CHAPTER - VII

TECHNOLOGICAL BASE OF RURAL CRAFTS

A major handicap in discussing the spread of modern industrial techniques in Asian Societies during the 17th and 18th centuries is lack of adequate research on the issues of technological innovation and its application in handicrafts and agriculture etc.Even in contemporary chronicles only scanty and scattered references have been made. Work has been sporadic after P.K.Gode had pioneered it along with the detailed descriptions of nineteenth century.Still many Indian technological practices have not yet been properly checked with earlier literary evidences.[1] The degree and level of the technological development during the proto-industrial period is the determinant of the degree and level of the development of industrialization. It,therefore, has been proposed to direct critical analysis to the level of technology during the proto-industrial phase and the internal social determinants of technological change in Bengal during the 17th and the 18th centuries.

Since the social environment of peasants,and rural and urban proto-industrial producers were somewhat different,the economic pressures upon them took different forms and the interests of the ruling classes led them to adopt measures in respect of the peasants which were largely irrelevant from the point of view of the urban artisans.It,therefore,would be appropriate to separate the treatment of agricultural technology and craft technology and to a large extent,describe them as autonomous (though undoubtedly interrelated) spheres.[2]

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1. Irfan Habib, "Technology and Barriers to Social Change in Mughal India," IHR, Vol.V, Nos.1-2,(July,1978-Jan,1979),p.152.
2. Ibid, p.152.

AGRICULTURAL TECHNOLOGY

India during the period under review in general and Bengal in particular, appeared as a country cultivated by my myriads of peasants,forming an impoverished and differentiated mass.[3] Closer scrutiny has borne out the truth implicit in this statement that peasants cultivated the land as individual producers,but it has also led to the discovery of the existence of considerable economic differentiation among village agrarian society which consisted of khud-kāshta, pāhi-kāshta, muzāri'ān and village menials,landless peasants, tanners and washermen etc.[4] The ruling class were in essence rent-receivers,who shared out the bulk of the agricultural surplus which reached to the peak under Aurangzeb, when the declared amount of the land tax was estimated at 332-387 million rupees,while about 60% of this amount upto Rs.200 million in actuality was collected.[5] These class of people who were constituted mainly of manṣabdārs,jāgīrdārs,and zamīndārs[6] who were assigned the duty to extend the cultivation.The zamīndārs[7] had special role to play in the extension of the production of agriculture through extending taqāvīs,laying out large irrigation works, orchards,fruits for their tables or sale,but this was perhaps the sum total of their interest in agriculture.

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3. Francois Bernier, Travels in the Mogal Empire,(ed.),V.A.Smith,(London,1916),pp.226-227.

4. Satish Chandra, "Some Aspects of Indian Village Society in Northern India during 18th Century:The position and Role of Khud-kasht and pahi-kasht," IHR,Vol.1,No.1,(1974),pp.51-64.

5. V.I.Pavlov, Historical Premises for India's Transition to Capitalism,(Moscow,1978),p.33.

6. S.Nurul Hassan, "The Position of the Zamindars in the Mughal Empire," IESHR,Vol.1,No.4,(April-June,1964),p.3.

7. B.R.Grover, "The nature and the evolution of Taluqdari System during the Mughal Age," IESHR,Vol.II,No.3 (July,1966),p.269.Also see Irfan Habib's "Technology and Barriers to Social Change in Mughal India," IHR, Vol.5,Nos.1-2(1978-79), p.153.

In the main the agricultural technology of Mughal India was determined by the situation of its peasant farming. Much more than 1/6th of the crops or the produce was the share as land tax of the ruling groups of Bengal in the middle and late decades of the 18th century.[8] But the imperial Government tried its best to ensure its share at less than 50% of the produce.[9] Including all the cesses, it further went up and since the imperial authority declined and since the burden on jāgīr increased, the agrarian economy had to face a crisis. During late 18th century, ijāradārs bidding higher than zamīndārs, speculating Calcutta baniās anxious to secure the most beneficial farms, zamīndārs tenacious of their hereditary possessions out bidding others composed the body of farmers under this new system.[10] The Indian peasants tolerated these constant and contradictory pressures by an extraordinary combination of superstition with knowledge and of rude equipment with ingenious desires.[11]

The agriculturist cultivated large number of crops for both the harvesting seasons. Moreland comprehensively compiled the varieties of crops produced in India.[12] Few countries (excluding, perhaps China) could have compared with Mughal India in the great multiplicity and variety of products of the soil.[13] Abū-l Faẓl in

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8. John R.Maclane, "Land Revenue Transactions in 18th Century Western Bengal," Bengal Past and Present, Vol.CIV, Parts I-II, Nos., 198-199, (1985), p.2.

9. S.Nurul Hassan, "Zamindars under the Mughals," See Robert Eric Frykenberg, Land Control and Social Structure in Indian History, (New Delhi, 1979), p.29.

10. N.K.Sinha, The Economic History of Bengal, From Plassey to the Permanent Settlement, Vol.II, (Calcutta, 1962), p.78.

11. Irfan Habib, "Technology and Barriers to Social change in Mughal India," IHR, Vol.5, Nos.I-II, (1978-1979), p.153.

12. W.H.Moreland, India At the Death of Akbar: An Economic Study, (Delhi, 1987), p.281.

13. Irfan Habib, "Technology and Barriers to Social Change in Mughal India," IHR, Vol.5, Nos.1-11, (1978-1979), p.153.

the A'in-i-Akbari (1595-96) lists, in its revenue tables, sixteen crops for the rabi harvest in all revenue circles of Agra province and 25 crops of the kharif harvest cultivated in all.[14] In other provinces also approximately same number of crops were cultivated. In other words, as many as forty or more crops might have been cultivated in each locality. Many of these crops, of course, were cultivated in small areas, and the crops that an ordinary peasant knew how to grow, were fewer.

The peasants in Mughal times does not seem to have harboured much defiance in accepting new crops. On the contrary, the high magnitude of land revenue demand compelled the farmers to grow any crops that could fetch higher returns on the market. As a result, tobacco and opium cultivated. The extension of these two crops was spectacularly rapid. Tobacco's cultivation had begun on the western coast soon after 1600, by 1650, it was being cultivated in almost all parts of the Empire.[15] The cultivation of Indian opiums were mainly confined to three centres which afford the following opiums: "Patna opium" in Bihar, "Benaras opium" in the north western provinces and "Malwa opium" in Central India.[17] By about the middle of the 17th century, India had emerged as a major producer of the drug. Gode has estimated the existence of Maize cultivation in 17th century Maharastra.[18]

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14. Abu-l Fazl, A'in-i-Akbari, (ed.), Blochmann (Calcutta, 1867-71), pp. 348-85.
15. Irfan Habib, "Technology and Barriers," IHR, Vol. 5, Nos. I-II, (1978-1979), p. 154.
16. Om Prakash, "Opium Monopoly in India and Indonesia in the 18th Century," IESHR, Vol. 26, No. 1, (1987), p. 64.
17. George Watt, A Dictionary of the Economic Products of India, Vol. VI, Part 1, (London, 1892), pp. 19-24.
18. P.K. Gode, Studies in Indian Cultural History, I (Hoshiyarpur, 1962), pp. 446-447, 450.

In the equipment that the peasant possessed, the use of iron was minimal and wood predominated. The diminutive ploughs are in vogue which barely scratches the first two inches of the ground. Heavier ploughs are used in Noakhali, and Tipperah district. In Bengal the soil is softer and for an aquatic plant like rice deep ploughing would be disadvantageous since by exposing too much of the subsoil leads to rapid transpiration. Again depth generally was attained with ordinary country plough by a system of ploughing and reploughing. In some districts of Bengal 4 to 5 ploughing was in operation.[19]

Indian ploughs were no stranger to European eyes. Terry described it as the "foot plough", a type used in England.[20] Fryer, whose observations were confined to coastal regions, found no peculiarity in the ploughs "except that their coulters unarmed mostly, iron being scarce, but they have hard wood will turn light grounds."[21] This statement could have been true only of the coastal belt and softy soil. Iron teeth would have been indispensible for the drier or harder soils inland. Other agricultural implements like khurpi, daggers, kudāl, axes, scissors, hasiya, tangi, tanga, etc. made of iron produced from iron of Birbhūm district in the workshops of Dobrajpur, Kharun, Lokpar, Rajnagar and Rampurhat.[22] Agricultural implements were also produced

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19. See Radha Kamal Mukherjee's, Rural Economy of India, (Calcutta, 1926), p.67.

20. Terry, Early Travels, p.298.

21. Fryer is quoted by Irfan Habib in his, The Agrarian System

22. Hitesranjan Sanyal, "The indigenous Iron Industry of Birbhum," IESHR, Vol.5, No.1, (March, 1968), p.105.

locally by Lohārs by charcoal iron attached to village menials and rendered industrial service in return for a fixed share in the agricultural produce of each village household.[23]

Drill-sowing as well as dibbling has been an old and familiar practice in India.[24] The peasant attached the bamboo seed drill to his plough and by using a simple stick, practised dibbling both great advances over the wasteful method of sowing broadcast.[25] W.M.Reid quoted the Gleanings of Science, No.5,for May 1829,for describing the drill plough used in Tirhut for indigo cultivation. The drill plough had the following advantages "the shares the furrow, the wheels of the machine turn those of the trough, the slanting holes bored in the wheels of the tourgh, during the passage through the seed,take up each one or more seeds and in the downward part of their revolution unload themselves with precision into the hoppers, which lead them in the hollow of the plough shares, which last deposit the seed in the furrow and in close the seed in an instant."[26]

The construction of the original indigo drill was as follows: It consisted of 2 to 2.5 inches diametre wheels,3 inches thick,made of Shisham wood,tyred with common hoop iron,on a trough,4 feet, inside measurement, of the same material as the

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23. Sabyasachi Bhattacharya, "Iron smelters and the indigenous iron and steel industry of India: From Stagnation to atrophy", see Surjit Sinha (ed.), Aspects of Indian Culture and Society, (Calcutta,1972),p.140.

24. Irfan Habib, Agrarian System of the Mughals,p.25.

25. Irfan Habib, "Technology and Barrier," IHR (1978-1979),p.154.

26. W.M.Reid, The Culture and Manufacture of Indigo,(Calcutta, 1887),pp.42-43.

wheels, the average depth of this trough being 6 inches. The side-walls of the trough were two feet long by 2 inches thick also made of <u>shisham</u>. In the front-board or platform was inserted the nipples for sowing the seed and also in front of these, the shares were attached which was of 4 feet long inside measurement by 9 to 10 inches broad, by three inches thick again of <u>shisham</u> wood and to it the trough was attached. This platform was bored at distances of six inches apart in a double line to receive the tubes and shares. A simple board, 1 inch thick, was fixed in one end between the nipples and shares to prevent the seed from being thrown outside. Thus, in a drill of 4 feet length, inside, there were eight tubes and 8 shares. These shares sides were generally 4.5 inches to 5 inches broad, and 2 inches wide at outer rim.[27] Inside the trough and upon the axle with which they revolve were placed, at equal distance with tubes and shares small round wheels, 7 inches in diametre, slightly perforated round the disc with small round holes, which with every revolution, raise the seed in the trough and eject it into the tubes in the frong board. The average number of holes in a 7 foot diametre seed-wheel would be 16.[28] Shaft, a thin piece of wood 8 feet long by 2 inches thick sloping, when the drill rested upon the ground, from 4 feet ground at point to 9 inches where it gains the platform, here it was operated on either side by strong stanchions of wood or iron. The shares should be kept at an uniform depth so as not to endanger the germination of the seed. Four shared, 8 shared, 20 shared drills were referred in the

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27. <u>Ibid</u>, pp.43-44.
28. <u>Ibid</u>, pp.44-45.

chronicles.[29]

Pin-drum gearing is found pre-eminent position in the arhat or rahat or sāqiya or the persian wheel. This device had originated in the Mediterranean world, but it reached India well before the 16th century[30] and was mainly utilised as common mode of water lifting in the Indus basin, its use did not spread to further east until the middle of the 19th century. This was because that the persian wheel could not compete with the charas, a method of lifting water through a leather bag drawn over a pully. In charas the oxen had to walk on the ground for a length equal to the actual depth of the well and back, for every turn with the water-bag. If the water-level was low, the walks would be longer, and the interval between each discharge of water greater. The charas were better suited to these regions where water level was very high like gangetic basin. Here the wood and rope arhat was clumsy to compete with the charas.[31] The dhenklī based on the lever principle was in vogue where the water table was close to the surface.[32] In case where a river rises and inundates the fields seasonally every year, both the irrigation and fertilisation were purely natural. But it is probable that the construction of embankments to train the rivers for the sake of canals or for the prevention of floods has considerably reduced the extent of land formerly enriched by this means.[33]

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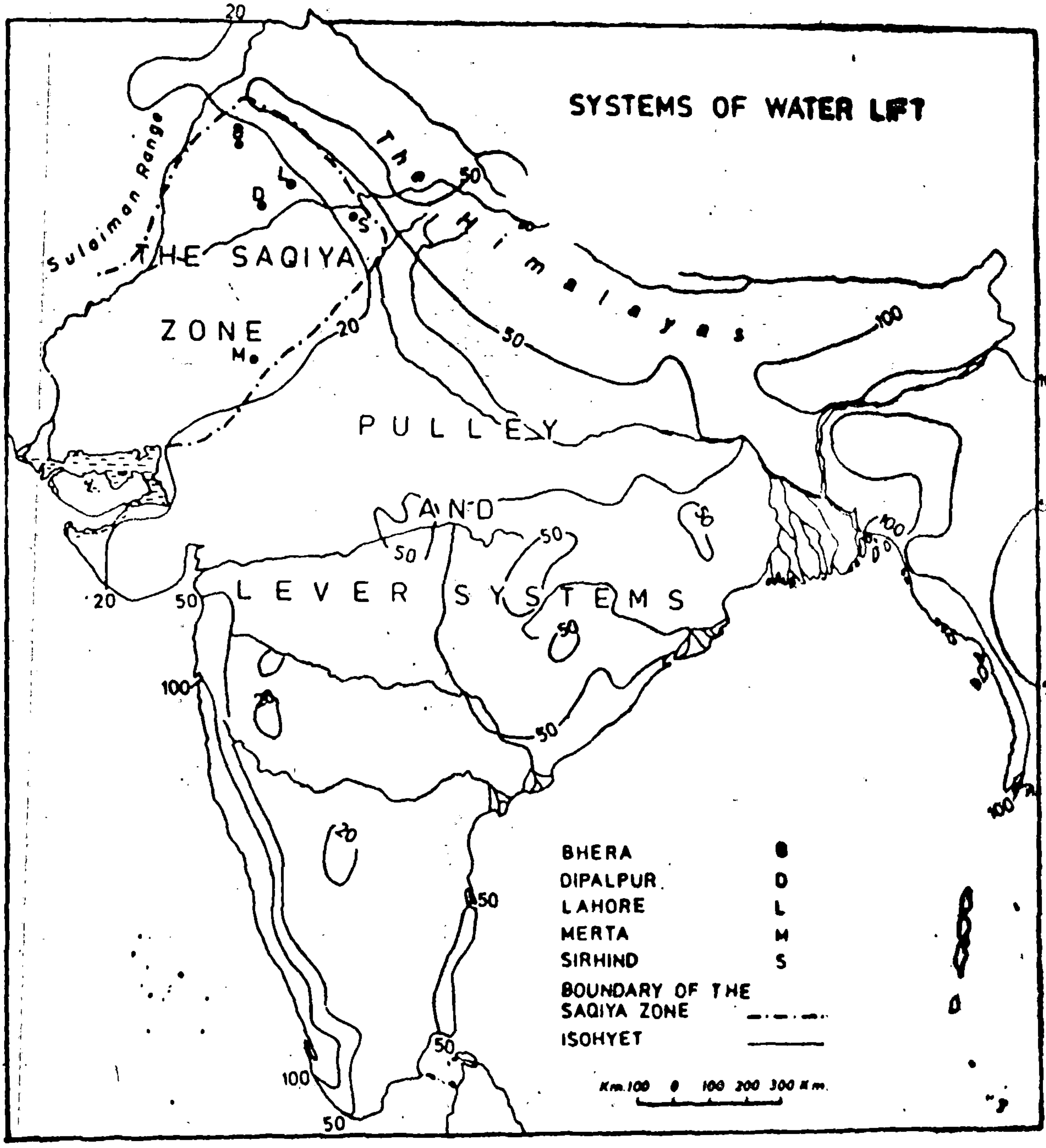
29. Ibid, pp. 44-45
30. Irfan Habib, "Technology and Barriers," p. 154.
31. Ibid, p. 155.
32. Irfan Habib, Agrarian Systems of the Mughal, p. 27.
33. Irfan Habib, Agrarian Systems of the Mughal, p. 29.



SYSTEMS OF WATER LIFT
Sulaiman Range
THE SAQIYA ZONE
The Himalayas
PULLEY AND LEVER SYSTEMS
BHERA
DIPALPUR
LAHORE
MERTA
SIRHIND
BOUNDARY OF THE SAQIYA ZONE
ISOHYET
Km.100 0 100 200 300 Km.

Large scale irrigation in 16th and 17th centuries India was of two kinds: (1) tanks created by embankments, from which canals of relatively small size would run to carry overflow for agricultural purposes: and (2) Long canals taking off from undamed rivers and traversing fairly long courses.[34] Only the later were largely found in Northern India and exhibit central Asian and Iranian influences; they were almost entirely laid out by the Mughal emperors and nobility.[35]

One of the most important objects of the Mughal Emperors and their nobles in building canals was to bring water to their orchards and gardens.Their own contribution to horticultural technology largely derived from their interest in growing central Asian and persian fruits in India by importing seeds and gardeners to India.[36] In the field of horticulture, the 17th century was a period of considerable innovation. Extensive application of grafting with important consequences for the field and quality of certain fruits might be traced out.[37] Grafting is not a single practice but involved a number of different methods namely tongue grafting,side,crown, deft,saddle and root grafting, veneering,inarching and inlaying.[38] But it is difficult to establish which particular method was ultimately utilised in each case.[39] Two distinct channels were under operation in bringing about these methods: the Mughal court and nobility,influenced by Persian,Central Asian traditions,and Portuguese with their roots in European Horticulture.[40]

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34. Irfan Habib,"Technology and Barriers",p.159.
35. Ibid, p.159.
36. Irfan Habib,"Technology and Barriers," p.161.
37. Irfan Habib,"The Technology and Economy of Mughal India," IESHR,Vol.17,No.1,(Jan,March,1980),p.4.
38. Ibid, p.4.
39. Irfan Habib,"Technology and Barrier,",p.166.
40. Irfan Habib,"The Technology and Economy Mughal India," IESHR, Vol.17,No.1, (1980),p.5.

The parallel worm is found in two different Indian devices, the cotton gin and the sugar mill and Nedham inclines to the belief that the rolling mill, based on parallel worm is an Indian contribution to technology.[41] Of the two, the sugar mill offers an extremely interesting problem in regard to the limits apparently placed upon its diffusion, for, two different methods of crushing sugar cane that were in operation in India.

First, there was the mortar and pestle-mill similar to the oil press. The mortar was best when made of stone, but in most areas, it became too expensive.[42] There was the Kolhu a large drum-shaped mortar, in which an almost upright timber beam or pestle was made to turn by an arrangement attaching it to a pair of circling bullocks.[43] The method was ill suited to milling cane, since cane had to be chopped into small pieces by katarwah and two ghaniwahs, fed the kolhu, removed the khoiya and drew off the juice. Finally, there was the specialist gur boiler who cooked after the fire under the boiling pan and superintended the preparation of gur.[44] Yet this mill was the only one used throughout the Gangetic plains except parts of deltaic Bengal.[45] Its presence in Mughal times is attested by the remains of large mortar

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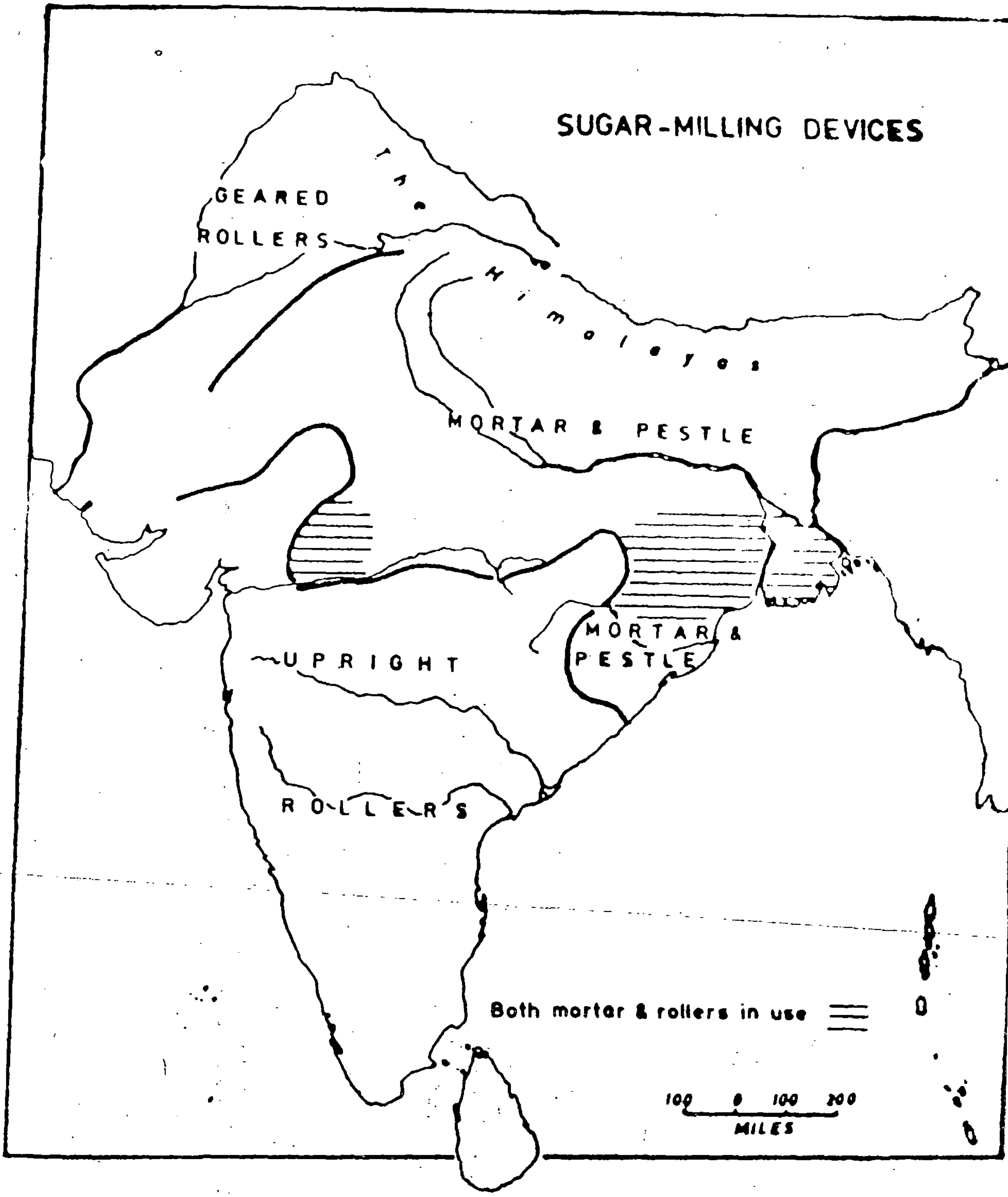
41. Joseph Nidham, Science and Civilization in China, iv, Pt. 2, p. 204.

42. Irfan Habib, "Technology and Barriers,", p. 155.

43. Shahid Amin, "Small peasant commodity production and rural indebtedness: The culture of Sugarcane in Eastern U.P., C. 1880-1920." See Ranjit Guha (ed.) Subaltern Studies I, writings on South Asian History and Society, (Oxford University Press, Oxford, 1982), p. 61.

44. Ibid, p. 63.

45. Irfan Habib, "Technology and Barriers", p. 155.


SUGAR-MILLING DEVICES
GEARED ROLLERS
The Himalayas
MORTAR & PESTLE
UPRIGHT ROLLERS
MORTAR & PESTLE
Both mortar & rollers in use
100 0 100 200
MILES

stones; an inscribed stone mill of A.D. 1553 and another of 1579, have been reported from eastern U.P.[46]

The second device, parallel to worm, was completely different one; involving the motion in opposite directions of two vertically mounted wooden rollers, one of which was rotated by oxen driven around it; the main roller moved the other through ridges on its upper part fitting into groves of the roller. In parts of Bengal, Bihar and Malwa both types of mills existed side by side. Other device in vogue during Mughal period was the roller. Careri in 1695 establishes its use in Bassein.[47]

Rollers were mounted only vertically (there by limiting the number of canes that could be milled at one time) so long as there was no gearing. This deficiency was improved in Punjab, where geared horizontal rollers were utilisêd by (1830-33) and were in general use as late as the 1880s.[48] The wooden rollers was actually more efficient than the mortar and pestle. But two or three pairs of oxen were required to operate the wooden horizontal rollers while in mortar and pestle mill one oxen operated the process.[49] Moreover the stone mortar was almost everlasting.

Undoubtedly, the minimal or the use of iron screws, hinges, clasps etc., the efficiency of the wooden implements was greatly affected and all of them would function properly.[50] The lack of the use of iron was, however, only because of costs. The price of good iron in 1595 is estimated, in terms of wheat to have

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46. A. Fuhrer, Monumental Antiquities and Inscriptions in the North Western Provinces, (Allahabad, 1891), pp. 187-319., (Azamgarh and Pratapgarh).

47. The Indian Travels of Thevenot and Careri, (ed.), S.N. Sen (New Delhi, 1949), p. 169.

48. A. Burnes, A Travel to Bokhara, i (Karachi, 1973), 44; See Also W.E. Purser's report 1884 and Hoshiyarpur District Gazetteer, pp. 97-101, both quoted in Watt Dictionary of Economic Products (DEP), Vol. VI, Pt. II, pp. 293-294, The rollers were called belna.

49. Fuller's report in watt DEP, VI, Pt. II, pp. 194-195.

50. Watt, DEP, VI, Pt. II, Pp. 293-299.

been three times it was in 1914.[51]

It is clear from the foregoing survey of agricultural technology that two separate sectors has been essentially traceable. The first, was the technology employed by the peasant, and, the second, was the technology employed or fostered under the aegis of the Mughal nobility. The peasants demonstrated little prejudice against new crops or techniques. It was merely their inability to afford any expense on their tools or on additional attractive power was the major obstacle on the line to further technological sophistication. This obstacle was further sharpened by heavy pressure of a regressive land tax, and this in its turn reduced the possibility of their affording any technological improvement. At the same time, the absence of latifundia precluded direct aristocratic interest in agriculture. Such interest was manifested, in large scale irrigation works and orchards, canal construction and grafting.[52]

The wood work of ploughs and other implements was manufactured and repaired by the carpenter; the cultivator merely supplying the wood. All the iron parts of the implement were supplied and repaired by the blacksmith, the iron, charcoal and working the belows had been provided by the cultivator and potter.[53] The payment of craftsman was either a payment in kind or a grant of land, besides perquisites on special occasions. For the

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51. W.H.Moreland, India At the Death of Akbar, (London, 1920), pp. 150-151.

52. Irfan Habib, "Technology and Barriers to Social Change in Mughal India," IHR, Vol. V, Nos. 1-2, (1978-1979), p. 161.

53. Ananda Kumar Coomaraswamy, The Indian Craftsman, (London, 1909), p. 1.

customary services, the craftsmen were repaid at harvest time, by receiving a fixed proportion of sheaves of grain from the crop collected on the threshing floor or they might be given a share of the communal land.[54] The carpenters used the Ari, Ārā, rukhani, basula, hole maker, reti, etc.[55]

From this survey it is quite clear that peasant class including pahī-kāshta, muzāri'ān, menials, washermen, tanners etc. had little or nothing to do with the development or sophistication of agricultural technologies i.e. technical advancement from below was an impossibility. Only the khud-kāshta and zamīndār classes were in a position to make some sort of contribution to the promotion of agrarian technology by encouraging rural craftsmen economically, socially, politically and culturally. Economically, if the rural craftsmen were pulled above the 'subsistence level' and were provided raw materials and other ingredients, there would be chances of further technological sophistication. Their social status should be uplifted so that their psychological feeling of inferiority complex had been eradicated and they had to work for new technical knowledge whole heartedly. Politically, the rural craftsmen should have been given liberty to think about things scientific and to use these in their day-to day life. Scientific knowledge should not be thrust upon them. Scientific culture and scientific temper should be made popular among the rural craftsmen and peasants and they should be made aware of the advantages of the utilisation of scientific knowledge.

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54. Ibid, p.5.
55. D.D.Kausambi, See his, An Introduction to the Study of Indian History, (Popular Prakashan, Bombay, 2nd edition, 1975), pp.345-352. Figurative description has been given.

CRAFT TECHNOLOGY

In Europe during 17th century many experiments had been undertaken by many individuals for searching for new and more efficient methods for nearly all processes of technological improvements that cleared the path for industrial revolution.[56] Larger and quicker outputs were required in all trades and only eventual mechanization could achieve this. These technological improvements, perhaps, could be grouped into two broad categories: first, the introduction of basic mechanical devices such as gearing, belt driving, screw, lever, crank, spring, etc. into one process after another; and second, the concentrated applications of longer and larger amount of power and heat in mechanical and chemical operations.[57]

Transferring our attention to the proto-industrialization of the late 17th and 18th centuries Bengal we notice that a number of mechanical principles were frequently operated in the machines of the proto-industries of Bengal with limited application. The first category of technological improvements were more or less applied in the simple machines of the proto-industries of 17th and 18th centuries Bengal. The second category i.e. longer and larger amount of power and heat in mechanical and chemical operations found meagre or no applications in the proto-industries of Bengal that made Bengal's proto-industrial system stagnant.

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56. Arther Raistrick, Industrial Archaeology, An Historical Survey, (London, 1972), p.221.

57. Irfan Habib, "Technology and Barriers," p.162.

Gearing,the premier device to control speeds of motion and convert vertical into horizontal motion and vice versa,was used extensively in the crafts of the Islamic world,which was brought about by Mughals to India and further adopted by Indian craftsmen.[58] But in actual fact gears were hardly applicable to other machines than persian wheel.In India,pin-drum gearing was applied in Persian Wheel.No other form of gearing was apparently known;[59] except the parallel worm used in the cotton-gin and sugar mill,which derived from a presumably indigenous and independent tradition.

BELT - DRIVE

The driving belt, a convenient device for transmission of power-especially for a reducing speeds of motion of a wheel in direct alignment to the main wheel - was an important addition to medieval technology. Lynn-White opines that driving belt was introduced through the spinning wheel towards the close of the 12th century.[60] In India the first explicit reference to the spinning wheel wab made in 1350.[61] The only other craft-apparatus in which it is known to have been employed in pre-colonial times is the jwellery's drill.

Since antiquity jwellers had been using the bow-string to impart rapid motion to the narrow shaft of their drill,[62] and was adopted by jwellers of the Mughal times and described by Thevenot

58. See Ibn-al-Razzaz-al-Jazari, The Book of Knowledge of Ingenious Mechanical Devices,tr.,Donald R.Hill (Dordrecht,1974), pp.274-275.

59. Irfan Habib,loc.cit.,p.162.

60. Lynn White, Medieval Technology and Social Change.(New York, 1966),p.119.

61. Irfan Habib has taken this statement from 'Isami,Futuh V's Salatin(ed.),A.S.Usha (Madras,1948),p.134.

62. Usher, A History of Mechanical Inventions,(Boston,1959), pp.153-154.

(in 1664).[63] This device was also used in cutting diamonds."Under steel wheels the Diamonds were fastened; and with its own Bort were worn in what cut the Artist pleased."[64] Till the early years of the 19th century, the "Common drill" were turned by the bow string; it had continued as a part of the standard equipment of the Indian carpenter and blacksmith.

SCREW

The threads screw, a metal fixing device, introduced in European technology from the middle of the 15th century only and contributed considerably in bringing about sophistication of instruments of abolishing soldering, rivets and wedge fittings. It also enabled the advancement of powerful lathes to cut grooves on the screw.[65] The first description of such a screw occurs in Thevenot in 1666. The Delhi craftsman had fastened to each of the two pieces that were to enter into one another, some iron, copper or silver wire, through souldering the wire to the pieces. The Indian metal smiths' screw was not made in direct imitation of the Europeans. The possibilities of the screw remained unexplored in India. The soldering of wire did not give way to the cutting of grooves, which alone would have given a strong enough screw and made its wider use possible.

TREADLES

Treadles are in actual fact levers operated by the feet. In China they have been ingeniously employed since ancient times. It appears universally in the weaver's loom. Treadles are

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63. Indian Travels of Thevenot and Careri, p. 138.

64. John Fryer, A New Account of East India and Persia, (ed.), W. Crooke, i (London, 1909), p. 285.

65. J. Nidham, Science and Civilization in China, IV, Pt. 2, pp. 119-120, Also see D.J. Price in Singer, A History of Technology, iii, pp. 628-629. Also see Usher, A History of Mechanical Inventions, pp. 361-362.

shown in the loom pictured in Mughal painters' depictions of the weaver-saint Kabīr at work.[66] Europe, too, received the treadles originally through the treadle loom that appeared there in the 12th century.[67] The use of treadles was then extended to other devices: to the lathe(13th century);to the pipe organ (early 15th century); to the spinning wheel(early 16th century).[68] Such applications of treadles never became known in India.[69]

CRANK

The crank has been assigned exceptional importance -"next to the wheel" - in the development of machine design.Lynn White points out that it appeared lately in Europe, as also to the development of compound crank from the 15th century onwards.[70] Cotton gin in India presented an example of crank handles in a crude form in 17th century depictions of the spinning wheel and in a refined in a late 18th century Kangra Miniature.[71] But no further sophistications developed;and the use of crank in craft equipment remained minimal.

SPRINGS

The knowledge of spring is as old as the bow. The metallic spring in use in pre-modern Indian technology was a simple bar bent into a bow shape. It is called kamānī in Hindi, Originated from Persian word kamān,(bow) comes naturally from this

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66. Irfan Habib quoted it from Album of Indian and Persian Miniatures(in the Lenin-grad Branch of the institute of the people of Asia),(Moscow,1962),Plate No.66(ascribed to the Mid 17th Century).See his "Technology and Barriers," p.164. Also see Irfan's, "Technology and Economy of Mughal India,"IESHR,Vol.17,No.1,(Jan.,March, 1980),p.7.
67. Lynn White, op.cit.,p.117.
68. Ibid,pp.117-119.
69. Irfan Habib,loc.cit.,p.164.
70. Lynn White, op.cit.,p.103.
71. See Irfan Habib, loc.cit.,pp.164-165.

shape. Its greatest use in Mughal India seems to have been in lock and in muskets.

The metallic coiled or spiral springs that developed in Europe about 1400, first for use in locks and then in muskets, never became familiar to Indian smiths. Since modern clocks and watches evolved when the weight-drive gave place to spring drive, spiral springs became an essential element in the working of the clock.[72] In India indigenously made clocks did not, however, make their appearance. Bowery (1669-79) supposed that the Indians did not make the mechanical clocks because they manufactured their own convenient and accurate water clocks.[73]

COTTON TEXTILE TECHNOLOGY

The cotton in the state of kāpās was cleaned and prepared by the women who spun the yarn. Fragments of the leaves, stalks and capsules of the plant were carefully picked out with the fingers and the adhered wool to the seed was then carded with the jaw bone of the boalee fish, the teeth of which, being small, recurved and closely set, acted as a fine comb in removing the loose and coarser fibres of the cotton and all other extraneous matter like minute particles of earthly and vegetable matter, from it.[74] The Hindu spinner cleaned with this instrument each separate seed of cotton.

The instruments which were used to separate the seeds from

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72. Lynn White, Medieval Technology and Social Change, pp. 126-127.

73. Thomas Bowery, A Geographical Account of Countries Round the Bay of Bengal., (Cambridge, 1905), pp. 195-196.

74. J. Forbes Watson, The Textile Manufacture and the Costumes of the People of India, (London, 1867), p. 64.

the wool were the charakhī, kamān[75] and dullun kathi.[76] There is evidence that the two important instruments for ginning and cleaning (charakhi and kamān) had been into operation much before the Mughal period. For the charakhī, the first textual reference was made in India in 18th century lexican. The bow-string was not the sole device for carding cotton in India. Other devices existed to clean the cotton.[77]

The charakhi was the common hand mill or pair of fluted cylinders, employed to clean cotton for the second rate qualities of thread while the dullun cathee was used to clean carefully the small quantities of the cotton for the finest thread. It was simply an iron pin that was rolled upon a flat board upon which the cotton was laid. An attempt was made to improve the machine for cleaning cotton on the principle of the charakha during the course of 19th century for which orders were placed to import them into Bengal and Bombay.[78]

The next step to be taken was to tease the cotton or to free it from the remains of husks by means of a small bow made of bamboo with a string of catgut or muggā silk. The bamboo slips were moveable within the centre piece and were drawn out or pushed back for increasing or diminishing the tension of the cord. This operation changed the cotton to the state of light

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75. Irfan Habib, "The Technology and Economy of Mughal India," IESHR, Vol. 17, No. 1, (Jan., March, 1980), p.6.

76. James Taylor, A Sketch of the topography and statistics of Dacca, (Calcutta, 1840), p. 165.

77. Irfan Habib, "The Technology and Economy of Mughal India," IESHR, Vol. 17, No. 1, (Jan, March, 1980), p.6.

78. See Mr. Huttmann, Official Papers Connected with the Improved Cultivation of Cotton, (Calcutta, 1939), p.4.

downy fleece.[79] The bowed cotton was never utilised for the manufacture of thread. It was exclusively applied to the manufacture of rough and coarser articles for winter clothing for the Musalmāns. The cotton used for the manufacture of the finest thread underwent a carding before it was teased and bowed.[80] Then it went to a thick wooden roller and was pressed between two flat boards. Next, it was rolled round a piece of lacquered reed of the size of a quill and lastly, enveloped in the soft skein of the <u>chuchia</u> fish, which functioned as a cover to prevent and preserve it from dust and other pollutants during the process of spinning.[81]

The spinning apparatus contained in a small flat work basket, comprised of the cylindrical roll of cotton, a delicate iron spindle, a piece of shell embeded in clay and a little hollow stone containing chalk powder for applying the fingers of spinners occasionally.[82] The spindle was not much thicker than a stout needle. It was from 10 to 14 inches long, finely polished, steel made, with large size of needle, with a small ball about the size of a pea of clay, unbaked, to provide enough weight in turning. The spinner held it in an inclined position, with its points resting in the hollow of the piece of shell. It was turned between thumb and forefinger of one hand and the single filaments, at the same time, had been drawn by holding it in the

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79. J.Forbes Watson, <u>The Textile Manufacture and the Costumes of the People of India</u>; (London, 1867), p.64.

80. James Taylor, <u>A Sketch of the Topography and Statistics of Dacca</u>: (Calcutta, 1840), p.166.

81. James Taylor, <u>A Descriptive and Historical Account of the Cotton Manufacture of Dacca in Bengal</u>, (London, 1851), p.18.

82. James Taylor, <u>Ibid</u>, p.18. Also see, J.Forbes Watson, <u>op.cit.</u>, pp.64-65.

other hand, and finally, twisted into yarn upon the spindle. Then it was wounded upon a reed. Since the dryness of the atmosphere forbade the filaments of cotton from being sufficiently attenuated and unfavourable to the spinning of fine yarn.[83]

SILK TECHNOLOGY

The spread of sericulture in Bengal was, however, more modern earlier than the 15th century. Before the introduction of the filature system, the silk was wound of with primitive instruments. The silk worms were first placed in boiling water in earthen reeling basin, boiled with cowdung fuel. Then, the silk thread was wound off the cocoons upon the reels made of bamboo. The reel known as nuttah or laya was fastened to wooden spindle twisted by the reeler round with his hand. This technique was faulty because it created inequality in the thickness of the skein with frequent breaks which impeded operations in the weaving factory.[84] Tools and models were procured from Novi and London. Double crossing machine[85] and cog wheels were introduced in India.[86] The machine introduced by Wiss in 1770 was moved by a winch. There was a furnace for heating the reeling basin. The Piedmont reel was larger than Indian nulta. The mechanism of double crossing and twisting the threads gave the silk a roundness and a "good body."[87]

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83. Ibid, p.19.

84. S.Bhattacharya, "Cultural and Social constraints on technological innovations and Econom Development: Some case studies," IESHR, Vol.III, 1966, p.242.

85. Copy of a letter from Mr. Wiss to the Court of Directors dated the 26th Feb, 1784. See Board of Trade, (Commercial), General letters from the Court of Directors, 18th Dec, 1765 to 15th Sept, 1785, p.301.

86. Extract of General Letter from the Hon'ble Court of Directors, dated the 14th July, 1779, Duke Kington received 1st July, 1780, Board of Trade, (Commercial), p.202.

87. S.Bhattacharya, op.cit., p.243.

The new machines were complicated, unfamiliar and costly. The production of some of the parts of the machine especially the winch and Cogwheel arrangement, required a higher degree of perfection and precision than the village blacksmiths and carpenters were capable of. They managed to manufacture the machine in course of time by fairly imitating it but without the mechanism for twisting the fibre as they were wound from the cocoon.[88]

Matkā spinning gave occupation to the poorest of women. The empty cocoons were kneaded with a little clay and left to be soaked in this paste for a little while and then they were taken up one by one with the left hand while a strand of fibres was drawn out of it with the thumb. The fibres were kept twisting with the revolution of the spindle. When the portion drawn out has been thus twisted into a single and firm thread, it was collected at the base of the spindle and another strand of the fibres drawn out of the cocoon and twisted as before. When one cocoon was finished, other was taken up, the fibres from this were joined to the fibres of the previous cocoon and the operation was continued. After one day of spinning, the thread was gathered on a lātāi. The profit of matkā spinning was extremely low. Lātāi was a skelton bobbin made of bamboo laths.[89]

The country method of reeling was called khāmru.[90] The ghai was the machine by which khāmru silk was made. Each ghai had a spinner for turning the handle of the tohbil. Ārā and tohbil were

88. Ibid, p.245.

89. Art in Industry through the Ages, Monograph series on Bengal, (Delhi, 1976), pp.22-23.

90. Ibid, p.24.

connected by means of a string passing through the groove of the wheel on the ārā and another on the offside of the axis of the reel. Ghai started by steaming the cocoons. The steaming made the cocoons easier to reel. The end of the lots were passed through the two holes of the kal. There were two upright wires on the kal to keep the two lots of the fibres separately during the reeling. These provided two croiseurs to the fibres, one between the wholes of the kal and the upright wires; and the others, between these wires and the reel. The friction caused by these croiseurs agglutinated the fibres together and made them pass on to the reel as two firm and single threads. Reel was turned by pakdār and the cocoons before the katāri got worked off. The function of katāri was to separate out the entangled cocoons, ends of new cocoons thrown along with the fibres which were being reeled, as the old cocoon work off. He feed cocoon after cocoon during the process of reeling.[91] Any interruption or break was assisted by pakdār in re-establishing order and union. In khāmru-reeling the re-establishing the end with a break and putting a knot like in European filature was not practised.

Bleaching of silk was also done through crude carbonate soda. A seer of silk was bleached by (a) one paw or (½ Lb.) of saji; was powdered and mixed up with 2.5 seers of hot water and steeped for a number of times, (b) half seer of ashes obtained by burning plantain leaves was mixed up with 2.5 seers of hot water and steeped for a number of times, (c) half seer of ashes

91. Ibid, p.27.

obtained by burning plantain leaves was mixed up with 2.5 seers of hot water and strained. A piece of cloth was spread over a basket and a mixture of powdered saji or ashes or mixture of the two with water was poured into the basket and strained. This process was repeated until the liquid looked like oil. This liquid or lye was mixed with about ½ maund of water and boiled. Into this boiling water a seer of silk was introduced and after taking out from this bleaching was done and washed into clean water. Some loss of weight could be observed. Korrahs were bleached by dhobis who were assisted by women.[92]

DYEING

The dyeing industry was in a flourishing state in Bengal during 17th and 18th centuries.[93] Coarser cotton clothes were either dyed or printed with a variety of well shaped and well coloured flowers and figures. Cloth printing seemed to be an Indian practice, which others were only beginning to follow.[94] In dyeing and imposing coloured designs after weaving we are referred to the employment of almost all the well known Indian methods, including simple immersion in dye.[95] Besides the ancient resist and mordant method of printing, direct colour-printing by blocks was also practised on a large scale. The tie and dye method, the bandhanon method, and painting with pencils were also in vogue.[96]

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92. Ibid, p.83.

93. Shiv Chandra Jha, Studies in the Development of Capitalism in India, (Calcutta, 1963), p.55.

94. Irfan Habib, "Technology and Barriers to Social Change in Mughal India," IHR, Vol.5, Nos.1-2, (1978-1979), p.167.

95. Irfan Habib, "Indian Textile Industry in the 17th Century," in Essays in Honour of Prof.S.C.Sarkar, (Delhi, 1976), p.184.

96. Ibid, p.184.

Forbes, supposes that the resist or mordant methods of dyeing represented early forms of calico printing proper and originated in ink seals (cf. black-on-white calico printing).[97] The resist and mordant, were applied for the multi-colour or pattern dyeing in India;the resist was applied to confine colours to pattern white mordants to take colours.[98] Printing blocks might have been used to apply the resist and mordants since early times as evidenced from Egypt and Iran for 3rd and 4th Century A.D. The methods of resists and mordants for painting and printing from wooden blocks vogue in Europe in the 17th century were also applied in India. The later saved time and cost but was not fine or of high value.[99] Indian textiles especially the painted and resist dyed cotton were far superior to the dyed fabrics then produced in Europe and were greatly praised by the English for their clear, long lasting and lovely colours.[100] The references of calico painting and calico printing were found repeatedly in Thevenot's accounts.[101]

The dyers of Bengal were noted for their simple and uniform colours, with the fabrics given a narrow border of a different shade. The use of indigenous vegetable dyes were practically utilized in Bengal.In Faridpur a yellow dye was obtained from the kusum tree,the petals of this were dried and boiled and the solution used for colouring yarn.[102] In the Chittagong Hill tracts blue

97. Irfan Habib, "Indian Textile Industry in the 17th century," op.cit.,p.185.

98. Irfan Habib,"The Technology and The Economy of Mughal India," IESHR,Vol.17,No.1,(Jan.,March,1980),p.8.

99. Ibid, p.9.

100.Peggy Woodford, Rise of the Raj,(New Jersey,1978),p.52.

101.Irfan Habib, "The Technology and Economy of Mughal India," IESHR. Vol.18,No.1,(Jan.,March,1980),p.9.

102.Rustam J.Mehta, The Handicrafts and Industrial Arts of India, (Bombay,1960),p.119.

dye was obtained from the indigo plant and a red dye from the roots of the tree known as rangach. The roots were first cut into small pieces and smashed to make pulp, water and ashes of tamarined woof had been added and carefully strained away, then was mixed with the pulp and the yarn was kept soaked in it for a night. It was placed 3 or 4 times into the solution and was sheared with vegetable oil before the last dipping. In Chittagong, a chocolate colour was achieved from the bark of a tree by cutting into clips, leaving into cold water for 4 or 5 days and then boiled for atleast a day.[103]

Lac work was a great and widely extended industry in India. Lac was manufactured on an wide scale in Elambazar in Birbhum, and Lohardagga district of Chotanagpur.[104] Lac dye was achieved from the small cells of the incrustation and formed the body of female insect. The entire incrustation including twig was called sticklac. For obtaining the largest quantity of dye, the sticklac must be gathered before the young come out which happened twice in the year in January and July.[105] That which remained, after the colour was extracted and was utilized embelish toys made in the lathe.[106]

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103. Ibid, pp.119-120.
104. George C.M.Birdwood, The Industrial Arts of India, Part II, (Piccadilly, 1880), p.223. Also see W.W.Hunter, The Indian Empire, (London, 1973), p.113. Lac is a cellular, resinous incrustation of a deep orange colour, secreted by an insect called coccus lacca round the branches of various trees. The chief among these were kusum, palas, pippal and baer. The principal component of lac was resin, forming about 60 or 70% from which was produced the shell lac commerce.
105. Ibid, p.113.
106. Tavernier's Travell in India, Vol.II, (ed.,), V.B.Ball, (New Delhi, 1977, p.18.

The other dyes were as follows: turmeric, produced a bright but perishable yellow; the wood of the jack tree, provided good yellow, less bright but more permanent, safflower gave two beautiful colours namely gulābī, and kusum, both of red rose, manjeet gave a fixed red colour, produced golden colour called sonāla applied after jack wood. There were three shades of colour called uda, (dark red) and produced by haritaki, the second by chamalati and the third by alum. A dye called labang, karanphuli were fixed brown. All these colours were applied to silk. The cotton thread was always dyed with one of the following three colours: sālu, a well fixed light pomegranate colour; uda, a dark red of various shades; and finally kusum, a beautiful light red but not well fixed.[107]

Various experiments of Patna manget in dyeing of cotton for the purpose of calico-printing had been undertaken.[108]

The printing was performed with thickened mordants and dyed in madder or with colours applied directly, (insoluble pigments

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107. W.W. Hunter, A Statistical Account of Bengal, Vol. VII, (London, 1876), p.97.

108. See Extract of Commercial General letter from the Hon'ble Court of Directors to the Governor General in Council dated the 24th March, 1791 in Board of Trade (Commercial), General letters from the Court of Directors, 1790 to 1796, Vol. 3, p.69. Following patterns had been applied: (1) after having been prepared by an acid and printed with the proper mordants, boiled in madder from turkey roots, worth at present 45/ton and bleached on the gras; (2) Piece of some cloth and the same pattern and printed exactly a like, boiled at the same time in an equal weight of Patna Manget and also bleached on the grass; (3) same piece boiled in the same weight of Manget but not bleached; and finally (4) piece boiled in madder but not bleached. It is obvious from these experiments that the Patna Manget was not as strong as the Turkey madder, although had superior brightness. But it had the peculiar property of fixing the mordant or colour without straining the ground or white part of the cloth, by which a great part of the expense and time invested in bleaching had been saved; this alone gave it a value far beyond any specie of madder.

diluted in a viscous supporting medium, thickened decoctions of tinctorial woods and plants), because the printed clothes were usually of an inferior quality compared to the painted fabrics.[109] For painting one must choose those of soft and less closely beaten clothes precisely because in the too hard clothes, the penetration of colour printed by painters was not deep and remained on the surface of the cloth, to be lost at second tanning. For choosing clothes for printing, one must prefer soft and good cotton yarn i.e. the warp threads should not be tightly twisted and should correspond in parity with the weft to make the fabric even and smoother for providing the blocks to be fully applied and the surface bloom well preserved and not to be cracked.[110] Another fact to be noted during the application of the blocks was the cleanliness of the blocks.If the pigment was sticky,it began to dry in the engraved lines of the block,it filled some passages in the design, produced fault and imperfectness in the printing.Broken points in the blocks or covering some flaw with wax were avoided, Properly and carefully choosen and inspected.Furthermore,narrower points in the blocks at one end than the other was productive of dirty tracks between the flowers and they could not follow the straight line,consequently,new blocks were always preferred to undertake the printing.[111]

All types of blocks were not suitable for the same fabrics.A fine sharp block could not be used in printing on a coarse

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109. Paul R.Schwartz, Printing on Cotton at Ahmedabad:India in 1678,(Ahmedabad,1962),p.1.

110. Ibid, p.4.

111. Ibid, p.4.

cloth.If the block was rough with raised and irregular grain,the block would be cracked at the second blow in printing.The blocks must be strong in the proportion to the body of the cloth and the fine sharp ones used for the finest fabrics. The fine <u>chintes</u> had the most delicately worked designs than the ordinary ones because the blocks were more artistically made and glide smoothly and consistently without resistance whereas on coarse cloth the workers failed to use them a second time.[112] These little insect pieces were used for changes of colours and each one had only a portion of a flower, when the <u>chinte</u> was of several colours. If they were of two colours like <u>jafracanis</u>,a single block was sufficient with one small piece, but,so far as <u>panchrangis</u> were concerned,sometimes upto 10 pieces were required to be applied at a time with increased time spent by labourers changing double or tripple wage.[113] The white ground demonstrated great variety of colour.[114]

The period from the month of October to June was regarded as appropriate for printing because this period offers calm,clear and radiant sun necessary for drying their work immediately.Very clear and clean water was also needed to wash out the dross of the printing and the dirt attached itself. Cold and damp conditions were injurious to printing as well as to the bleaching.

The clothes were washed to remove the dressing, which the weaver had applied before painter applied any colour.It was

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112. <u>Ibid</u>, p.5.
113. <u>Ibid</u>, p.5.
114. Milburn, <u>Oriental Commerce,Vol.I</u>,(London,1813),p.46.

then steeped in gingely oil for five days if it was hot season and doubled the time if it was cold. The gingely seed from which the oil was extracted were of two kinds: one flat and white and the other black which was like powder for a musket.[115] After it was thoroughly absorbed in the oil, they daub it with camel dung; dried and washed it, beaten it to flatten the thread. Then, the first application of dye was made. They prepared a black colour with myrobalan and wheaten flour soaked in water until it had become thoroughly sour, mixed it with iron rust and boiled together to make fast black and for further more fastening they added into it couldron, several seers of gum. Afterwards, the painter spread out the cloth lengthwise on the tables, soaked the blocks in this black dye and started printing in row along the left side and continued with others in the same way until the width was filled. The first block of the pattern only distinguished the outlines by its lines and hollows. Another block of the same size, covered this one completely with same pattern but differently worked, utilized in the places where the first had raised outlines. Its voids went directly on the imprint of the first, which it conserved entirely without any detriment to the colour. The rest of the second block were without engravings, because it were applied for filling the ground of the cloth with the desired colour. When the ground with red or violet was dried, little blocks with a detail of the designs applied by changing it with the selected colours between the black outlines of the first block. When this was dried, a third block upon this last, worked in the form of rays, providing shading to the

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115. P.R.Schwartz, Printing on Cotton at Ahmedabad:India in 1678, p.7.

flower by little lines, which was ordinarily the colour of indigo was carefully applied and operated.[116]

The last operation in the process of printing was to soak the cloth in hot water to remove the wax, which had conserved the white and green, again shaped into river water and dried it in very hot sun. This was performed many times for about 8 days depending on the season since the application of much more sun heat provided beautiful colour. Lastly, green colour was applied with small block made for the purpose and delivered to the customer.[117]

POWER METALLURGY AND MINING TECHNOLOGY

In most of the rural crafts of the Mughal period excluding agricultural technology, human muscles were the sole source of power although cattle power were occasionally dispensed with.[118]

The bellows in common use in India was made of the skin of a kidor goat taken of the animal by opening the hinder part only. The holes corresponding to the legs were sewn up; at the neck end was inserted a nozzle of bamboo while the tail end was out transversely, so as to form a long, straight slit for the admission of air, when the edges were brought together. For achieving considerable length of each of the edges, a piece of split bamboo was firmly tied on the exterior for readily closing or opening and to get the act the part of valve.[119] The skin functioned as supple by rubbing it with oil or butter-milk. Each furnace was provided with

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116. *Ibid*, pp.7-8.

117. *Ibid*, p.8.

118. Irfan Habib, "Technology and Barriers to Social Change in Mughal India," *IHR*, Vol.5, No.1-2, (1978-79), p.166.

119. John Percy, *Metallurgy: the art of extracting metals from their ores and adopting them to various purposes of manufacture, Iron and Steel*, (London, 1864), p.255.

atleast two such bellows. One man sitting cross legged on the ground between the bellows for moving them alternately to operate a continuous and regular blast.[120]

Large bellow of similar make was constructed of buffalo hide, with some alterations that the skin was sewn up along the line of the belly. The bamboo strips were attached together at one end of the valve and could be separated only at the other where they were prolonged beyond the skin, so as to form convenient handles. This bellow required one man to operate the instrument.[121]

In some parts of Bengal, bellows of a very different and ingenious construction were in vogue. Small single-acting blowing cylinders of wood, of which the piston packed with feathers were in operation.[122]

The Indian furnaces were frequently smaller. The furnace may be divided into three typical kinds: The first was wide prevalent along the western coast of India, in the western ghats and usually through the Deccan and the Carnatic. It was of the rudest form. The second and third greatly in advance of the first and had the ability of manufacturing considerable quantities of wrought iron as well as natural steel were in wide operation in central India and North West provinces.[123] The ores employed were magnetic

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120. *Ibid*, p.255. The bellows was operated in the following manner: A leather thong passes from one of the lips of the vale round his hand and to fill the bellows he drops the lower lip and raises the upper one, when air enters, swelling out the skin into the shape of a conical bag. He then quickly catches up the lower lip, closes the valve and bears with his weight on the inflated skin, forcing out the contained air through the nozzle into the furnace.
121. *Ibid*, p.256.
122. *Ibid*, p.256.
123. *Ibid*, p.255.

oxide, rich red and haematites. The process of smelting varies according to the districts and localities due partly to local custom and partly because the art had most advanced.

The failure to impart a sufficient amount of air to the furnaces failed to melt sufficient amount of metal at one time in each furnace. This adversely affected the quality of metal when it had to be used in large mass like in cannon.[124] One of the earliest illustrations of a cannon was appeared in a manuscript by walter de Millemete dedicated to Edward III in 1327. Edward III used them in the siege of calais in 1345.[125] The commercial utilisation of cannon occured in the capture of St. Malo in 1378 (about 400 of it were used).[126] Cannons were manufactured in Bengal and Assam.[127] The reference to gun in Bengal was traced as early as 1406 AD., when Mahuan visited the country.[128] Excellent guns were manufactured in Bengal during 17th and 18th centuries.[129] Abū-l Fazl remarked: "Some pieces of cannon are so large as to carry a ball of 12 maund and other require each several elephants and thousand bullock for their transportation. Darogāh and clerks were appointed to look after this department."[130] Some of these were so contrived as

124. Irfan Habib, "Technology and Barriers to Social Change in Mughal India," IHR, Vol. 5, No. 1-2 (1978), p. 166.

125. W.H.G. Arymtage, A Social History of Engineering, (London, 1976), p. 49.

126. Ibid, p. 49.

127. Shiv Chandra Jha, Studies in the Development of Capitalism in India, (Calcutta, 1963), p. 46.

128. P.K. Gode, Studies in the History of Culture, p. 7.

129. See, K.K. Datta, Alivardi and His Times, (Calcutta, 1963), p. 184.

130. P.K. Gode, loc. cit., p. 14.

to carry them into pieces and when the army halts they were nicely put together again. This difficulty enabled to the production of gun carriages. At the beginning of the mid 18th century the manufacture of gun carriages was concentrated at Cassipur in Calcutta and Fathegarh in the upper provinces.[131] Reference to gun carriages was made in consultations, dated the 3th Dec., 1752 that gun carriages were made both in Calcutta and Qassimbazar, in the former place these were made cheaper and better than in the latter.[132]

There were others which could be easily transported by one elephant and were called gujral. Still others could be easily carried by a man and were called nurnal. Bunducks were now also manufactured with least fear of their bursting. Some of the bunducks were not required fire to be operated rather they require a little motion to trigger.[133] Flint muskets were also manufactured.[134] It is not surprising then that in spite of good quality of domestic iron ore and the celebrated method of making steel,[135] Indian iron manufactures generally could not compare with the European in quality.

In metallurgy it displayed some successes as well. Already by the end of the 16th century zinc had been isolated in India; instruments were manufactured, of "refined metals not employed in Europe."[136] Alloys of copper and tin known as bronze, brass was the

131. J. Kumar, Company India, A Comprehensive History of India, (1757-1858), (Patna, 1980), p. 249.
132. Consultations, dated the 4th Dec, 1752 quoted in K.K. Datta's, Alivardi and His Times, (Calcutta, 1963), p. 184.
133. P.K. Gode, op. cit., p. 15.
134. K.K. Datta, Studies in the History of Bengal Subah, Vol. I, 1740-70, (Calcutta, 1936), p. 434.
135. C.S. Smith in Singer, (ed.), History of Technology, iii, p. 35.
136. Nicolao Manuci, Storia do Mogor, 1656-1712, tr., W. Irvine, (London, 1907-8), ii, p. 71.

alloys of copper, zinc and lead. Bharan, an alloy of brass or zinc, bronze or tin etc. and sold as kansa.[137] The hammer, the anvil of various shapes and sizes, the chisel, the iron tongs, the file, the lathe, the scraper used for the lathe called noyali, chhurri, katāri, rod of iron called sabal of various sizes etc. used in making various house utensils.[138] A proposal for extracting lead was made during the later half of the 18th century.[139]

Prof. Irfan Habib quoted Thevenot to discuss the working of gold-enamelling and opined that gold-enamelling was not practised in Mughal India.[140]

A closer and comprehensive scrutiny of the synthesis of Hindu and Muslim decorative arts, its era of progress and high watermarks during the Mughal period, demonstrates that the art of enamelling reached its zenith.[141] During Mughal age enamelled jewellery took many of the attributes of the Mughal miniâture paintings. Even the backs of the ornaments were superbly designed with floral and geometrical patterns with birds, beasts, trees, etc. The front of the ornament was also set with precious stones held in place by pure gold bands called the kundān. Only the finest and purest gold was used for enameller's art.[142] The art of soldering gold wire and inlaying it on other material was exceptionally well-developed.[143]

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137. Art in Industry through the Ages, Monograph series on Bengal (Delhi, 1976), pp. 281-283.
138. Ibid, p. 284.
139. Letter to the Court of Directors, Jan. 1778, See Board of Revenue, General letters to the Court of Directors, 1778 to 1780, Vol. 4, p. 61.
140. See Irfan Habib's, "Technology and Barriers to Social Change in Mughal India," IHR, Vol. 5, No. 1-2, (1978-79), p. 167. Also see Thevenot, Indian Travels, pp. 55-56.
141. Rustam J. Mehta, The Handicrafts and Industrial Arts of India, (Bombay, 1960), p. 17.
142. Ibid, p. 18.
143. Thevenot in Indian Travels of Thevenot and Careri, pp. 55-56.

Razi (866 AD) was the first to list equipment for melting metals and attempted a systematic classification of chemical substances. They found native aluminium sulphate, treated it with stale urine and other materials to make alum-a 'fixer' for dyes. The production of alum was, actually the earliest chemical industry.[144] Alum dye was also practised in Bengal during our period.

In chemical industries, a major achievement was lacquer ware which inspired the varnish techniques in Europe.[145] Distillation of oils to obtain essences, as well as the manufacture of distilled liquor, was wide spread.[146] A new practice, in whose discovery India was ahead of Europe, was chemical refrigeration, in which water was cooled by utilising salt petre.[147] Manufacturing of ice in Bengal was done on a large scale. The Bengalis had a method of manufacturing artificial ice with boiled water. This ice was manufactured from November to February.[148]

Mr. Keir informed in January 1778 that he had succeeded in manufacturing industrial potash and requested to sell it duty free. The Company was desired to encourage this industry agreed to exempt Mr. Keir from the payment of duties on potash till the

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144. W.H.G.Armytage, A Social History of Engineering, p.40.

145. For Mughal Indian Lacquer ware, see Mandelslo's Travels in Western India, AD. 1638-39, p.17. Also see J.Marshall's, Notes and Observations in Bengal, 1668-72, (ed.), S.A.Khan, p.415. For influence on Europe, see, F.W.Gibbs (ed.), History of Technology, iii, p.696.

146. P.K.Gode, Studies in Indian Cultural History, Vol.I, pp. 15-37.

147. J.R.Forbes, Studies in Ancient Technology, VI, p.105.

148. K.K.Datta, Studies in the History of the Bengal Subah, Vol.I, 1740-70, p.435.

19th of October 1779.[149] The first utilisation of washing with soap was made by barbarians i.e. the Fanti of West Africa and the Gauls of the first century AD discovered soap independently. To pling (Natural History Book 28, Chapter 51) soap was invented by the Gauls for 'giving a reddish tint to the hair' and a propaedeutic for scrofullous sores.[150] The cloth washing soaps were mentioned first by the time of Aretaeus (AD 250). Soap appears to have been introduced into India by Muhammadans, who were the principal manufacturer of soap during 19th century in Bengal. The Hindus used a liquid formed from the ashes of different plants, particularly the plantain tree, in washing clothes. The Indian name of soap (sabun) is an Arabic word, and appears to be the origin of <u>sabun</u>, a Crimean word. The soap manufactured at Dacca was the best in Bengal and exported to different parts of India, Bassora, Jeddah etc. It was comprised of the following materials viz: shell-lime 10 maunds; <u>sajee mattee</u> 36 maunds; common salt 15 maunds; <u>sessam</u> oil 12 maunds; goat's suet 15 seers.[151]

One of the important segments of modern chemical industry was the development of the glass industry. Glass-making in England was encouraged by Norman Workers like Laurentius Vitrearius around 1226.[152] The industry developed especially in the weald, and enjoyed virtually a national monopoly both of window and vessel

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149. Letter to the Court of Directors, January, 1778, See Board of Revenue, General letters to the Court of Directors, 1777 to 1780, Vol.4, p.61.
150. W.H.G. Armytage, <u>A Social History of Engineering</u>, p.42.
151. J.Forbes Watson, <u>The Textile Manufacture and the Costumes of the People of India</u>, (London, 1867), p.71.
152. W.H.G.Armytage, <u>op.cit.</u>, p.44.

glass until the 16th century.[153] Stained glass techniques stimulated works on pigments, lenses and practical chemistry. Laws of optics were discussed by Robert Grosseteote (1168-1253) while his student Roger Bacon (1217-92) pointed the way to the microscope and telescope.[154] Some products of these developments percolated to India. One was sand glass. The glasses were made to show the passage of a ghari or 24 minutes and thus were essentially of Indian made.[155] It has been exhibited that the use of spectacles (made of glass lenses) in India was traceable first only in the second decade of 16th century.[156] Spectacles made of crystal could have been indigenous manufacture.[157]

A significant sector which was provided particular promotion for Technological improvement in Europe was mining. Deep excavations necessitated improvements in haulage, survey methods, pumping and so on.[158] The mining in all field in the 17th century in Europe had been badly hampered by water and any expansion in the 18th century depended upon securing the means of adequate drainage. These were provided in two ways: by the invention of the steam engine to operate more powerful pumps, and by the development of adits.[159] In the 18th century Bengal, some mines had

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153. Ibid, p.44.
154. Ibid, p.44.
155. Irfan Habib, "Changes in Technology in Medieval India." Studies in History, Vol.ii, No.1 (jan, June, 1980), p.35.
156. A.J.Qaiser, "Level of Technology in India on the eve of the 18th Century: The case of Glass," Studies in History, Vol.ii, No.1, (Jan, June, 1980), p.85.
157. Irfan Habib, "Changes in Technology in Medieval India," op.cit., p.35.
158. Irfan Habib, "Technology and Barriers to Social Change in Mughal India," IHR, Vol.5, No.1-2, (1980), p.173.
159. Arthur Raistrick, Industrial Archaeology: An Historical Survey, (London, 1972), p.223.

considerable workforce. Blanford in his report stated that in 1858-60 within the coal producing area of about 500 square miles, near about 50 collieries in operation belonging to 15 proprietors.[160]

All borings for probing the coal fields were done by hand and any boring of over 250 ft. was considered a fine performance. Sinking operation was also primitive and shafts were sunk to a depth of 100 feet. The pits were circular in shape varying from 8 to 10 feet in diameter. Double pits in which two buckets were used were operated. Quarries were either opened in nullahs where outcrop appeared or few yards away from their beds.[161]

The large collieries were working their seams according to pillar and stall system[162] for preventing the fall of the roof consisted essentially in cutting out the coal in a rectangular pattern of rods, which were left between them unworked blocks of coal, the pillars of larger dimensions than the roads to support the roof.[163] In this method at best only half the coal was taken and in some cases as little as a quarter. This method was operated in Raniganj and Burdwān collieries. But of this coal not more than two thirds was marketable in fact in most collieries not more than 1/2. Again, it was

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160. W.W.Hunter, A Statistical Account of Bengal, Vol.5, p.112.

161. B.R.Seth, Labour in the Indian Coal Industry, (Bombay, 1940), p.3.

162. Ibid, p.3. Also see W.W.Hunter, A Statistical Amount of Bengal, Vol.5, p.113.

163. Aurther Raistrick, Industrial Archaeology: An Historical Survey, (London, 1972), p.52.

preferred to have the roof of the mine of coal, since it was safer and finer than either sandstone or shale. Thus at Tapasi, where the seam was 22 ft. in thickness only 12 feet were mined. This mode of functioning was best adopted for seams of moderate thickness.[164]

Crowbars, big hammers and wedges were utilised. The wedges were shapeless pieces of any kind of old iron forged up, the hammers were also made of poor materials while the crowbars were round irons of five feet and 6 inches in length.[165] The coal cutting was also faulty. The coal instead of being 'holed under' and cut away at the bottom, wedged afterwards, down from above, was cut above and broken away from below by crowbars and wedges.[166]

The second method employed in coal mining consisted in chipping out a small hollow near the face of the coal through crowbars. This coal was brought to blocks through wedges and hammers. An opening at the side of the gallery was constructed.[167] Some collieries also used country gun powder as explosives that left volumes of smoke and did very little work.[168] Buckets were employed for carrying the coal by boys. The miners used the common earthen lamp for light in the shape of lipped saucer. Torches prepared from a narrow strips of cloth or twisted ropes

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164. W.W.Hunter, A Statistical Account of Bengal, Vol.V, (New Delhi, 1973), p.113.
165. B.R.Seth, Labour in the Indian Coal Industry, p.3.
166. Ibid, p.3. Also see W.W.Hunter, A Statistical Account of Bengal, Vol.V, p.114.
167. B.R.Seth, op.cit., p.4.
168. Ibid, p.4.

and saturated in castor oil were used for more light.[169]

A prominent feature of the Mughal road system was that it designed mainly to facilitate cart-transportation. For this purpose, on main roads they constructed stone and massonary bridge for convenient transportation.[170] Van den Broucke's map (1660) provide us with some information of Bengal road system. He marks a principal road passing over Patna, Munger etc. to Suti. From this place a branch went to Murshidābād to Burdwān and finally to Katak. Another branch from Suti ran along the right bank of the Podda to Fathabad and finally to Dacca. This was regarded as Shahi Rostah.[171] A second road from Burdwan to Bakleswar in Birbhūm and finally, to Qassīmbāzār was constructed. This road went from Harinarhatti to a place called Harwa and from there to Sirpur. Third road went from Burdwan to Indrakpur via Salimabad, Hughlī, Jessore, Bosnah, Fathabad etc. Fourth road went from Dacca to Harial via Balari, Piaarpore, Bedlia etc.[172] Renell discussed road system of Bengal in his, "Description of the Roads of Bengal and Bihar, 1778." He gave a list of roads connecting Patna, Murshidābād, Dacca, Calcutta. Among the old military roads of East Bengal, mention must be made of the road from Dacca to Toke.[173] Another road stretched from Dacca to Khulna in the Sunderbans via Vikrampur, Padma, Ichamati and

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169. Ibid, p.5. Also see W.W.Hunter, A Statistical Account of Bengal, Vol.V, pp.115-116.

170. Irfan Habib, "The Technology and Economy of Mughal India," IESHR, Vol.17, No.1, (Jan,March,1980),p.12.

171. H.Blochmann, Contribution to the Geography and History of Bengal (Muhammadan Period),(Calcutta,1968),p.13.

172. Ibid, p.14.

173. S.Bhattacharya, The East India Company and the Economy of Bengal, from 1704 to 1740,(London,1954), p.192.

Faridpur. The land route from Dacca to Calcutta were also opened during the months of November to June via Faridpur, Jassore, Barasat and Dum Dum.[174]

On the large rivers, the best that could be done was to build bridges of boats.[175] But these were operative only during summer.

Carts, carriages, Eka and tanga in Mughal India were pulled almost exclusively by bullocks, Chariot, even for princely conveyance were pulled by bullocks.[176]

In ship building during 17th century India was hardly influenced by European Technologies.[177] Indian Carpenter's techniques of riveting planks, water tank made of planks were considered to be more superior, sophisticated, and convenient than European practices of simple caulking and coopers' casks.[178] In smearing the planks, indigenous pitch or tin and lime was applied with double advantage of stopping up any seams and of preserving the timber. Pitch in the Eastern parts was made by mixing 2/3rd of dammer and 1/3rd of oil properly boiled together. Oil extracted from fish and probably mixed with other ingredients was also used in daubing the planks. Lime was applied at least once a year as protector for wood against sea worms. Iron anchors had been utilised by Indians in the 17th century. For the haulage of ships from water to land for the purpose of repairing, the crab and tackle

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174. Ibid, pp.192-93.

175. Irfan Habib, "The Technology and Economy of Mughal India," IESHR, Vol.17, No.1, (1980), p.13.

176. Ibid, p.11.

177. Irfan Habib, "Technology and Barriers to Social Change in Mughal India", IHR, Vol.V., No.1-2, (1978-79), p.168.

178. A.J.Qaiser, "Ship building in Mughal Empire during the 17th Century," IESHR, (1968), pp.150-154.

were utilised.[179]

From this selective description of Indian craft technology, as the volume of craft and non-agricultural production went, it is possible to regard India in the 16th and 17th centuries from any standard, as one of the advanced countries of the world. Money economy was functioning by any definition, accompanied by extensive employment in the craft sector, a large urban population probably about 15% of the total, and a considerable volume of manufactured goods produced for Foreign Markets. In technology, also, there were certain areas of exploration that were exploited by Indian craftsmen where contemporary Europe had only started.[180] When we set this incomplete catalogue of the success of the Indian craftsmen together with their failure to adopt significant Mechanical techniques, we observe a minute contradiction, also envisaged by contemporary European observers and travellers. They recognised both the crudeness of the Indian craftsmen's equipment as well as the excellence of their product, a clear triumph of human skill over material equipment acquired by persistent practice in the same craft of Bengal. Staforinus writes:

"Artifices confine themselves to one sort of work so that a goldsmith will not work in silver, nor a silversmith in gold. In the aurangs or looms, a weaver will only weave one single sort of stuff during the whole life, unless he be compelled to take another in hand."[181] The division into specialized skills was

179. Irfan Habib, "Technology and Barriers to Social Change in Mughal India," IHR, Vol. V, No. 1-2, (1978-79), p. 167.

180. Irfan Habib, "The Technology and Economy of Mughal India," IESHR, Vol. 17, No. 1, (1980), p. 15.

181. John Splinty Stavorinus, Voyages to the East Indies, 1768-71, (London, 1798), p. 411.

greatly facilitated by the caste system. There is a fixed caste for every sort of work and "for every thing, which had done that work or that thing from father to son till now."[182] At the same time due to the barrier so raised between one craft and another, diffusion of techniques across the craft must have been correspondingly difficult. This negative aspect of skill specialization through caste i.e. a segregation of skills was stressed by Weber in analysing the low level of Indian craft technology. Morris has challenged this view[183] by arguing that no specific instance of the rejection of technology of this nature by Indian craftsmen based on the caste ritual or traditions have been recognised. No complaint of this nature had been heard of in the Mughal period. Thus Irfan Habib says: "It was not, therefore, any scarcity of skilled labour brought on by the caste system, but its very opposite, namely, its plenitude, that as we have seen, constantly inhibited attention to labour and skill saving devices".[184] The non-application of important technological innovations in various proto-industries of Bengal hampered the transformation of proto-industrialization into capitalist industrialization proper.

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182. Baburnama, Tr. Beveridge, ii, p.520.

183. M.D.Morris, "Value as an obstacle to Economic growth in South Asia," JEH, Vol. XXVII, (December, 1969), pp. 588-607.

184. Irfan Habib, "Technology and Barriers to Social Change in Mughal India," IHR, Vol. 5, No. 1-2, (1980), p. 171.