen centuries of the Christian era and four or five centuries prior to that. Is it not very striking and significant that China has nothing whatever to show comparable with the use of slaves on the *latifundia* in agriculture or at sea in galleys in the Mediterranean? Sail, and a very refined use of it, was the universal method of propulsion of Chinese ships from ancient times. China has few records of the mass use of the human motor comparable with the building methods of ancient Egypt, though the building of the Great Wall is an outstanding exception. So also it is remarkable that 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 before the 19th century.[13] If Chinese labour-power was so vast as most people imagine, it is not easy to see why this factor should not sometimes have come into play. We have numerous examples of labour-saving devices introduced at early times in Chinese culture, very often much earlier than in Europe. A concrete case would be the wheelbarrow, not known in the West before the 13th century but common in China in the +3rd and arising there almost certainly two hundred years earlier than that. It may well be that just as the bureaucratic apparatus will explain the failure of modern science to arise spontaneously in Chinese culture, so also the absence of mass chattel-slavery may turn out to have been an important factor in the greater success of Chinese culture in fostering pure and applied science in the earlier centuries.

The far greater problem that arises when we compare the histories of Europe and China, however, is how far and in what way did Chinese feudalism (if that is the proper term for it) differ from European feudalism. In my early days, when I was still a working biochemist, I was greatly influenced by Karl A. Wittfogel's

[11] At least we have been able to show (vol. 4, p. 2, pp. 35 ff.) that servile or semi-servile rank was no barrier to official, if not very exalted, positions. This was so in the case of Hsin-Tu Fang 信都芳 (*fl.* +525) and Keng Hsün 耿詢 (*fl.* +593). The former was in charge of all the scientific apparatus at the Thopa court of Northern Wei and the latter rose to moderately high rank in the Bureau of Astronomy and Calendar under the Sui.

[12] It is always said that the Greeks and Romans were less interested in labour-saving devices than they might have been because there was always a large slave population around to carry out desired changes by muscle-power.

[13] With the mass introduction of Western technology in the 19th century, however, the situation was altered. J. Dyer Ball's article in *Things Chinese* (1904) on 'Railways', for example, quotes descriptions and sources in the Chinese press from 1891 to 1899 of the resistance to the building of railways by the Chinese government. These articles were written from the point of view of the capitalist developer and do not stress Chinese fears of unemployment and foreign domination.

book, *Wirtschaft und Gesellschaft Chinas*, written when he was a more or less orthodox Marxist in pre-Hitler Germany.[14] He was interested in developing the conception of 'Asiatic bureaucratism' or 'bureaucratic feudalism' as I found later on that some Chinese historians called it.[15] This concept arose from the works of Marx and Engels themselves who had based it partly on, or derived it from, the observations of the 17th-century Frenchman François Bernier, physician to the Mogul emperor Aurangzeb in India.[16]

Marx and Engels spoke about the 'Asiatic mode of production'. How exactly it could or should be defined has been the subject of animated discussions in recent decades.[17] Broadly speaking, it was the growth of a State apparatus fundamentally bureaucratic in character and operated by a non-hereditary élite upon the basis of a large number of relatively self-governing peasant communities, still retaining much tribal character and with little or no division of labour as between agriculture and industry. The form of exploitation here consisted essentially in the collection of taxes for the centralised State, i.e. the royal or imperial court and its regiments of bureaucratic officials. The justification of the State apparatus was, of course, twofold: on the one hand it organised the defence of the whole area (whether an ancient 'feudal' state or later the entire Chinese empire), and on the other hand it organised the construction and maintenance of public works. It is possible to say without fear of contradiction that throughout Chinese history the latter function was more important than the former, and this was one of the things that Wittfogel saw. The necessities of the country's topography and agriculture imposed from the beginning a vast series of water-works[18] directed to (a) the conservation of the great rivers, in flood-protection and the like, (b) the use of water for irrigation, especially for wet rice cultivation, and (c) the development of a far-flung canal system (Fig. 2), whereby the tax-grain could be brought to granary centres and to the capital. All this necessitated, besides tax exploitation, the organisation of corvée labour and one might say that the only duties of the self-governing peasant communities *vis-à-vis* the State apparatus were the payment of tax and the provision of labour power for public

[14] I also learnt much from a golden little book by Hellmut Wilhelm, the son of the great sinologist Richard Wilhelm, *Gesellschaft und Staat in China* (1944). It is most unfortunate that this non-Marxist work has long been quite inaccessible, and that there has never been an English translation of it. My views on 'feudalism' in China may be found in Needham (1969a), pp. 167–8.

[15] I think, looking back, that I first fixed upon the phrase 'bureaucratic feudalism' during the years when I was in China (1942–6) during the Second World War. 'Feudalism' was then becoming a term of abuse for all previous societies but that did not deter me from using it. I see now, however, that for such a term to pertain, you should have a lowest stratum of society which was bound to the land they tilled – the serfs – and if that was never the case in China, then the term should not be used. It might be better then, to say 'feudal bureaucratism'. Elsewhere in this volume I have given sufficient examples of what 'bureaucratism' meant in China, and that is the main thing.

[16] *The History of the Late Revolution of the Empire of the Great Mogul*, originally published in French (Paris, 1671); many times republished, as by Dass (Calcutta, 1909). In the course of it Bernier said, 'There is no meum and tuum among them, as there is among us'. He was one of the first to use the word 'prebendal' to mean that stage of society in which all the officials get their incomes from the imperial treasury and not from direct ownership of feudal lands. See the famous letter of Marx to Engels, 2 June 1853.

[17] See below, pp. 12 ff., for which I have had the advantage of collaboration with Gregory Blue, who originally learnt Russian in order to be able to study at first hand the debates of the 1930s on the 'Asiatic Mode of Production'. See Blue (1979).

[18] This point is developed by Dorn (1991), pp. xvi, 33 and 35 ff.

Figure 2. Illustration of a flash-lock gate (bottom-left). From *The Grand Titration*, Fig. 27, from Baylin (1929).

purposes when called upon to give it.[19] Besides this the State bureaucracy assumed the function of the general organisation of production (Fig. 3), i.e. the direction of broad agricultural policy, and for this reason the State apparatus of such a type of society may well be given the appellation of 'an economic high command'. Only in China do we find among the most ancient high officials the *Ssu Khung* 司空, the *Ssu Thu* 司徒 and the *Ssu Nung* 司農 (Director of Public Engineering Works, Director

[19] One can detect in this model similarities to the system of people's communes, by which the Chinese countryside was organised between 1958 and 1979. See, for example, Strong (1964), writing on changes introduced at that time. The principle of the rational and maximal utilisation of manpower is one which goes back more than 2,000 years in Chinese history, and its timing was one of the functions of the 'economic high command'.

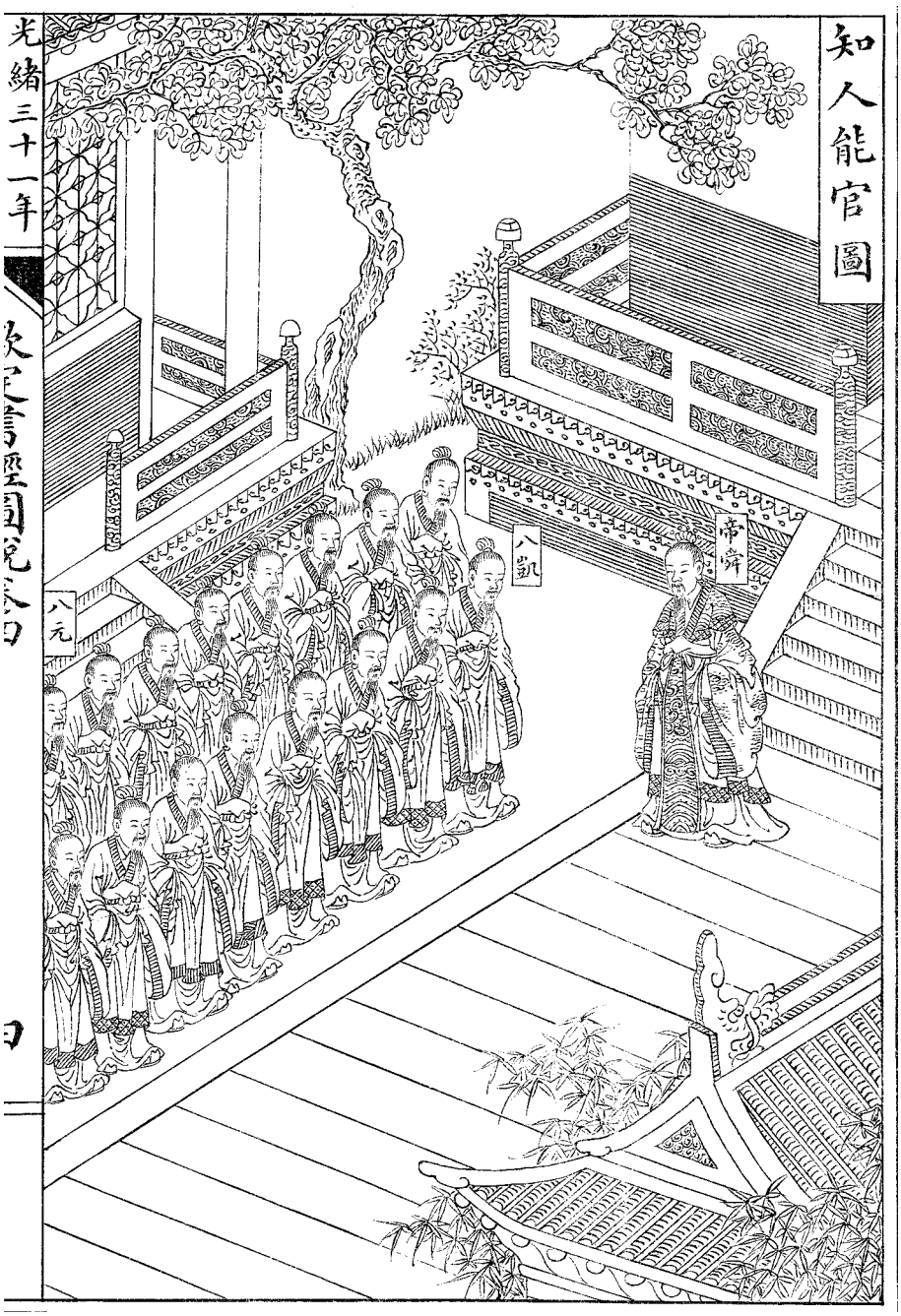

Figure 3. Nominating the Right Men for Office. From *The Grand Titration*, Fig. 28.

of Public Instruction and Minister for Agriculture). Nor can we forget that the 'nationalisation' of salt and iron manufacture (the only commodities which had to travel, because not everywhere producible), suggested first in the –5th century, was thoroughly put into practice in the –2nd century. Also in the Han there was a governmental Fermented Beverages Authority; and there are many examples of similar bureaucratic industries under subsequent dynasties.[20]

Various other aspects of this situation reveal themselves as one looks further into it; for example, peasant production was not under private control, and theoretically all the land within the whole empire belonged to the Emperor and the Emperor alone. There was at first a semblance of landed property securely held by individual families, but this institution never developed in Chinese history in a way comparable with feudal fief tenures of the West, since Chinese society did not retain the system of primogeniture.[21] Hence all landed estates had to be parcelled out at each demise of the head of the family. Again, in that society, the conception of the city-state was absent; the towns were purposefully created as nodes in the administrative network, though very often no doubt they tended to grow up at spontaneous market centres. Every town was a fortified city held for the Prince or the Emperor by his civil governor and his military official. Since the economic function was so much more important in Chinese society than the military it is not surprising that the governor was usually a more highly respected person than the garrison commander.[22] Lastly, broadly speaking, slaves were not used in agricultural production, nor indeed very much in industry; slavery was primarily domestic, or as some would say, 'patriarchal' in character,[23] throughout the ages.

In its later highly developed forms such as one finds in Thang or Sung China the 'Asiatic mode of production' developed into a social system which, while fundamentally 'feudal', in the limited sense that most of the wealth was based on agricultural exploitation,[24] was essentially bureaucratic and not military-aristocratic. It is quite impossible to over-estimate the depth of the civilian *ethos* in Chinese history. Imperial power was exercised not through a hierarchy of enfeoffed barons but through

[20] Cf. Schurmann (1956).

[21] Primogeniture was, however, less widespread in Europe than is usually imagined.

[22] In a recent book on the Yangtze, van Slyke (1988) has much to say about merchants and mercantile activity in traditional China, especially in connection with rice, salt, silk and *thung* 桐 oil. He well describes the activities of the rich merchants of medieval China, and though he trembles on the verge of stating that bureaucratic feudalism meant that capitalism (as well as modern science) could not develop in China, he doesn't actually do so. But he makes interesting statements such as, 'The fact that both officials and merchants centred their activities in cities large and small meant that the merchants had no urban arena of their own in which autonomously to develop their own values and institutions, to become, that is, a genuine bourgeoisie.' Again he says that guilds in China were defensive with respect to political authority, not vehicles for the development of an alternative vision of society. Central Asia may have known some city-states, but descending from their Greek antecedents, they were overwhelmingly characteristic of Europe, where they again appeared, first in Italy, like Venice, Pisa and Genoa, then in Holland, like Rotterdam and Amsterdam, finally Antwerp and London, together with the cities of the Hanseatic League. All these were by a long tradition children of the Greek city-state.

[23] See Tokei (1959), p. 291.

[24] This must not be taken to mean that industry and trade were poorly developed in medieval China. On the contrary, especially in the Southern Sung in the 12th and 13th centuries, they were so productive and prosperous that the continuance of the typical bureaucratic form is what surprises.

an extremely elaborate civil service which Westerners know of as the 'mandarinate', enjoying no hereditary principle of succession to estates but recruited afresh in every generation. All I can say is that throughout nearly fifty years of study of Chinese culture, I have found that these conceptions have made more sense in my understanding of Chinese society than any others. I believe that it will be possible to show in some considerable detail why Asian 'bureaucratic feudalism' at first favoured the growth of natural knowledge and its application to technology for human benefit, while later on it inhibited the rise of modern capitalism and of modern science, in contrast with the other form of feudalism in Europe which favoured it – by decaying and generating the new mercantile order of society.[25] A predominantly mercantile order of society could never arise in Chinese civilisation because the basic conception of the mandarinate was opposed not only to the principles of hereditary aristocratic feudalism but also to the value-system of the wealthy merchants. Capital accumulation in Chinese society there could indeed be, but the application of it in permanently productive industrial enterprises was constantly inhibited by the scholar-bureaucrats, as indeed was any other social action which might threaten their supremacy. Thus, the merchant guilds in China never achieved anything approaching the status and power of the merchant guilds of the city-states of European civilisation.[26]

In many ways I should be prepared to say that the social and economic system of medieval China was much more rational than that of medieval Europe. The system of imperial examinations for entry into the bureaucracy, a system which had taken its origin as far back as the –2nd century, together with the age-old practice of the 'recommendation of outstanding talent', brought it about that the mandarinate recruited to itself the best brains of the nation (and the nation was a whole sub-continent) for more than 2,000 years.[27] This stands in very great contrast with the European situation where the best brains were not especially likely to arise in the families of the feudal lords, still less among the more restricted group of eldest sons of feudal lords. There were of course certain bureaucratic features of early medieval European society, for example the office of the 'Counts', the institutions which gave rise to the position of 'Lord Lieutenant', and the widely customary use of bishops and clergy as administrators under the king, but all this fell far short of the systematic utilisation of administrative talent which the Chinese system brought fully into play.

Moreover, not only was administrative talent brought forward and settled thoroughly into the right place, but so strong was the Confucian *ethos* and ideal that the chief representatives of those who were not scholar-gentry remained for the most part conscious of their lesser position in the scheme of things. When I was giving a talk to a university society on these subjects, someone asked the excellent question, 'How was it that the military men could accept their inferiority to the civil officials throughout Chinese history?' After all, 'the power of the sword'

[25] See Needham (1986). [26] See Morse (1932).
[27] A remarkable sidelight on this will be found in the paper by Lu Gwei-Djen & Needham (1963), 'China and the Origin of (Qualifying) Examinations in Medicine'.

has been overwhelming in other civilisations. What immediately came to my mind in replying was the imperial *charisma* carried by the bureaucracy,[28] the holiness of the written character (when I first went to China the stoves for giving honourable cremation to any piece of paper with words written on it were still to be seen at every temple), and the Chinese conviction that the sword might win but only the *logos* could maintain. There is a famous story about the first Han emperor who was impatient with the elaborate ceremonies devised for the court by his attendant philosophers, till one of them said to him, 'You conquered the empire on horseback, but from horseback you will never succeed in ruling it'.[29] Thereafter the rites and ceremonies were allowed to unfold in all their liturgical majesty.[30] In ancient times the Chinese leader was often an important official and a general indiscriminately, and what is significant is that the psychology of military men themselves clearly admitted their inferiority. They were very often 'failed civilians'. Of course, force was the ultimate argument, the final sanction, as in all societies, but the question was – what force, moral or purely physical? The Chinese profoundly believed that only the former lasted, and what the latter could gain only the former could keep.

Furthermore, there may have been technical factors in the primacy of the spoken and written word in Chinese society. It has been demonstrated that in ancient times in China the progress of invention in offensive weapons, especially the efficient crossbow (Fig. 4), far outstripped progress in defensive armour.[31] There are many cases in antiquity of feudal lords being killed by commoners or peasants well armed with crossbows, the penetrating power of which made the wearing of armour useless, a situation quite unlike the favourable position of the heavily armed knight in Western medieval society. Hence, perhaps, arose the Confucian emphasis on persuasion. The Chinese were Whigs, 'for Whigs admit no force but argument'.[32] The Chinese

[28] One should add the high moral standards of Confucianism which exerted great social pressure throughout the ages upon the members of the mandarinate.

[29] These were the words of Lu Chia, in –196 (*CHS*, ch. 43, p. 6b, *TCKM*, ch. 3, p. 46b). Another court liturgiologist was Shu-Sun Thung, who reported in –201 that 'the Emperor had abolished the complex and difficult rites of Chhin . . . but the result was that when the officers drank together, they disputed about precedence, got drunk, shouted and banged their swords on the columns of the halls. The Emperor was disgusted. Shu-Sun Thung said to him, "Scholars may not be able to conquer an empire, but they can help to preserve it. I suggest that you convoke all the literati of Lu and instruct them to draw up an imperial code of rites" . . . [After the first trial of it] the Emperor said, "This day for the first time I see what imperial majesty means." ' This comes from *CHS*, ch. 43, pp. 15b ff. Hence *TCKM*, ch. 3, p. 25b.

[30] See *SCC*, vol. 1, p. 103.

[31] On the early date of the crossbow, and its remarkable effects, see *SCC*, vol. 5, pt. 6.

[32] This is a quotation from an amusing battle between the Whigs of Cambridge and the Tories of Oxford in the 18th century. George I precipitated it by sending at the same time a present of books to Cambridge and a troop of cavalry to Oxford. Joseph Trapp (1679 to 1747) began it with the following verse:

> The King, observing with judicious eyes
> The State of both his universities
> To Oxford sent a troop of horse, and why?
> That learned body wanted loyalty.
> To Cambridge books, as very well discerning
> How much that loyal body wanted learning.