THE ADVANCEMENT OF INDUSTRY.

THE

ADVANCEMENT OF INDUSTRY

BEING A STUDY OF CERTAIN MANUFACTURING INDUSTRIES IN INDIA WITH SUGGESTIONS FOR THEIR DEVELOPMENT

BY

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"Get thy spindle and thy distaff
And God will send thee flax."—
Arabic Proverb.

WITH 32 ILLUSTRATIONS

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PREFACE.

The early years of the present century have witnessed the birth of a new era in this country which is likely to be remembered as much for the industrial awakening it has caused as for the political aspirations it has aroused in the people. But of these two new features of current Indian thought the former was not altogether unexpected as its advent had been retarded by peculiar causes for several centuries. In the age preceding the Christian era, India had attained a pre-eminence in her arts and industries which was world-famed, but as the centuries marched on, her economic splendour gradually waned. While I have endeavoured in these pages to trace in brief outline some of the causes which have brought about this decline and to ascertain what appeared to be the striking features of our economic history, my object in writing this book has been to place before people interested in economic industry a study of certain manufactures, principally indigenous, which are now sought to be developed. To this study, I have been devoted since the last five years, although I must avow that I have not had the advantages and the facilities of those of my fellow-workers who labour with the help of the state or of public institutions. I have unfortunately had to contend with slender resources, but in such work it is the heart that often makes good what the means fail to supply. After observation and study of these crafts, I have attempted herein to make some suggestions for their improvement. In the case of hand-loom weaving and the rice industry, I have spoken from a knowledge derived by personal experience. To render this work as useful and interesting as possible, I have added some illustrations prepared from photographs of industrial workers taken during the last three years.

I desire here to express my thanks to Mr. S. M. Hadi, the well-known sugar expert of the United Provinces, who was kind enough to take me round the experimental factory at Baraon near Allahabad; to Mr. J. Thomson of the Titaghur Paper Mills in Bengal, for permission to visit the Mills; to Mr. A. N. Moberley, Deputy Commissioner of Sambalpur, for affording me information regarding the iron-smelters of that district; to Mr. P. N. De, Vice-Principal of the Government Weaving Institute at Serampore, for much help and assistance; to Mr. Alakh Dhari, Secretary of the Upper India Glass Works at Umballa, for showing me over his works; to Mr. Satyasundara Deb, the ceramic expert of the Calcutta Pottery Works, for explaining to me the working of his factory; to Mr. Harold Brown of Messrs. Burn & Co. Calcutta, for furnishing me with a history of the Ranigunge Pottery Works; to my brother Mr. R. Ghosh and to my friend Mr. W. J. Bolst for revising several proof-sheets of this book.

Calcutta, 12th February, 1910.

H. H. G.

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THE

ADVANCEMENT OF INDUSTRY

THE INDUSTRIAL REVIVAL.

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THE history of India offers an illustration of what may be regarded as an economic anomaly and for which no parallel can perhaps be found in the annals of any other country. The remarkable circumstances, constituting this anomaly, are the existence of certain economic conditions which possess essentially a material value but which have, deviating from the natural law of economic progress, actually directed the religious thought of the Indian people and even affected their political career. Instances are not wanting in political history of the disruption of empires by the unwieldiness of their political power,

The eccentricity of economic progress in India.

But the course by which the economic extinction of these people was brought about is different. It was primarily due to their adoption of an extravagant spiritual fervour. Endowed with enormous natural resources, they commenced with a vigorous industrial life, but owing to this economic pre-eminence they were led by a singular process to ultimate economic downfall.

During the early civilisation of India, we have reason to believe that some of the crafts, most necessary to the ministration of material wants, were devised in the country. In the practice of these crafts, it appears that the inhabitants realised the untold bounties which nature had conferred on their soil and as a result of this joyous discovery, they turned their hearts in grateful and spiritual ecstasy to the great Giver. It is easy to understand how a people, whose minds were thus uplifted, were naturally led to the culture of the arts, for we find that this accomplishment was also attained by them at a later period. Nor is it difficult to perceive how into their works of art was introduced a forcible expression of religion and the contemplative life.

Nature's bounty, the cause of spiritual enthusiasm.

The culture of the arts, which in the evolution of other nations is a late development, was with the Indian people, apparently by the process we have just observed, an early one. Yet it must not be supposed that these people cultivated the finer arts of music, painting or sculpture at this period, or that if they did so, the fact was worthy of any note. Their accomplishment chiefly consisted in the perfection of the industrial arts, and this pursuit showed an apparent deviation from the progress and extension of their useful industries. As they excelled in these arts, a trade in their exquisite artistic productions gradually appeared between India and the Mediterranean. Thus, in the writings of Hekataios, Homer, Pliny and in the Hebrew Bible, references are found to articles of Indian merchandise. These exports ultimately drew the attention of foreign peoples to the wealth of this country and led to successive, covetous invasions. While Greek, Scythian, Tartar, Afghan, Mogul, Portuguese, Dutch, Dane and French swept over India, her inhabitants were mainly absorbed in spiritual contemplation. How deep their gratitude and great their thanksgiving, but how disastrous the results of such devotion upon their material life! Hence it is evident that the religious fervour of India, though fostering her artistic productions, has always stunted her material development by arresting the growth of her useful crafts.

Religious fervour leads to political and economic extinction.

Unlike the spiritual tone which has so long characterised the industrial life of the people, there has recently been a change in temper. A new wisdom creating a new spirit has now possessed the minds of the people. During the extended period of Indian history, no such change has ever taken place; and the future historian, looking back to this period, will discover the source of an industrial revival.

This singular movement is born of the spirit of the day and is a child of materialism. It is a distant call from the Buddhistic age, when Indian fabrics charmed the Western world, to the era of invention, when European goods flood all India; but the divergence in thought is as great as the lapse of time. How then comes this widely different perception, this light amidst the unending darkness of their material life? For generations the people have heard that in a single invasion, lasting merely fifty-eight days, Nadir Shah had taken away from Delhi a pillage valued at forty-eight crores of rupees. Before their eyes were visible signs of the plunder of their treasures—the desolate site of the temple at Somnath and the vacant seat of the 'Peacock Throne'. In their own day, they have seen the destitution of the masses and have watched their sufferings in years of famine. Poverty with its concomitant misery has oppressed almost every son of this soil. Yet why were they not stirred before? The reason is not far to seek. In their religious faith, they saw no sign of a call from the Almighty till the close of the Russo-Japanese War. The generations that were overswept by the storm-clouds of our history had left no greater heritage to their sons than the steadfast belief in a power overruling the highest human struggle. It is thus natural that in the unexpected victory of Japan they should see the hand of Providence visibly directing the advance of Asia.

The change from spiritual to material thought.

It will be remembered how an administrative measure—the political separation of the eastern and western portions of Bengal—carried into effect on the 16th of October 1905, ushered in a new era in India. The people of Bengal thought that their racial unity was ignored, their venerable traditions slighted and their patriotic feelings trampled under foot. The other Indian provinces argued that if the Bengali race—the most powerful in the country—were thus treated, it would not be difficult for the rulers to extend similar treatment towards them some day. Consequently the whole of India united and in one voice cried down this scheme of the Government. Their indignation took the form of passive resistance against the measure by the boycott of British imported goods. For a short while indeed Manchester cotton goods were eschewed, but as this step was economically weak, it was gradually abandoned, and the sounder one of reviving our own industries was seriously set on foot. It is not easy to understand how sensible men could have taken vows, which they did then, to relinquish English goods, when not long before, they were almost enveloped in them. The boycott move, it now appears, was merely the backward swing of the pendulum. Instances of such reactionary feeling are not few in history. Were it not for the rigorous bondage of Puritanism in England, the unbridled laxity of the Restoration would never have appeared.

The violent cause of transition.

In the winter following the 16th of October 1905, we have just seen that active steps were being taken to revive the languishing industries of the country. The question of resuscitating these industries was for many years being considered by the Government who also conducted from time to time certain experiments with a view to introducing improved methods into some of them. What these attempts were will be seen hereafter. In connection with this work, it may be remarked that the Government tried to do its duty, for every civilised State must, in its own interests, endeavour to improve the material condition of its people. But, as rightly observed by the Sage of Chelsea—"the government cannot do by all its signalling and commanding what the society is radically indisposed to do." * The work of the Government did not attract any attention beyond that of a few enthusiastic journalists or public men. Knowing the apathy of the people in this direction, these men suggested but rarely to them that they should develop the industries. Nor would mere suggestions have sufficed. Few of the manifold conditions, under which such development can take place, then existed.

Industrial work of the Government.

A definite appeal was however made to the people, at the commencement of the year 1905, by Mr. E. B. Havell, then Principal of the Government Art School at Calcutta, to

* Carlyle's "Past and Present." P. 367.

revive the hand-loom industry of Bengal. This gifted and generous spirit, at the suggestion of an educated weaver of Chinsurah who had applied the 'fly-shuttle' to the old Indian loom, repeatedly addressed the public on the great reform that would be effected by the general adoption of this shuttle in the industry. He showed by certain figures that the production of hand-loom fabrics would thereby be largely increased. But the people were either not sufficiently stirred or did not place much confidence in the appeal of an Englishman. Knowing that the Partition was impending, their faith in English people generally was for the moment rudely shaken, and the voice of this well-wisher seemed for a time a voice crying in the wilderness. The efforts of these workers were however not lessened. Mr. Havell conducted certain experiments in his school on an English hand-loom, and the weaver of Chinsurah toiled at his factory for the development of the Indian loom, in poverty and obscurity. This humble harbinger was no other than Mr. Preo Nath De, now the Vice-Principal of the Government Weaving School at Serampore.

The hand-loom movement.

When the great political scheme which the people were hoping to avert was finally carried into effect, they seriously thought of the hand-loom and sought the advice of its first advocate. Mr. Havell did all he could for them, and referred them to Mr. P. N. De, as well as to another educated weaver in Calcutta, by the name of Dinobundu

Mukerjee, who had constructed a 'warping frame.' The hand-loom movement rapidly spread throughout India. Mr. A. Chatterton, then Principal of the Government Art School in Madras, was conducting certain experiments for the improvement of hand-weaving in his province. Mr. Raoji Bhai Patel, Director of Agriculture and Industry in the Baroda State, was engaged in similar work. Hand-loom factories were set up in almost every part of the country and a regular campaign was carried on by some of these industrial pioneers for the resuscitation of hand-weaving. They knew full well that if the people did not take up this industry, they could not take up any other; and it was most imperative that, after the sleep of ages, their first desire for material development should not meet with a repulse. Moreover, the people believed for the moment that their only hope of effectually carrying out the boycott lay in the success of the hand-loom movement.

The Industrial Revival.

In that day of anxiety, there was scarcely a newspaper or public man in India that did not speak of the hand-loom.* That this movement was to a certain extent successful cannot be denied, for a large number of quondam weavers went back to their occupation and again found a

* The extent of the popular interest at the time in hand-weaving may be gauged from the fact that, from all parts of India, hundreds of enquiries regarding this industry, daily poured into the experimental factory of Dinobundu Mukerjee with which the writer was associated. The latter's connection with this movement is well-known, and his name is therefore kept out of these pages.

living by it. Had it not been for the hand-loom campaign, the industrial movement might have received as little attention as social reform does to the present day. Once the hand-loom was set agoing and its prospects appeared somewhat hopeful, the attention of the public was directed to lesser industries. It was thus that the industrial revolution in England, which has since turned the destiny of economic history in Europe, commenced with the unpretentious inventions of the 'spinning-jenny,' the 'water-frame' and the 'mule-spindle.' In this country, however, it is evident that the revival will be effected not by original inventions so much as by the adjustment of modern scientific improvements to our systems of manufacture and by various other economic methods which will be discussed hereafter.

When the country was sufficiently roused by these events, extraordinary activity was seen on every side. Both the people and the government entered whole-heartedly into the work of industrial regeneration. The most important step taken at the time was the summoning of a conference during the Christmas recess of 1905, to discuss the situation and devise means of improving it. This convention, the first session of the Indian Industrial Conference, was held in Benares immediately after the meeting of the National Congress and was presided over by the historian and economic writer, Mr. Romesh Chunder Dutt. It was supported by the government and attended by most of the industrial workers and thinkers

The Industrial Conference.

in the country. The President explained the object of the meeting and briefly described the industrial situation in the following words :—"Impressed with the growing need for the expansion of our industries, that great and representative body (the Congress) has held an Industrial Exhibition from year to year ; all classes of manufacturers, European and Indian, have sent in their goods to these exhibitions and the Government of India and the Provincial Governments have generously helped and fostered their growth. This year you have taken a new departure; you have felt that, beyond exhibiting our goods, we might as practical men compare notes with each other in reference to the various industries with which we may be familiar ; and you have resolved therefore to hold an Industrial Conference as a necessary adjunct to the Industrial Exhibition. For the rest, the object of this Conference is the same as that of the Industrial Exhibition, namely, the promotion of Indian industries.... There are two extreme views often expressed about our industries both of which I believe to be wrong. One is a despondent view—a cry of despair—that Indian industries have no future against European competition and that India is sinking lower and lower as a purely agricultural country. The other is a roseate view—that the trade of India is increasing by leaps and bounds under the British rule—and that the increasing figures of Indian imports and exports are an index to the growth of Indian manufactures and of the prosperity of the

The Presidential address.

people.... As usual the truth lies midway. We are beset with grave difficulties but we have no reason to despair. Our industrial condition in the present day is lamentable but it is not hopeless. We have to face a severe and in some respects an unequal competition, but our future is in our own hands if we face our difficulties like men.... Our difficulties are of a two-fold nature. In the first place, our old industries have undoubtedly declined and we have to recover lost ground. In the second place, we have to recover our position under exceptional economic conditions which few nations on earth have to face.

The discourses of the assembly.

Having thus disclosed the declining position of our industries, the President invited the views of the delegates on the exigencies of the hour. These were expressed on some important economic subjects such as "Power-Looms and Hand-Looms" by Mr. E. B. Havell, "Hand-Loom Weaving" by Mr. Raoji B. Patel, "Industrial Work in India" by Mr. A. Chatterton, "Industrial Development" by Rao Bahadur R. N. Mudholkar, "the Indian Cotton Industry" by Sir Vithaldas D. Thakursey, "Co-operative Credit" by Sir Frederick Lely and Mr. J. Hope-Simpson, "the Mineral Development of India" by Sir Thomas Holland, "Agricultural Banks" by Sir Daniel Hamilton, "An Industrial Bureau" by the Hon. Mr. Dhaji Abaji Khare, "the Organisation of Capital" by Mr. Reginald Murray and "A Note on Agriculture" by Dr. Harold H. Mann.

The Conference having discussed the immediate needs of the country, summed up with the following principal resolutions:—

I. To appeal to the Government of India, the provincial governments and administrations, as also the people of India according to their power and opportunity, (*a*) to found technical schools in large centres for the industrial education of the Indian peoples on an adequate scale, (*b*) to encourage and help Indian manufactures, and (*c*) to foster and extend the products of such manufactures in preference to foreign goods.

The decisions of the Conference.

II. That all provincial governments and administrations, as well as the proprietors and managers of private schools and colleges should be urged to add industrial classes as those of weaving, dyeing, and carpentry, to the existing educational institutions whenever practicable, so that boys trained in such institutions may learn some manual industry.

III. It specially invited the attention of Indian capitalists to the great importance of introducing the use of improved hand-looms among the weavers of India, and recommended the establishment of weaving schools where boys may learn the use of hand-looms in the towns and villages of India.

IV. In order to afford facilities to boys of all castes and classes to learn such useful industries as a means of their livelihood, it urged Indian capitalists to establish at their own cost, schools for spinning, dyeing, pottery, carpentry and the manufacture of iron and brass wares.

V. When it was possible to raise large funds for industrial education, it recommended the placing of such funds in the hands of trustees, with a view to the establishment of technological colleges on the modern methods adopted in Europe, America and Japan, for the training of students in the various industries which are profitable in India.

The Conference has since developed into an annual institution which along with the National Congress holds its sessions during the Christmas vacation at different centres in the country. The 2nd Indian Industrial Conference met in Calcutta in December 1906. An inaugural address was delivered by H. H. the Gaekwar of Baroda. This intellectual prince is no less an economic thinker than an administrator. His address contained within a brief compass the striking features of the industrial situation and some of his suggestions for the advancement of our mineral industries are among the most pertinent that have yet been made. Having surveyed the position and stated the prospects of the textile industries, he observed that recent geological investigations had brought to light the rich iron ores that were lying concealed so long in Central India and that there was a great scope for the development of the iron industry. "If the quality of indigenous coal," he explained, "is only improved and the means of communication made more easy and cheap, so as to considerably reduce the cost of transport, it would appear

The second Conference.

more profitable to smelt our iron in our own furnaces, rather than to import large quantities from abroad....Bengal is rich in coal-fields and out of the 8 millions of tons of coal (worth about 2 crores of rupees) raised in all India in 1904, no less than 7 millions of tons were raised in Bengal. These will seem to you to be large figures, but what are 8 millions of tons compared with considerably over 200 million tons annually raised in England?.... The importance of coal consists in this that its abundance makes every other industry on a large scale possible. Coal and iron have been the making of modern England, more than any other causes."

Inaugural address.

Referring to the indigenous crafts, the remarks of the Gaekwar were also very appropriate. "A great deal of attention," he proceeded to say, "is naturally paid to the mill industries of India, to tea, indigo, coffee and other industries in which European capital is largely employed. We know, however, that the labourers who can possibly be employed in mills and factories form only an insignificant proportion of the industrial population of India. Very much the larger portion of that industrial population is engaged in indigenous industries carried on in village homes and bazars.... It is the humble weavers in towns and villages, the poor braziers and copper-smiths working in their sheds, the resourceless potters and iron-smiths and carpenters who follow their ancestral vocations in their ancestral homes, who form the main portion of

Indigenous workers.

the industrial population, and who demand our sympathy and help. It is they (more than the agriculturists or the mill and factory labourers) that are most impoverished in these days and are the first victims to famines.... Help and encourage the large industries, but foster and help also the humbler industries in which tens of millions of village artisans are engaged."

The president of this Conference, Sir Vithaldas Thakursey, who was then promoting the Indian Specie Bank, had some practical suggestions to make in his presidential address regarding the organisation of capital, but his remarks on the industrial revival were unimportant. The principal features embodied in the decisions of this Conference were as follows:—

Lamentable state of technical education.

I. On finding that the number of technical schools in India was exceedingly small compared to those of other countries—for instance, the number in this country being only 84 as against 854 in Japan—it urged the Government of India to establish a sufficient number of secondary, technical and commercial schools, a superior technical college for each province and one fully equipped first-class college of technology for the whole of India.

II. Owing to the same defect, it requested the public men and philanthropists of India to raise technical institutions in every province, irrespective of government work in this direction, commending at the same time the founders of the 'Victoria Jubilee Technical School' in Bombay and of the 'Bengal Technical Institute' in Calcutta whose work it declared was worthy of emulation.

III. It requested the Provincial Governments to conduct industrial surveys in their respective provinces.

The third Conference.

The third session of the Conference was held at Surat in December 1907. The progress of industrial work during the previous year was noted with satisfaction but the great lack of technical training was deplored by the assembly. Referring to the mode of imparting such training, the president observed that "there ought to be a living connection between the technical schools of a district or a province and its actual or projected industries." The most important decision of the Conference was to the effect that the nascent industries of the country should be assisted by substantial protective duties.

The fourth Conference.

The fourth meeting of the Conference was held in Madras during the Christmas recess of 1908. The principal feature of this meeting was a virtual denunciation of the policy of boycott from the chair. Taking the instance of country-made sugar as against foreign sugar, the president explained that unless our home productions were cheaper in price, they had little chance of competing against imported goods.

While the conference has been carrying on its useful work, the people have displayed their zeal towards the movement in various practical ways. The industrial exhibition which was organised annually by the Congress prior to 1905, has since grown in popularity and importance.

Activity of the people.

An association which was formed in Calcutta, some years ago, by Mr. Jogendra Chandra Ghose, for the technical education of young men by public contribution, now sends out for this purpose to Europe, America and Japan, a larger number of students than before. As a result of this revival, the 'Bengal Technical Institute' has been founded by the philanthropy of a citizen of Calcutta. But the most hopeful feature of the awakening has been the ardent support which joint-stock enterprise has obtained from the Indian people. This form of industrial endeavour was seldom found among them, except in Bombay, before the movement. It would certainly have been impossible to acquire capital from the people for large concerns like the Tata Iron and Steel Company and the Indian Specie Bank at the beginning of the year 1905. Yet these and many other smaller companies were recently floated with comparitive facility.

Knowing that its efforts towards the restoration of industries would no longer be futile and becoming acquainted with the needs of the people through the Conference, the

Efforts of the government.

government has also done its share of work during the last four years. The provincial governments have caused industrial surveys to be held in Bengal and in the United Provinces; monographs have also been written by their officials on some indigenous industries. The Government of Bengal has established a weaving school in Serampore and that of the United Provinces has set up several experimental sugar factories in its own territory.

With these various steps taken both by the people and the government, a beginning has merely been made; for the work of industrial advancement will need persistent effort for many years to come. In most of the European countries, it has taken generations of arduous toil to build up the industries; but we have at least the advantage of knowing what the economic and scientific experience of those countries have been.

THE IRON INDUSTRY.

The dearth of records regarding Indian industries.—Skill of early iron workers in India.—The famous Damascus blades made of Indian iron.—The indigenous industry now languishing.—Seats of the industry in the last century.—A few of its present centres.—The ore and fuel used by indigenous smelters.—The industry in the Sambalpur district.—The blast furnace.—The blasting bellows.—The process of smelting.—Extracting the slag.—The bloom of iron.—Quantity of charcoal and ore used.—Smelting in the Palamau district.—Small blast furnaces in Central Bengal.—Tall blast furnaces in the Malabar district.—A comparison of indigenous furnaces and systems of smelting.—Their few variations.—The excellence of indigenous iron.—Indigenous steel.—Its method of manufacture.—The proportion of raw materials used in the indigenous industry.—Sir Thomas Holland's opinion.—Mr. F. W. Hughes's calculations.—The proportion in modern English smelting.—Prospects of the indigenous industry.—Suggestions for its improvement.—The market for indigenous iron.—Mistaken steps in industrial development.—The indigenous industry compared to iron-smelting in England during the 17th century.—The modern industry in India.

The dearth of records regarding Indian industries.

If the ancient chronicles of India were protected and preserved as those of Greece and Rome, there can be no doubt that a fuller light would have been shed on the origin of her various arts and industries. But when the mere outlines of her early history have been traced from the Sacred Books, the Buddhistic inscriptions, the pillars of Asoka and the accounts of foreign invaders, it would be futile to expect anything from these sources beyond occasional allusions to the manufactured products of the country. It is only from the remnants of ancient Indian work that we are now able to gather a small and fragmentary history of our crafts. Yet few and scattered as these relics may be, they stand as the monuments of living truth, telling a tale more convincing than the pages of history, where the materials are obtained from a chain of recorded or traditional evidence. The picture of early industrial life in this country, as may be drawn from these remnants, is one of surpassing excellence; the allusions made to its products, even by those who have treated the Indians most unrighteously, are full of surprise and fascination.

Judging from the relics of early iron work that exist in this country, it may be rightly inferred that the manufacture of iron was practised by the ancient Indians, in no crude fashion, long before the Christian era. It is not possible to state with any certainty, in which country the art of iron-making was first devised, for its early history, like that of almost all the crafts, is shrouded in obscurity. But referring to the antiquity of the art in India, and speaking of the 5th century before this era, the observations of an eminent writer on this subject, Professor T. Turner, are worthy of note. "Probably about this time," he says, "the art of iron-making was carried eastward into India, as the inhabitants of that part of the world were well versed in the manufacture of iron centuries before the Christian era. The famous iron pillar at the Kutub, near Delhi, stands 22 ft. above the ground and its weight is estimated to exceed 6 tons. It consists of malleable iron of great purity and was probably made about A. D. 400, by welding together discs of metal. So great a forging at this period indicates a remarkable

Skill of early iron workers in India.

skill among the early iron workers of India which has not survived to the present day."*

A well-known Anglo-Indian geologist, Mr. V. Ball, refers to the art of steel-making as an indigenous craft of this country and even believes that the Indian metal was exported to the West in ancient times. "For a time," he remarks, "Indian *wootz* or steel was in considerable demand by cutlers in England. Its production was the cause of much

The famous Damascus blades made of Indian iron.

wonderment and became the subject of various theories. The famous Damascus blades had long attained a reputation for flexibility, strength and beauty before it was known that the material from which they were made was produced in an obscure Indian village and that traders from Persia found that it paid them to travel to this place, which was difficult of access, in order to obtain the raw material...... There are reasons for believing that *wootz* was exported to the West in very early times—possibly 2000 years ago."† This village has been traced by Mr. F. R. Mallet, at one time Superintendent in the Geological Survey of India, who states that Persian dealers travelled to Konasamundram in the district of Indore in Hyderabad, for the purpose of obtaining steel from there, which was used in making the celebrated Damascus sword blades.‡

* Turner's "Metallurgy of Iron" edited by Prof. Sir W. Roberts-Austen, p. 4.

† Ball's "Geology of India," Part III, pp. 339 and 340.

‡ Watt's "Economic Products of India," Vol. IV, p. 507.

There does not appear to be any record showing the growth or progress of this industry during the many centuries of its existence in this country. Occasional references to iron tools and weapons are found only in the Vedas and the Code of Manu. But it is well-known that the manufacture of iron by indigenous methods was practised throughout the provinces of India not very many years ago. It is only during the latter half of the last century, since the advent of foreign iron in the country, that the indigenous craft—being unable to withstand with its expensive and pristine methods the competition of the cheaper metal—has begun to languish.

The indigenous industry now languishing.

The iron industry, in its widest sense, implies not only the preparation of iron by the smelting of the ore, but the conversion of iron into steel as also the manufacture of every description of hardware and machinery from either metal. We are here concerned only with the primary section of the industry which, apart from being the most important, is the one for the development of which this country has all the natural resources. India is considered by geologists to be particularly rich in iron ore which is found in almost every part of the country, but it is known to be most abundant in the Central Provinces, the Madras Presidency and the western portion of Bengal. The following principal seats of the indigenous industry during the closing years of the last century according to Mr. F. R. Mallet, formerly of the Geological

Seats of the industry in the last century.

Survey of India are abstracted from his essay on Iron in Dr. Watt's "Economic Products of India"*:—

In the Central Provinces—The zemindaries of Daundi-Lohara and the feudatory state of Khairagar in the Raipur district; the villages of Lohara, Pipalgaon and Dewalgaon in the district of Chanda which is one of the most remarkable districts in India for enormous accumulations of the finest ore; the parganah of Chandpur in the Bhandara district; the village of Tendukhera in the Nursinghpur district; and the villages of Mangeli, Mogala, Gogra and Danwai in the Lora ridge in the Jubbulpur district where there are said to be unlimited quantities of scattered ore.

In the Madras Presidency—The district of Salem; the taluk of Shenkotta in the state of Travancore; the taluks of Kurmenaad, Shernaad, Walluwanaad, Ernaad and Temelpuram in the district of Malabar; almost every taluk in North Arcot district; and the zemindari of Jaipur in the Vizagapatam district.

In Bengal—Lalcher and Dhenkanal in the Orissa Division; Barakar in the Burdwan district; and the districts of Birbhum and Hazaribagh.

A few of its present centres.

The district reports of these provinces generally show the location of the industry during the year under review. In the Central Provinces, one of the chief seats of the industry at present is Dalhi, a place 38 miles south of Rajnandgaon in the district of

* See Vol. IV, pp. 505—512.

Raipur.* The district reports of Bengal show that the chief seats of the industry during 1907 were in the Sambalpur district and the Tributary States adjoining the district of Cuttack. In the district of Sambalpur, the villages of Belpahar, Kudaloi, Lakhanpur, Pikol and Grindola are among the localities in which the industry is now being conducted.†

The ore and fuel used by indigenous smelters.

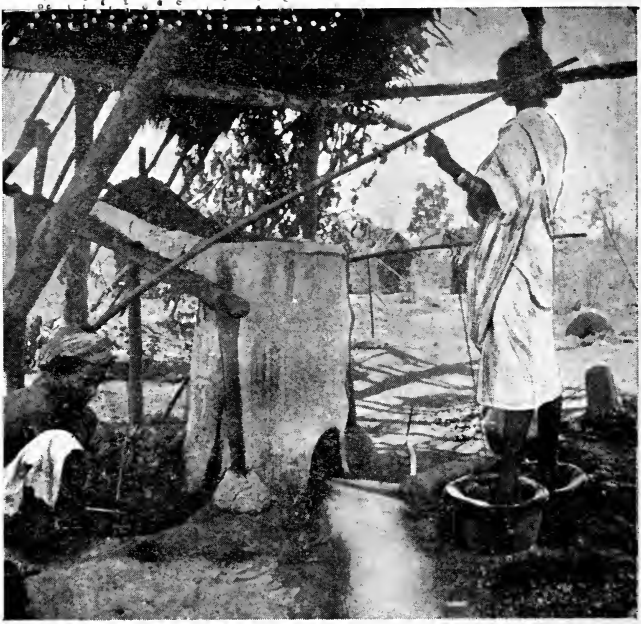
The species of iron-ore generally used for indigenous smelting are the haemetite and the magnetite found in lumps of stone or other earthy substance on the surface of the ground and sometimes—as at Nellumbur in the Malabar district—in gravel in the beds of rivers. The indigenous smelter can ill afford to mine for his ores, as this operation would not only entail an expenditure which he could not meet, but the ores thus obtained, being in the massive form, would involve the labour of reduction into nodules. He collects, therefore, the weathered pieces which are usually found scattered about in the iron-ore district. In Southern India, however, the ores are often obtained from lodes in the laterite. The pieces thus gathered are broken up into small nodules or reduced to powder and then smelted into iron in a blast-furnace. The fuel used in the furnace is charcoal

* The writer is indebted to the office of the Geological Survey of India at Calcutta for this information.

† The Deputy Commissioner of the Sambalpur district was good enough to furnish the writer with this list of localities, two of which the latter has had the opportunity to visit.

Plate I.

[To face p. 25.



INDIGENOUS IRON-SMELTING.

Showing the front view of the blast-furnace and the process of smelting.

From a photo taken by the author.]

which is generally obtained by burning the wood of a deciduous tree such as the *sal*, the *kullah*, or the *irool*. The iron-workers are therefore found in regions, containing not only a plentiful supply of scattered ore, but where timber for fuel is also obtainable; and for this reason they are generally seen settled near a forest. The smelting process, though somewhat crude, produces a pure and malleable iron of the finest quality.

An illustration of the smelting process is given in Plates I and II, which the writer witnessed in a forest glade about three miles south-west of Belpahar, a village in the Sambalpur district. Under a scanty shed, beside which was his abode, the iron-maker had built a blast-furnace of clay, known by him as the *bhatti*. In shape it resembled the trunk of a large tree. It stood nearly 3½ ft. in height with a diameter of 16 inches on top and 18 inches at the bottom. Along the top of the furnace was a slanting platform called the *ghuncha* resting on four posts driven in the ground. The platform was made of split bamboo which was plastered over with clay. There was a passage running through the middle of the furnace which was round on top having a diameter of 5½ inches, but elliptical as it came down to the hearth with a major and minor axis of 1 foot and 8 inches respectively. In front of the furnace and touching the ground was a semi-circular opening nearly 6 in. wide and 8 in. high. Down the furnace also, but on

The industry in the Sambalpur district.

The blast furnace.

the left side, there was a slit leading to a little trench in the ground.

On either side the platform, a flexible bamboo shoot about 10 ft. long was fixed in the ground. The ends of these shoots were then bent towards the bellows and were attached to them by a pair of strings, the left-side shoot to the left-hand bellows and the right-side shoot to the right-hand bellows, so that the shoots rebounding pulled up the bellows. These latter consisted of two small wooden tubs covered over with leather caps, in each of which was a hole in the middle. Under each hole was a bit of stick to which was tied a string from each shoot.

The blasting bellows.

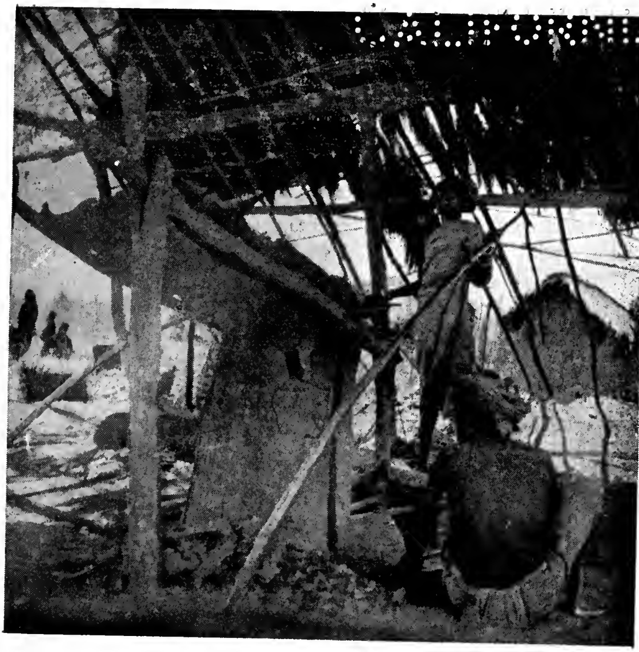
The ore used by the smelter was a hæmatite which he had collected from the adjoining hill in weathered pieces more or less about the size of a man's fist. These pieces were broken up into nodules by the women of his family who also prepared the fuel by burning *sal* faggots, obtained from the jungles, in pits near the shed. The charcoal thus prepared and some nodules of ore were put on the platform which was used as a receptacle for these materials.

Ore reduced to nodules.

Through the front opening of the furnace, some coal dust was then placed on the hearth or *uli* and over it some rice husk sprinkled. A tuyere or blast-pipe, made of fire-clay and conical in shape, was next placed in the opening. The tuyere was about 9 inches in length, over 1

Plate II.

[*To face p.* 26.



INDIGENOUS IRON-SMELTING.

Showing the back view and the 'side-slit' of the blast-furnace.

From a photo taken by the author.]

inch in diameter at the thinner end, and nearly 3 inches across at the wider end. The thinner end was placed inwards, and the opening blocked up all round by a thin wall temporarily raised with wet burnt mud. The side-slit was also filled up with mud. The passage of the furnace was then filled right down to the hearth with charcoal, and at the mouth of it was placed some ore. Some lighted coal was then put into the hearth through the blast-pipe. Two bamboo tubes each about a yard in length and an inch in diameter, which were fixed to the bellows, were inserted into the tuyere. The bellows were then arranged side by side, and the leathers on them wetted with water to make them soft. An elongated boulder was placed on the tubes to keep them in position.

Preliminary arrangements.

A girl finally stepped on the bellows, placed her hands over the shoots and depressed the leather on the right-hand bellows, blocking up with her foot at the same time the hole in it. She thus sent a current of air through the right-side tube into the furnace. She similarly depressed the left-hand bellows and sent a current of air into the furnace through the left-side tube. She continued thus, alternately putting her weight from one side to another, like a worker on the tread-mill, and sent an almost continuous blast of air into the furnace. The leathers on the bellows were occasionally wetted to keep them pliant to the tread. As the

The process of smelting.

materials burnt down, fresh coal and ore were put into the mouth of the passage from time to time, so that the charge was always kept level with the top of the furnace. The tuyere was used as a peep-hole, and after nearly an hour, white heat was plainly visible inside the furnace.

Extracting the slag.

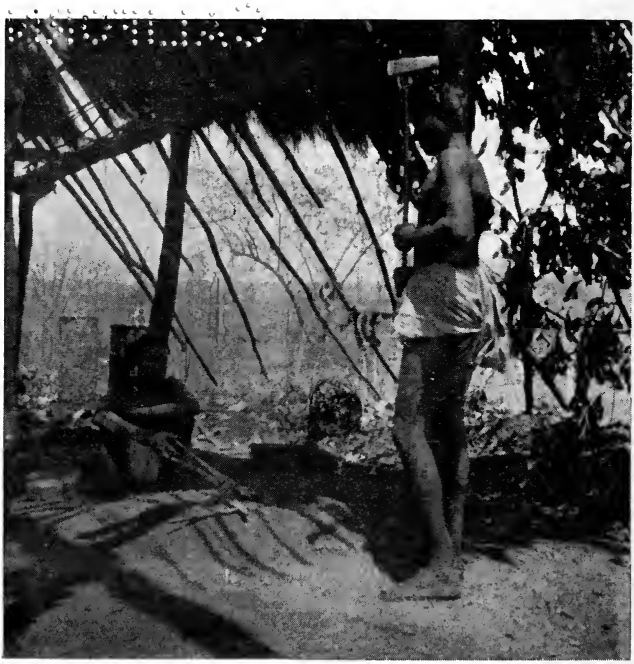
During the next hour, a stick was pushed into the side-slit or slag-hole of the furnace, now and again, to get out the slag or fused dross of the ore. In a little while, the slag appeared through the hole and trickled into the trench below. It was vitreous and of a dark blue colour. The smelting proceeded and the furnace was thus tapped occasionally. As the liquid poured out into the trench and solidified, it was removed into the open ground by means of tongs. Portions of it, that were suddenly cooled by this removal, behaved like glass under a similar condition and splintered into many pieces.

The bloom of iron.

The smelting continued for over five hours in this manner, until the inner end of the tuyere was vitrified, when the craftsman said that the ore had smelted and become into metal in the furnace. The front aperture was then opened, the tuyere removed, and the slag-hole cleared. The burnt mud and cinders were also pulled out of the hearth. The bloom, a rough mass of malleable iron intermixed with slag, was finally drawn out with tongs. It was taken to one end of the shed and hammered over a block of iron while it was

Plate III.

[*To face p.* 29.



INDIGENOUS IRON-SMELTING.

Showing the mode of expressing intermixed slag.

From a photo taken by the author.]

yet hot. By this treatment, a good portion of the intermixed slag was expressed from the bloom. An illustration of this process is given in Plate III.

The quantity of charcoal and ore used was measured with a basket, which the smelter called the *bhugli*. When the smelting commenced, 3 baskets of coal and 1 of ore were put on the platform or *ghuncha*. When it was finished, the smelter said that he had used 6 such *ghunchas* of material, that is, 18 *bhuglis* of coal and 6 *bhuglis* of ore, which was the regular quantity put into his furnace during a day's smelting. This *bhugli* or basket was about 12 inches in diameter and 5 inches in depth, and contained in each fill nearly 3 *powas* of coal or over 5 *powas* of ore. The weight of the 18 *bhuglis* of coal was therefore 18×3 or 54 *powas*, and of the 6 *bhuglis* of ore 6×5 or 30 *powas* approximately. The iron after being beaten weighed nearly 12 *powas*. The materials were thus in the proportion of 54 of charcoal, 30 of ore and 12 of iron roughly. The smelter said that he expected to sell the 12 *powas* or 3 *seers* of iron for a price varying between 5 and 9 *annas*, the value depending upon the number of buyers and the quality they required. It was evident that he did not know the extent of the market in which he was selling, nor the quality of metal which would be wanted at the time, which was a distinct disadvantage to him. It may here be mentioned

Quantity of charcoal and ore used.

The metal obtained.

that in the indigenous process of smelting, the use of mere charcoal, without any flux or mineral mixture to promote fusion, produces a very pure metal. It is known in metallurgy that the use of flux generally introduces into the bloom the impure elements of sulphur and phosphorus. Mr. E. R. Watson of the Bengal Educational Service has written an interesting account of the smelting process adopted by the Kols in the Sonthal Pergannahs which is very similar to the one just described.*

In the Palamau district, the native furnace spoken of by Mr. Ball, is also similar to the one just described and the method here employed for smelting seems to be the same, with the slight difference that the ore put in the furnace is reduced to powder and not merely broken up into nodules. Describing the process of this district, Mr. Ball observes that "the blast is, when once started, kept up

Smelting in the Palamau district.

for six hours, the people engaged changing places from time to time. Powdered ore is sprinkled in alternate layers with charcoal on the top of the charcoal in the shaft, as soon as it is fairly ignited, and as slag is formed it is tapped by a hole, which is every time pierced for the purpose in the side of the hearth, at different levels as the smelting proceeds and is again closed with lumps of well-kneaded clay. For ten minutes before the conclusion of the process, the supply

* See Watson's "Monograph on Iron and Steel Work in Bengal," p. 22.

of ore and fuel from the top is stopped and the bellows are worked with extra vigour. The clay luting of the hearth is then broken down and a *giri* or ball of semi-molten iron including slag and half-burnt charcoal is taken out and immediately hammered, by which a considerable portion of the included slag, which is still in a state of fusion, is squeezed out and the ball is then half-cut in two to show the quality of the iron."*

Small blast furnaces in Central Bengal.

Professor Turner has given a description of two types of indigenous furnaces which may here be quoted. "At Rajdoha (in Central Bengal) small blast furnaces," he says, "are employed which are made of a mixture of mud from the hills of white ants, together with rice straw. The furnace is 4 ft. 6 in. in height and tapers from an external diameter of 3 ft. 6 in. at the base to 1 ft. 10 in. at the top. The interior of the furnace tapers in a similar manner from a diameter of 5 in. at the top to 1 ft. 5 in. at the point where the bloom is formed. The blast is introduced by a single tuyere, which consists of a hollow bamboo set with clay. The air is forced by means of a pair of goat-skin bellows, which are worked by hand by a native squatting on the ground ..... A charge is worked off in about 6 hours; this requires about 106 lbs of charcoal and yields an irregular pear-shaped bloom of crude iron, weighing about 38 lbs; no flux of any kind is added. When the bloom

* Ball's "Economic Geology," p. 380. (Edition of 1881).

is ready, the thin wall of the front arch in taken down and the iron removed. The bloom, while still hot, is hammered into an irregular disc and cut up into pieces about 8 in. long and 2½ in. square; these pieces weigh about 5 lbs each and are in a convenient form for subsequent re-heating and working into bars."

"In the district of Malabar in Southern India," he continues, "the natives use tall blast furnaces which from the hearth to the throat are 10 ft. high and rectangular in section. At the throat the inside measurement is 1 foot from front to back and 3 ft. from side to side. The interior of the furnace is widest about 4 ft. from the top where it measures 2 ft. from front to back and 3 ft. 6 in. from side to side; from this point the furnace narrows down to the hearth. Several furnaces are built together and the walls below extend into a common platform, while above they are about 2 ft. thick. The front wall of the furnace is only 3 in. thick, but is strengthened with wedges made of hardened clay and straw; these wedges are inserted between the furnace itself and a wocden framework which binds the furnace together. The furnace walls are built of a mixture of red clay and sand. The platform abovementioned is a solid structure and adds greatly to the strength of the erection while at the same time it acts as working place for the man who charges the furnace. Immediately behind each furnace a pit is hollowed out

Tall blast furnaces in the Malabar district.

and into this the slag trickles through a hole in the bottom of the furnace and cools as a black ropy-looking mass. In front of each furnace two small platforms are erected, on each of which is a pair of goat-skin bellows. Each pair of bellows is worked by one man and the blast is introduced by separate clay tuyeres, one on either side of the front of the furnace. Between the two tuyeres in the front of the furnace, a row of about a dozen clay tubes is placed; these tubes enable the workman to see the interior of the furnace and their ends are stopped with a daub of wet clay when not being thus used as peep-holes. In these furnaces a bloom of iron weighing 5 cwts. is produced in from 48 to 60 hours; the bloom is removed by breaking down the lower front of the furnace when the iron is allowed to cool for two days and is broken into small pieces for the market."*

A comparison of indigenous furnaces and systems of smelting.

From the accounts given by writers on this craft, it appears that the furnaces most generally used in the country are built of clay, having a shape more or less like a cylinder, and are almost uniform in height, standing between 3 to 4 feet. They have an orifice in front, near the ground, which is stopped with clay during the smelting operation, and through which the tuyere is connected to a pair of skin bellows which supply the blast. The slag is taken out through a hole in the side of the furnace which is then blocked with clay,

* Turner's "Metallurgy of Iron," pp. 326 to 329.

and the tuyere is used as a peep-hole. The fuel used is charcoal, no flux being added with the ore, and the operation lasts from 5 to 6 hours. When the smelting is over, the bloom is removed through the front orifice and immediately hammered to express the intermixed slag.

Variations in the shape of the indigenous furnace and the methods of work are however noticeable in Malabar, as we have just seen, and in certain other districts. It is said that in Manipur, the tuyere is inserted from the back of the furnace, the front orifice serving merely as an exit for the products of combustion, and that in Birbhum, tall furnaces were once in existence producing pig iron which was subsequently reduced to a malleable condition. It is also stated that the smelters of the Waziri hills add limestone as a flux, and that in the Malabar district, the iron-makers use sea-shells brought from the coast for this purpose.

Their few variations.

Speaking of the direct process, adopted in the indigenous industry, of producing wrought iron from the ore, Prof. Turner remarks that "it is not without its advantages and is perhaps, under the circumstances, preferable to the production of cast iron as a preliminary stage of the process."* He further expresses an opinion to the effect that the iron thus produced is of very superior quality. On this point, his words convey no little encouragement to those who seek

The excellence of indigenous iron.

* Turner's "Metallurgy of Iron," p. 329.

a revival and improvement of the industry. "It is evident," he observes, "that the metal is equal to the best obtainable from any other source and suitable for the production of steel of the very best quality ..... Its composition supports the statement made in an official Indian hand-book that the metal is perfectly tough and malleable and superior to any English iron or even the best Swedish."*

Indigenous steel.

A few writers have described the process by which *wootz* the celebrated Indian steel was prepared, which does not appear to have been either a crude or a laborious process. It is therefore difficult to understand how this section of the art became extinct, while the mother industry—the smelting of iron—is still being carried on in the home of its manufacture. From the scarcity of this metal, it would appear that the art was practised by a very limited number of men, and it is quite possible that it died out with the families of these workers, as a knowledge of the valuable arts in former days was jealously confined to the artisans themselves. Referring to it, Mr. F. R. Mallet states that the Salem district in the Deccan used to be an important centre of the production of steel. "The iron," he relates, "which is smelted from magnetite in the usual way, is refined by repeated heatings and hammerings, and eventually formed into bars

Its method of manufacture.

* Turner's "Metallurgy of Iron," p. 327.

measuring about $12 \times 1\frac{1}{2} \times 1\frac{1}{2}$ inches. These are cut into small pieces, a number of which aggregating from half a pound to two pounds in weight are packed closely in a crucible together with a tenth part by weight of dried wood chopped small; the whole is covered over with one or two green leaves and the mouth of the crucible filled up with tempered clay, rammed in close. As soon as the clay is dry, from 20 to 24 crucibles are built up in the form of an arch in a small furnace, which is lighted and the blast kept up for about $2\frac{1}{2}$ hours; the crucibles are then removed, allowed to cool, broken, and the cakes of steel, which have the form of the bottom of the crucible, taken out.....It appears that in some cases the blooms produced in the ordinary iron furnace, after refining in the usual way, are sufficiently steely for employment in the fabrication of edged tools, which are tempered by plunging them while hot into water."*

The proportion of raw materials used in the indigenous industry.

The amount of charcoal and ore used in indigenous smelting is of considerable importance to the proper study of this craft. The proportions given by the different writers are so varied—due perhaps to the varying quality of the raw materials used—that it is difficult to arrive at any one conclusion on this point. Yet this question cannot be lightly passed over, as upon it depends to a large extent, as we shall see later on,

* Watt's "Economic Products of India," Vol. IV, p. 503.

the economic development of the industry. Mr. Ball states, in his description of Indian furnaces, "that in some cases the consumption of charcoal fuel for the production of finished iron is as much as 14 tons of the former to 1 ton of the latter."* His figures, however, do not show the average quantity used by the smelters under his observation and should be taken, as intended by him, to indicate the maximum amount of fuel used. The estimate of Mr. E. R. Watson, who says that "in all, probably 1 maund of charcoal and 20 seers of ore were used," does not throw much light on the subject. The calculations given by Sir Thomas Holland, according to Prof. Turner, appear to strike a very fair average and may here be quoted:—"For these reasons Mr. T. H. Holland is of opinion that the future of iron smelting in Southern India is a forest question and points out on the authority of Sir Dietrich Brandis, that if a large manufactory were erected to produce 10,000 tons of wrought iron per annum, by methods similar to those at present in use, some 35,000 tons of charcoal or 140,000 tons of wood would be needed."† The same writer, speaking of the industry in Southern India, says that "the charge is added in small quantities at a time, each addition consisting of about 4 lbs of ore, 8 lbs of charcoal and a few shells. The yield is only about 20 % of the ore used."‡

Sir Thomas Holland's opinion.

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* Ball's "Economic Geology," p. 341.
† Turner's "Metallurgy of Iron," pp. 329 and 330.
‡ Ibid, p. 329.

Mr. T. W. Hughes's calculations.

Some very useful figures have also been given by Mr. T. W. H. Hughes in his "Note on the Iron Deposits of Chanda (Central Provinces)," an extract of which is here made from the records of the Geological Survey of India, 1873. "My present contribution," says Mr. Hughes, "to the records of the Geological Survey refers to a few only of the deposits of iron ore found in the Chanda district, and gives some details relative to the amount of ore and fuel ordinarily used in native furnaces." His figures are as follows :—

Tahsil.	Iron ore used.	Charcoal used.	Iron yielded.
1. Muhl	49 seers.	82 seers.	17·5 seers.
2. Do	65 do	88 do	13·5 do
3. Do	72 do	90 do	21·5 do
4. Brahmapuri	38 do	68 do	12 do
5. Do	52 do	114 do	12 do
6. Do	44 do	88 do	12·5 do

The average of the above figures gives a proportion of $88\frac{1}{3}$ seers of charcoal, $53\frac{1}{3}$ seers of iron ore and $14\frac{5}{6}$ seers of iron, or roughly, 9, 5 and $1\frac{1}{2}$ respectively. Considering that the district of Chanda is noted for the richness of its ore, there can be no doubt that the quantity of fuel used was too great compared to the amount of iron obtained. We are therefore confronted with the unpleasant fact that the proportion of charcoal to iron, smelted from one of the richest qualities of ore in India, is 6 to 1. However superior the quality of indigenous iron may be, this proportion reveals a very great waste of fuel when compared to the conditions of modern smelting.

Discussing the quantity of fuel utilised in English smelting, and referring to a calculation of it by Sir Lowthian Bell, Professor Turner speaks to this effect: "So long as this is the case, the figures just given appear to prove that nearly one ton of coke would be needed to produce one ton of pig-iron.... But though what has been above stated may be regarded as proved for Durham coke and Cleveland ore, it has been found possible in modern American practice to produce a ton of pig-iron with only 16 cwts. of coke."* This great reduction of fuel in modern smelting is due to the intense heating power of mineral coke as compared to charcoal, and to the fuel-saving furnaces now used.

The proportion in modern English smelting.

It appears, therefore, that in considering the lines upon which this industry may be reformed, certain experiments with a view to a change of fuel is most desirable. In the recent expansion of the coal industry of Bengal there seems a ray of hope for indigenous smelting in western Bengal and the Central Provinces. There is little room for doubt that if proper experiments with Bengal coke were made in the indigenous furnace, a more economic process of carrying on the craft would be laid bare. It is possible that some alterations would be needed in the construction of the furnace, but this would not

Prospects of the indigenous industry.

* Turner's "Metallurgy of Iron," pp. 204 and 205.

be a very difficult thing to accomplish. Nor does the difference in the cost of the two kinds of fuel appear to be so great as to preclude a change from the one to the other. Under these circumstances, it is desirable that an honest attempt should be made to save this industry from extinction ; and the preliminary work in connection with it, being entirely experimental, would have to be undertaken by the Governments of Bengal and the Central Provinces.

Experimental work in connection with indigenous iron-smelting would, consequently, have to be conducted on the following lines:—

Suggestions for its improvement.

1. The calculation of heat produced in the indigenous furnace by different qualities of coke from the Bengal fields in comparison with charcoal prepared from the wood of deciduous trees.

2. The observation of thermo-chemical effects of these qualities of coke on the metal during the smelting process.

3. If the use of coke effects an economy of fuel as well as of labour but deteriorates the quality of the iron, the alteration of the furnace so as to prevent, if possible, this deterioration.

The market for indigenous iron.

It has been observed before that the indigenous smelter is placed at a distinct disadvantage by not knowing the nature of the market in which he sells. In a decaying industry, it is however natural that the sellers will lose touch with the buyers, as the production of their goods is uncertain. No extent of commercial organisation can keep such a market alive, and the trade connected with such a manufacture can never be restored unless the manufacture itself is first placed on a proper footing. When the latter is organised on a sound economic basis, a trade results from it almost automatically. If indigenous smelters could produce a superior quality of wrought iron and lay it down in the local market at a lower price than a similar quality of the imported metal, the agent of distribution would appear, and he would acquaint them with the conditions of the market, and buy the metal from them whenever offered for sale. An organised system of distribution, such as exists in every trade, would thus be established in this industry. It is therefore evident that all attempts to improve the market for our indigenous products must fail until the processes connected with their manufacture are rendered economic. Owing to this reason also, enquiries as to the existing state of the market for goods produced by decaying indigenous crafts do not possess much value, and disparaging inferences drawn from the present condition of such markets are wholly erroneous.

Mistaken steps in industrial development.

The languishing condition of indigenous smelting at the present day in India is, however, not much worse than the position of the iron industry in England during the 17th century, when it is said that, owing to the development of iron manufacture in the continent of

Europe and more particularly in Germany, the English industry sunk to a very low ebb. How it gradually recovered from its state of decline, and attained within a century the leading position amongst its rivals in Europe, is a brilliant chronicle and should serve us an object lesson.

The indigenous industry compared to iron-smelting in England during the 17th century.

Up to the end of the 16th century, the smelting of iron was conducted in England entirely with charcoal fuel, and, for this reason, iron works were situated in the neighbourhood of large woods or forests. Small blast furnaces built of masonry were used, and the blast was produced by leather bellows. At the beginning of the 17th century, these bellows began to be driven by water-wheels and the iron works were naturally shifted to the vicinity of running streams. But about this period, with the increasing demand for timber for purposes of ship-building and other growing industries, there occurred a scarcity of charcoal. During the year 1619, Dud Dudley, a son of Edward, Earl of Dudley, successfully used coke, prepared from Staffordshire coal, in producing pig-iron in the blast furnaces of his father's iron works near Dudley. The use of coke for the purpose of smelting was, however, forgotten in England after the death of Dudley. The method practised in this industry during the 17th century is described by Dr. Plot in a book written by him in 1686. "When they have gotten," he says, "their ore before it is fit for the furnace, they burn or calcine it upon the ground with small charcoal, wood, or sea-coal to make it break into small pieces, which will be done in three days, and this they call annealing it or firing it for the furnace. In the meanwhile, they also heat their furnace for a week's time with charcoal without blowing it, which they call seasoning it; and then they bring the ore to the furnace thus prepared and throw it in with the charcoal in baskets—*i. e.*, a basket of ore and then a basket of coal. Two vast pairs of bellows are placed behind the furnace and compressed alternately by a large wheel turned by water, the fire is made so intense that after three days the metal will begin to run; still after increasing until at length in fourteen nights' time they can run a sow and pigs once in twelve hours, which they do in a bed of sand before the mouth of the furnace."* In 1713 the use of coke in the manufacture of iron was revived by Abraham Darby, and has continued ever since with splendid success. Although a few improvements were made in this manufacture by the adoption of continental methods, the opinion is held by some well-known writers on this subject, that the success of Darby, in doing away with the use of charcoal for the production of cast iron, laid the foundation for that pre-eminent position in the iron trade of the world which Britain has so long enjoyed.

Since the year 1833, several attempts were made in the Central Provinces and Southern India to manufacture iron

* Dr. Plot's "Natural History of Staffordshire," p. 161.

on the European system, but owing to the use of charcoal in these experiments not one of them proved successful. An alteration in fuel was eventually made after about forty years of intermittent toil. About the year 1874, an iron manufactory with a blast furnace constructed for the use of mineral coal, was set up by a company of workers at Barakar, in the vicinity of the old Ranigunge coal-fields. The ore used in the furnace was a form of hæmatite and was collected from the surface of the soil in the neighbourhood of the works. The fuel employed was chiefly coke prepared from the coal of the adjoining fields. Limestone obtained at Hansapathar, a few miles from the works, was used as flux. It is stated that this company produced 12,700 tons of pig-iron but, being commercially unsuccessful, closed its works in 1879. In 1882 the Government took up the works, and placed it in charge of a German smelter by the name of Ritter von Schwartz, whose services it had engaged for this purpose. Schwartz commenced operations in 1884, and in four years is reported to have smelted in one blast-furnace 30,616 tons of pig-iron. Ritter von Schwartz was, therefore, the first person to show that iron could be smelted on the improved method in this country with commercial success. The factory was ultimately sold in 1889 by the Government to the Bengal Iron and Steel Company, which has since developed it considerably and worked it with a certain amount of success, in the face of a prejudice against Indian iron.

The modern industry in India.

At the present day, this is the only manufactory in India which produces iron and steel in any quantity on the modern system, and a description of its works is here given from the official publication of Mr. E. R. Watson. "These works," he writes, "are situated on the grand chord line of the East Indian Railway, a few miles from Asansole. They consist essentially of blast furnaces and a foundry. There are three blast furnaces, which are all of the same type, with cup and cone arrangement for feeding and closing the mouth, and the hot blast is supplied by five tuyeres to each furnace. The blast is heated by cowper stoves, of which there are eight. At the time of my visit, two furnaces were in blast, and two stoves were in blast and six in gas. The size of the furnaces may be judged from the production. When three furnaces are in blast, this amounts to 6000 tons per month. The coke for the furnaces is at present largely obtained from Jheria...... The ore is obtained under a considerable area in the Bengal coal-fields, and very different grade ores are obtained from the various workings. The ores all contain the iron in the form of Fe_2O_3; and some, *e. g.*, the Kalimati ores, are high grade and contain as much as 65 per cent iron. The majority, however, contain a high percentage of silica, often as much as 20 per cent. With the present system of working, the various ores are mixed so as to feed the furnace with a material of constant proportions. The Company are, however, prepared to work with purer ore in one furnace, so as to produce a hæmatite pig suitable for acid-hearth steel-making, if there is sufficient demand. The limestone used comes from Sutna.... The Company claim that their pig compares favourably with the best English foundry pig."* The latest venture in the adoption of the modern system of smelting in this country is that of Messrs. Tata Sons and Company of Bombay, who are erecting an extensive iron and steel factory near Kalimati in Bengal on the Bengal-Nagpur Railway line. The firm has discovered extensive and valuable deposits of iron ore in the Mohurbhanj State in Raipur, and in the Chanda district, which it intends to utilise in conjunction with fuel from the Jherria coal-fields. The success of this venture should lead to a development of the modern system of iron-smelting in India.

* Watson's "Monograph on Iron and Steel Work in Bengal," p. 47.

GLASS-MAKING.

Records of the industry in India.—The home of glass manufacture.—Composition and properties of glass.—The principal constituent of country-made glass.—The indigenous process of glass-making.—Seats of the industry.—Manufacture of glass-ware.—Methods of the 'churigars.'—Their process of making.—Methods of the 'shishgars.'—Their process of preparation.—Seats of glass-ware manufacture.—Suggestions for improvement of the indigenous industry.—The modern system of glass manufacture.—The melting process.—Regenerative furnace.—The annealing oven.—Automatic blowing.—The modern industry in India.—Suggestions for its development.

THERE was a tradition amongst the classical writers of the Græco-Roman period that the best glass of the ancient world was made in India, owing, it is supposed, to the use of a pure rock crystal in its manufacture. Whether this tradition had any basis in truth, it is almost impossible to tell after this lapse of ages, but it appears probable from the references made in the 'Yajur Veda' to glass ornaments worn by the women of this country, that this substance was manufactured in India about the eighth century before the Christian era. Occasional mention is also made in the 'Mahabharatha' of ornaments and fancy ware made of this material, and it is believed that the glass beads used in the Buddhistic age were of native manufacture. It is further recorded that about the 7th century of this era, some Chinese travellers visited north-western India and there learnt the art of glass-making, which they subsequently introduced in their own country. They are said to have

Records of the industry in India.

prepared, on their return home, a kind of opaque glass known as *liu-li.* Judging from these records it is possible to infer that relics of ancient Indian glass still lie buried in this country. But none of them appears to have yet been discovered, or even if discovered, to have been traced back to its origin, archæological research being a recent pursuit in India. It is almost certain that the investigations of this science will gradually reveal a quantum of knowledge regarding our crafts, of which we have perhaps no conception at present. But be there any such relics or not, there is a sufficiency of recorded evidence to prove that the existing art of glass-making in India is of such remote origin that it may safely be called an indigenous craft.* As we pursue its history from the days of antiquity, we find from the frequent allusions made to it in the literature of the country, that in the middle ages it was widely practised. In so great a book as the 'Ain-i-Akbari' we see that glass for window-panes was included in a list of building materials.† From the various relics that have come to us of that period, it is quite evident that the industry attained its high-water mark during the Mogul

* Since writing the above account, the discovery of some bones of Gautama Buddha in a 'transparent rock crystal receptacle' recently made near Peshawar by Dr. Spooner, reveals the existence of a relic of ancient Indian glass and proves that there was an amount of truth in the aforesaid tradition. This receptacle from its make and composition was evidently of Indian manufacture just as the casket enclosing it is supposed to be of Grecian construction.

† "Ain-i-Akbari" by Abul Fazl Allami (Blochmann's translation), Ain 88, p. 226.

dynasty, and there can be no question that it was then conducted on a much larger scale in this country than in our own times.

The home of glass manufacture.

There is an opinion among present day antiquarians that the art of glass-making first originated in Egypt. This belief is based upon the fact that relics of the earliest glass have been brought to light in that country. In the winter of the year 1891, Dr. Flinders Petrie is known to have discovered traces of glass and evidences of its manufacture in the town established by Akhenaten at Tell-el-Amarnah about the years 1450 to 1400 B. C. But it is now also clearly established that this glass was prepared by a very crude method in which the blowing process did not come into play. The glass-ware which was made in the remote ages seems to have been obtained by melting the ingredients into shape in a mould.* In what country or at what period the later process of blowing first came into existence is not known.

Christopher Merret, one of the earliest writers on this subject, tells us that glass is a concrete of sand or stone, and salt, which the modern manufacturer of this product would technically express by saying that it is a composition of silica with an alkali. These, however, though the

* The 'transparent receptacle' found near Peshawar being hexagonal in shape, hollow inside, and with a hole on top, was apparently cast in a mould.

essential constituents of glass, could not merely by themselves be worked into any practical shape. A combination obtained by melting sand or quartz with a salt of soda or potash would indeed be transparent, but it would at the same time be too fragile to work with. There is, therefore, the necessity of another base which is generally supplied in the form of lime. It is this which imparts the requisite toughness and the working qualities to this artificial product. Like most mineral substances, glass melts in a strong fire but here ends its similarity with the family of minerals. When melted it is tenacious and clings to iron or any other metal. Whilst red hot it is ductile and fashionable into any shape. "In passing from a liquid to a solid state," says a modern writer, "there intervenes a viscous stage when the glass may be gathered at the end of an iron rod. If the rod be hollow, the glass may be blown out into a vesicle or bulb." The essential materials required for the manufacture of glass are, therefore, sand or quartz, soda or potash, and lime, which are generally used in the proportion of 71, 17, and 12 respectively.

The composition and properties of glass.

Speaking of the ingredients used in the preparation of indigenous glass, the well-known Anglo-Indian botonist, Dr. George Watt, says that "India abounds in materials which readily yield these necessary constituents. Perhaps the simplest of these is *reh* which contains soda in the form of a carbonate and a large quantity of silica ready mixed."* *Reh* is the saline efflorescence of unculturable tracts of land in Upper India. It is obtained from the soil by a very simple method, generally during the hot weather. In canal districts, the glass-maker hires a plot of barren land about the end of March. He divides the plot into small square beds and erects low mud ridges round each of them. Water from the canal is then run into these beds which are thus converted into a number of shallow tanks. The water dries up in a few days, but by a chemical process a saline substance, which has risen from under the soil, is deposited on these beds. These deposits are finally gathered by being scraped off the earth. In districts having no canal irrigation, the *reh* which is found on the surface of the ground, generally after a wet night, is scraped off the earth and gathered in a heap which is surrounded with a low mud wall. Water from a well is then poured over it, and the mass is thus allowed to stand for a few days, when the pure *reh* rises to the surface. It is finally collected and made into small balls.

The principal constituent of country-made glass.

By the above method, a large quantity of *reh*, sometimes amounting to a few thousand maunds, is collected by each glass-maker in the season. But before being converted into glass, it is baked or calcined by being put into a kiln for a whole day and night till all the moisture in it dries up. It is then taken out, mixed with some other

* Watt's "Economic Products of India," Vol III, p. 503.

ingredients and finally melted into glass in a furnace. Both the kiln and the furnace are built in one structure, the former being above the latter. A description of this structure and the process of melting by Mr. H. R. C. Dobbs, of the United Provinces Civil Service, who has written a monograph on this industry, may here be quoted. "The kiln (bhatti)," he says, "used for the scorching of the *reh* and for its manufacture into crude glass is of quite a different kind from that used by bangle-makers or by glass-blowers. Its shape varies slightly in various districts. In Aligarh and Bulandshahr it resembles a cone with a semi-circular section taken out of it. It is built of sun-dried bricks and rises from three feet below the surface of the ground to seven feet above it, being from 12 to 15 feet in diameter. It consists of two stages of which the lower, the furnace, called *taq*, reaches to the level of the ground; while the upper one, in which the *reh* is held, fills up all the space above the ground. The two stages are separated by a flooring of clay, on which the *reh* rests. In front of the furnace is a pit in which the fuel is kept, and into which the two doors of the furnace open. One of these doors, used as a stoke-hole is called *int* or *jhokant*, the other for raking out the ashes is *pathar*. Between the two is an ash-pit, *tinia*. The *reh* is introduced into the upper stage through a hole called *majli bari* or 'middle window' which is on a level with the ground and on the opposite side to the stoke-hole. On

The indigenous process of glass-making.

either hand of this hole are two smaller ones through which the *reh* is watched and stirred. These three holes are covered with earthen covers while the fusing is in progress. Besides these there are four air holes on the crown of the kiln, one in the centre of the top and the other three ranged in a semicircle exactly above the 'middle-window'...... When the ingredients have been properly mixed with it, the *reh* is once more thrown into the kiln and melted up continuously for about 18 days and nights, being from time to time stirred with an iron shovel and a long iron hook. It is then run out into a pit, allowed to cool for 10 days and broken up into big blocks which are ready for exportation. Four hundred maunds of *reh* and other substances are usually melted up at one time, producing about 300 maunds of glass."*

Crude glass, in which *reh* is the principal constituent, is chiefly manufactured in the United Provinces where the districts of Aligarh, Etawah, Mainpuri, Agra, Bulandshahr, Etah, Fyzabad, Meerut, and Rai Bareilly are mentioned by Mr. Dobbs as the seats of its manufacture.

The seats of the industry.

Speaking of the method of producing indigenous glass in the Punjab, Mr. C. J. Hallifax says: "the commonest way of making *kanch* (glass) is that of mixing together equal parts of powdered sandstone and *sujji* (carbonate of soda) and melting them together. This

* Dobb's "Monograph on the Pottery and Glass Industries of the North-West Provinces and Oudh, pp. 32-34.

is the method followed in Lahore, Jhelum and Panipat (for *churis*) and also in Multan and Dera Gazi Khan....... In Gurgaon *reh* is mixed with saltpetre and heated for one night over a slow fire, after which it is subjected to fierce heat for a day.....The finer kind of glass used at Panipat is made of red sandstone, *sujji* and saltpetre."* The indigenous process of glass-making, though simple yields a product which is generally a dark-coloured mass containing air-bubbles.

Manufacture of glass-ware.

Besides the preparation of block-glass, glass-ware is also manufactured by indigenous workers, which consists of beads and bangles, *attar* and other scent bottles, ink-pots, lamp-chimneys, globes and toys. The bangle-makers are known as *chuigrars*, and the makers of miscellaneous glass-ware as *shishgars*. The quality of their ware is rather inferior owing to the coarseness of the glass and their crude process of manufacture. In spite of the early origin of this industry and its apparent expansion during the Mogul period, we find that its methods of preparation at the present day are not more advanced than in its original and rudimentary stage. "The furnace for the manufacture of glass bangles," says Mr. Dobbs, "is always roofed over and is a roughly pentagonal dome of clay, varying in size with the number of workers and covering a pit about

* Hallifax's "Monograph on the Pottery and Glass Industries of the Punjab," p. 23.

three feet in depth in which the fire burns. The fire is fed through a large stoke-hole called variously *jotak* and *jhokant.* All round the sides of the dome about three inches above the level of the ground are small horse-shoe shaped openings called *bari* or *bara* through which the workers hold the glass in the heat of the furnace. During the process of manipulation each of these openings is flanked by two clay walls or wings, so that every worker has a separate stall or compartment for himself...... Inside the furnace on a level with the sill of each opening runs a clay ledge all round, three inches broad, and on this is rested in front of each opening either an earthen crucible *ghariya* or a curved potsherd *tikra* in which the crude glass or the colouring matter is melted up. Before the spot where the workman sits and resting on the ground, in the centre of the space between the extremity of each wing of the stall, is a big flat stone called *pathri, thumba*, or *gather.* One edge of this stone hangs over a square pit called *pait* for receiving completed bangles...... Each man keeps inside his special opening two crucibles, one for half melted and one for completely molten glass, and between these is the ledge on which he manipulates his instruments..... Over the furnace is a framework of wood called *machan* on which the fuel is placed to dry before being thrown into the furnace..... To make plain bangles, the furnace is lighted and some big blocks of crude glass are set on the floor

Methods of the 'churigars.'

of the furnace almost in contact with the fuel. After they have been heated for about ten minutes they are thrown into a basin of water, which causes them to split up into small pieces. These are then thrown into the crucible for half molten glass with such colouring matter as may be required, and when properly fused, ladled out into the second crucible for completely molten glass. The workman next dips the end of the iron hook (*ankuri*) into the crucible and takes out a small ball of molten glass enough for one bangle. This he winds off like treacle upon the end of the iron spit (*sallakh*) into a thick irregular ring. He now throws down the iron hook, takes up the dagger shaped pressing tool (*mala*), and resting the end of the iron spit, round which the glass ring is wound, on the stone slab (*patri*), taps and squeezes the ring until it has half cooled. The iron wire (*barhana*) is next inserted between the spit and the ring of glass, which is thus detached from the spit and left on the iron wire. From the end of the iron wire it is transferred to the tip of the tapering clay cone (*kalbut*). The workman then holds the clay cone towards the opening in the furnace, pressing its thin iron handle between his open palm and the surface of the stone slab in such a way that the clay cone is slanted upwards towards the furnace. In his other hand, he holds the iron wire which he inserts between the clay cone and the glass ring. Next by rubbing his

Their process of making.

Plate IV.

[*To face p. 57.*

INDIGENOUS GLASS-MAKING.

Showing the front of the chamber used by 'shishgars.'

From a photo taken by the author.]

open palm with the handle beneath it backwards and forwards over the stone slab he causes the clay cone to spin rapidly round, and the glass ring upon its tip becomes gradually enlarged and slips down to the broad base of the cone until it has grown to the size of a bangle. It is then slipped off and thrown to cool into the pit between the stone slab and the furnace."* The manufacture of bangles forms a very large section of the indigenous industry in the United Provinces, and in the Punjab it is stated that nearly all the glass-workers are *churigars*. The large extent of this section of the industry is due to the universal use of bangles among the women of India.

The furnace used by *shishgars* in the manufacture of blown glass-ware is quite different from that of the *churigars*. An annealing oven is attached to it. An illustration of the chamber, combining the furnace with the oven, as used by the glass-blowers of Calcutta, is given in Plates IV and V. It is a clay-built rectangular structure roughly resembling the letter L. The front portion (shown in Plate IV) is about $4\frac{1}{4}$ ft. in length, 2 ft. in width, and 3 ft. in height, while the back extension on the left is $2\frac{1}{2}$ ft. $\times$ 2 ft. $\times$ $2\frac{1}{2}$ ft. The right wing (seen in Plate V) is built over a pit in the ground. This pit continues open to the end of the structure as far back as the extension

* Dobb's "Monograph on the Pottery and Glass Industries of the N. W. Provinces and Oudh," pp. 35-37.

on the left. The chamber, known as the *bhatta*, is two storied. The lower story contains the furnace, and the upper, the annealing oven. In the lower story the left wing is completely solid, and the right wing, together with the portion of the pit below it, constitutes the furnace called the *lao*. In this story is an arched aperture leading to the furnace through which the melter carries on his work. A thick burnt-mud screen, shaped like the head of a duck, is placed in front of this aperture when the heat from the furnace is so great that the melter cannot stand it. The opening in the aperture is thus lessened. In front of it and sunk in the ground, is a furrow leading into the furnace ; through this the latter is fed with fuel. Opposite this furrow and down below at the back of the furnace is the stoke-hole, leading to the open pit where all the ash and refuse of the furnace is collected. The lower aperture seen in Plate V is the side door of the furnace through which the fire is regulated. A thick mud screen shaped like a horse-shoe is placed before this door. The whole of the upper story forms the annealing oven which consists of two compartments, a square one on the right called the *chanda*, and a rectangular one on the left called the *ghor*. There is a passage joining the two compartments and a small hole in the floor of the right compartment. Through this hole the heat rises from the furnace below and makes this compartment the hottest part of the oven. The centre

Methods of the 'shishgars.'

Plate V. [To face p. 58.

INDIGENOUS GLASS-MAKING.

Showing the right-wing or the chamber used by 'shishgars.'

From a photo taken by the author.]

portion of the oven is less hot, while the projection at the back is the coolest part of it. The semi-circular opening in the upper story, seen in Plate V, is the entrance to the oven through which the blown articles are put into the right compartment. They are gradually pushed on to the centre of the oven, then to the projecting portion, and finally taken out by a semi-circular opening at the back.

Their process of preparation.

The methods, adopted by the *shishgars* in preparing blown glass-ware are entirely different, as they must be, from those of the *churigars* in the manufacture of bangles. An iron bar called the *molli*, about 3¼ ft. in length and ¾ inch in diameter, is first covered over with a paste made of mud, jute fibre and ground glass, at one end which is knobbed. The other end has a wooden handle by which the bar is manipulated. A strong fire is then lighted in the furnace with faggots of wood which are stacked in a platform above the oven. A handful of broken glass is placed on the ledge of the arched aperture. After a little while, the glass becomes soft through the heat of the furnace. The knobbed end of the bar is shoved into the furnace, its handle resting on a wooden sill in front of the aperture. The mass of softened glass is then taken up by the melter with an iron hook, and placed on the paste at the end of the bar. When the glass approaches the viscous stage, he twists the handle round and round to prevent the glass from falling off the knob. While he slowly winds the bar with the left hand, he takes off with the right at the end of a blow-pipe or *dhandari*, a small lump of glass as it trickles down the knob and hands the pipe to the blower. The blower, by first rolling the lump over and then pressing it against a stone slab placed before him, brings it to a pear-shaped bulb. He now stands up and swings round the pipe to elongate the bulb, then puts it into a divided mould which is promptly closed up by a lad. He blows into the bulb, the air forcing the glass to take the form of the mould, whether it be that of a lamp-pot or a scent bottle. He then draws away the blow-pipe from the mould thus thinning down the glass between the two which ultimately gives away at the neck of the pot or the bottle by the touch of a pair of wet nippers. The lad uses the nippers, opens the mould, and puts the newly-made article into the annealing oven by means of a wired rod. Each article takes about 3 to 4 hours to go through the oven in the manner already described.

The fuel used in indigenous furnaces consists of wood of a quality which is most easily obtainable in the locality of manufacture. It does not appear to be selected owing to any heating capacity. Thus, in the United Provinces, *arhar* stalks, tamarisk and *babul* wood are generally used. It will be seen later on how the poorness of the fuel affects the melting process.

The spread of this industry in the middle ages to almost every part of India can only be attributed to the plentiful supply of *reh* and other glass-forming materials in this country. "Now-a-days indeed," says Dr. Watt, "the glass-making industry is almost entirely confined to a few families in the Lahore, Karnal, Jhelam and Hoshiarpur districts of the Punjab; in the Bijnor and Shaharanpur districts of the North-West Provinces; in Lucknow; in Ahmednagar, Kaira and Baroda in Bombay; in Seoni in the Central Provinces; in Patna in Bengal; in Jeypore; and in the North Arcot district of Madras."* Besides the above localities the manufacture of blown glass-ware is also conducted in Calcutta.

Seats of glass-ware manufacture.

It has been already stated that the principal defects of indigenous glass consist in the darkness of its colour and the air-bubbles that it contains. The former is due to the impurity of the ingredients and an excessive use of alkali, which can be remedied by improving the process of preparing the ingredients and by their proper composition. These improvements would have to be based on the corresponding system employed in the modern industry. The latter defect is due to the insufficiency of heat in the melting furnace which does not bring the ingredients fully to the liquid state, thus preventing the escape of air-bubbles formed in the crucible. A higher temperature must therefore be applied to the indigenous furnace by the use of mineral coal instead of

Suggestions for improvement of the indigenous industry.

* Watt's "Economic Products of India," Vol. III, p. 504.

wood-fuel. A change of fuel would, of course, necessitate a slight alteration in the construction of the furnace, but this could be easily effected. Although coal might be more expensive than wood in certain districts, it would save time and labour in the melting process, and thus prove to be a more economic fuel in the long run. Besides the above defects in the indigenous craft, we have observed that the *churigar* has no annealing oven, but throws his bangle when prepared into a pit. This is really a drawback, as his articles cannot be durable not being properly tempered. An annealing oven similar to the one used by *shishgars* would be an improvement in his workshop.

It is evident that the aforesaid improvements would have to be introduced by a glass expert working in a centre of the industry in the United Provinces or in the Punjab. After making a study of indigenous processes throughout the province, he would necessarily set up an experimental works in some convenient centre. If, in course of time, the improvements devised by him proved successful, he would naturally set up several small factories in other centres which could be worked by pupils trained by him. He would probably find the necessity of touring round these factories himself for the greater part of the season. The indigenous glass-workers in the province could then be invited to attend and learn the improved methods in these factories.

The system employed in the modern industry are based upon the principles underlying the glass-making art ever since the blowing process came into vogue. It is possible to find in the crude craft, as it is still practised in this country, the germ and counterpart of almost every modern process. In the modern system, however, nearly all the operations have been perfected and the entire manufacture rendered so economic that glass-making has now reached a very advanced stage, particularly in certain parts of Europe. In an up-to-date factory, the ingredients out of which glass is made are so prepared and composed as to give the resulting materials purity, strength, and transparency. Although the last is not regarded as an essential quality in good glass, some of the finest products being opaque, yet it is the one most generally required in this substance. In such a factory, the system by which the ingredients are combined and converted into glass is well worth an enquiry. As in the older craft, the first process is the *calcination* of the different ingredients, so that a chemical union among them is commenced, producing what the manufacturer calls the 'frit.' This is done in a reverberative chamber called the 'calcar' or 'fritting' oven which has a low roof, so that the flames in passing from the fuel to the chimney are reflected down on the hearth. Here the ingredients are baked without coming in direct contact with the fuel.

The modern system of glass manufacture.

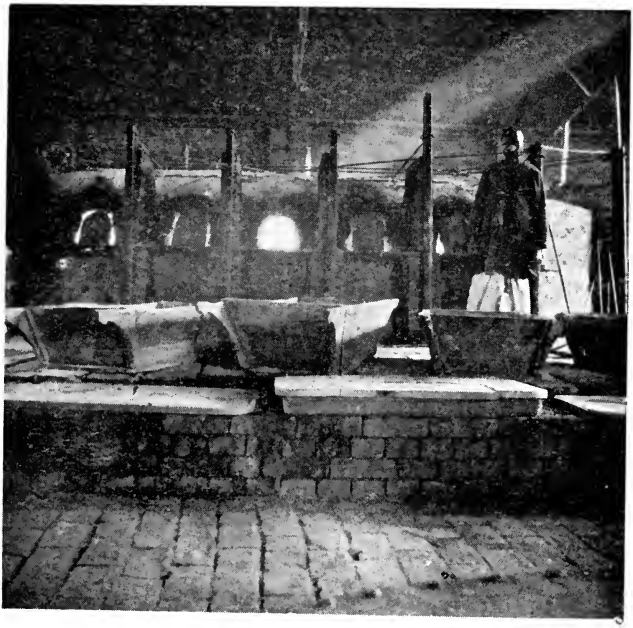
The next process consists in *melting* down the 'frit.'

This is done in the 'melting furnace' which is a circular chamber with an arched-dome interior terminating in a chimney. At the centre of the furnace is a grating, the fire on which is fed with air from a vault below. The frit is put into fire-clay pots or crucibles which are placed all round the centre of the furnace equally distant to each other, but each pot is put opposite to an aperture in the furnace, so that it may be charged or discharged by the workmen from outside whenever necessary. The flames and hot air acting upon the crucibles placed round the fire, melt the ingredients and escape through the chimney. Two such furnaces are often built together which terminate in one chimney by means of flues. Plate VI shows the melting furnace of the Upper India Glass Works at Umballa, where the heat generated varies between 1400° to 1600° centigrade. There are 10 crucibles inside the furnace producing 80 mds. of glass in 14 hours. In some factories, the use of crucibles for the process of melting is done away with, and in their place a reservoir is constructed in the melting chamber. Such chambers, which are known as 'tank furnaces,' yield a continuous flow of glass. But the most economic system of melting is carried on in Siemen's regenerative furnace which has now come into extensive use. This is a chamber where gas reproduced from the fuel helps to raise the heat needed for fusion. "In modern furnaces," says Rosenhain, "the process of

The melting process.

Regenerative furnace.

Plate VI. [To face p. 64.



MODERN GLASS MANUFACTURE.

The melting-furnace of the Upper India Glass Works at Umballa.

From a photo taken by the author.]

combustion is carried on in two distinct stages; the first stage takes place in a subsidiary appliance known as a 'gas producer,' where part of the heat which the fuel is capable of generating is utilised for the production of a combustible gas; this gas passes into the furnace proper, either direct, while it is still hot from the producer, or after being conveyed some distance, when it is again heated up by the waste heat of the furnace. In either case the gas is hot when it enters the furnace proper, and there it meets a current of air, also heated by the aid of the waste heat of the furnace. Hot gas and hot air burn rapidly and completely, and if properly proportioned yield exceedingly high temperatures."* "In regenerative furnaces," he continues, "the hot products of combustion, after leaving the furnace chamber proper, and before reaching the chimney, pass through chambers which are loosely stacked with fire-bricks; these chambers absorb the heat of the escaping gases, and thus rapidly become hot. As soon as a sufficiently high temperature is attained in these chambers or 'regenerators,' the path of the gas currents is altered; the escaping products of combustion are made to pass through, and thus to heat a second set of regenerating chambers, while the incoming gas and air are drawn through the heated regenerator chambers before entering the furnace chamber proper. The incoming gas and air are thus heated, absorbing in turn the heat stored in the brickwork of

* Rosenhain's "Glass Manufacture," pp. 62 and 63.

the regenerators. It is evident that two sets of such regenerators are sufficient, the one set undergoing the heating process at the hands of the escaping products of combustion, while the other set is giving up its heat to the incoming gas and air."*

The final process in the manufacture of glass and all articles made of it is the *annealing* or slow cooling of the products so as to temper them and make them less brittle.

The annealing oven.

This is done in the annealing oven where the temperature begins at a point just lower than that required for fusion and gradually comes down to the cooling point. The glass is kept in this chamber for several days while the heat is very gradually diminished. The utmost care is necessary in the conduct of this process as the slightest defect in annealing renders the glass liable to break by a subsequent change of temperature. Plate VII shows the annealing ovens of the Upper India Glass Works where the course of annealing is extended to seven days.

The method by which blown glass-ware is prepared in Western countries has been greatly improved in recent years. In place of the mouth-blowing process, which rendered the

Automatic blowing.

manufacture of this class of ware a most difficult occupation for those engaged in it, machine-blowing has been introduced. The bottle-making machine, devised by Ashley, performs the operations of

* Rosenhain's "Glass Manufacture," p. 66.

Plate VII.

[To face p. 66.

MODERN GLASS MANUFACTURE.

The annealing-ovens of the Upper India Glass Works at Umballa.

From a photo taken by the author.]

pressing with a plunger and blowing by compressed air; an automatic glass-blower, patented by Michael Owens of Toledo, U. S. A., for the manufacture of tumblers, chimneys, bottles and other hollow ware, has taken the place of human glass-blowers. The only manual operations necessary in connection with this machine are:—(1) gathering the molten glass at the end of a blowing iron, (2) placing the blowing iron in the machine, and (3) removing the blowing iron with the finished article attached. This machine is said to turn out seven tumblers or five lamp chimneys per minute.

During the closing years of the last century, several attempts were made in this country to manufacture glass on the modern system, but only a few of them have proved successful. The majority, therefore, have failed not through the impossibility of success, but owing to various causes arising out of the incapacity of the workers, the insufficiency of capital, or the want of skilled labour.

The modern industry in India.

There is no doubt that, owing to the high temperature and heavy strain to which operatives are exposed in a glass factory, it is more difficult to acquire labour in this manufacture than perhaps in any other. But the strain on the blowers at least has been overcome in the modern industry by the introduction of improved machines, the adoption of which would undoubtedly enhance the position of present-day workers in India. A brief survey of the attempts which have been made here to introduce the modern system would be helpful to new-comers in this field.

The first experiment in glass manufacture is reported to have been made in the Punjab, apparently about the early seventies, by a certain Mr. H. Whymper, then Manager of the Murree Brewery Company at Jhelum. Before embarking on his venture, this pioneer sent a report on indigenous glass with samples of its products to experts in Europe, and, having received encouraging opinions from them on the prospects of its manufacture, set to work on the modern system. He brought over a German manufacturer, who put up a factory and commenced operations. Bottles were indeed turned out by him similar to those made in Europe, but for some reason or other, upon which no information can be obtained at present, the experiment was abandoned. Referring to this enterprise, an official record attributes the cause of its failure to the incompetence of the expert. Considering that he was specially brought out for this purpose, it is more probable that his ignorance of local conditions stood in the way of success rather than his inability. An inference which may be drawn from this failure is that a knowledge of local conditions is essential to the success of an industrial undertaking; and, as a pioneer cannot always start with such knowledge, it is evident that he must possess a sufficiency of capital and patience to continue till he has attained success. If he can gradually acquire a mastery over the resources that are available, success will naturally follow.

The next venture recorded was made in 1879 at Aligarh, then a seat of the indigenous glass industry. It was conducted by Mr. H. Smith, an indigo planter, who received some facilities, including a grant of money, from the Government of the North-Western Provinces for this purpose. Bottles were also turned out by him, but owing, it is stated, to their not being of uniform weight and thickness, the experiment was discontinued after about two months. If the facts above recorded are correct, it is evident that the impatience of the worker added to his inability rendered this undertaking a failure. Another experiment was also made under Government patronage at Bhagalpur in 1882 by a Mr. Wilson, Assistant Engineer. Before taking up the enterprise, it is said that he visited some glass factories at Venice and there made a study of the manufacture of glass beads. He returned with a set of implements used by the Venetian makers and commenced work, but, failing to generate sufficient heat in his furnace, abandoned the project after a time.

About the year 1890, some citizens of Calcutta formed a syndicate known as the Pioneer Glass Manufacturing Company, Ld. with a capital of $2\frac{1}{2}$ lakhs of rupees, and erected a factory at Tittaghur near Calcutta. It contained two pot furnaces in which coal alone was used to generate heat for the purpose of fusion. This was the old process of direct firing in which gas producers had no place. The company obtained from Birmingham and Austria six blowers who commenced work rather successfully and produced some very fair specimens of medicine phials, soda-water bottles, lamp-pots and chimneys, ink-pots and *churi* glass. The ingredients used were sand from Rajmehal, quartz from Giridhi, lime from Sylhet and alkali imported from Europe. These European blowers initiated a large number of Indian workmen, recruited principally from the lower classes, into the processes of manufacture and the factory progressed, making rather high profits by the preparation of *churi* or block glass. It declared dividends of 2½% and 8% for two years. After a time the European blowers asked for higher salaries, but the company not acceding to their wishes, they left its service and went back to their homes. The works were then conducted entirely by the Indian staff. In the year 1895, a new glass factory was started in the vicinity of Tittaghur, which, it is said, allured with increased wages almost the entire staff of the old factory, and left it practically crippled. Being deprived of its skilled labour, the Pioneer Company dragged on for a little time with difficulty, trying to train up new men, but finally went into liquidation early in 1897.

The new company, known as the Sodepur Glass Works, was floated in England by Messrs. F. W. Heilgers & Co. of Calcutta, who took over its managing agency and located its factory in the village after which the company was named. It possessed a capital of eight lakhs of rupees and put up extensive works, the main feature of which was a set of tank furnaces with gas producers. The company brought over fourteen European blowers, and, with the skilled labour obtained locally, made a variety of glass-ware of excellent shape and finish. These articles, however, used to crack by change of weather owing, it appears, to defective annealing. The factory was closed in 1898. In 1895, the Upper India Glass Works were set up at Umballa by some enterprising Indians. This factory experienced some difficulty at the commencement of its career in securing and training up operatives, and also, it is said, by reason of its not having a sufficiency of working capital. It consequently changed hands after a time and passed on to its present proprietors, who are conducting the works with success. This is the only glass factory at present in India. It prepares block glass for *churigars* and *shishgars*, the business in which is considered lucrative. Portions of its plant have already been described.

About the year 1902, the manufacture of glass was undertaken on a fairly large scale at Rajpur, near Dehra Dun, by the Himalayan Glass Works, Ld., a company floated with Indian and European capital. Its principal outturn consisted of block-glass; but lamp-pots, chimneys, tumblers and a variety of other glass-ware were also manufactured. The factory turned out articles of very fair quality and finish which were used all over Upper India and known even in Bengal. After a successful career of some years, the company is said to have got into difficulty during last year for want of capital, and has since stopped its works.

A review of the attempts, which have been made to manufacture glass on the modern system during the last forty years in India, shows that the principal causes of failure were as follows:—

1. Ignorance of local conditions.
2. Impatience and inability of the workers.
3. Ill-constructed furnace.
4. Want of skilled labour.
5. Defective annealing.
6. Insufficiency of capital.

Suggestions for development of the modern industry.

It is, therefore, obvious that new-comers in this field would have to bear in mind these causes of failure and provide against them as far as possible. With a certain amount of forethought, none of them seem difficult to avoid. If a factory were started with a sufficiency of capital, with an up-to-date plant containing regenerative furnaces and automatic blowers, and if it were situated in one of the centres of the indigenous industry, within easy reach of skilled labour and the raw materials, nobody would doubt its ultimate success. The difficulty of attracting operatives to a glass factory in a hot climate is not insuperable. Considering that the indigenous industry has been carried on in this country for centuries on a fairly large scale, and that the Indian labourer is naturally more accustomed to heat than the European workman, there is no reason why it should not be possible to secure labour for this manufacture. It will, however, be necessary to keep pace with the extension of the modern industry in India by imparting a knowledge of this art to the sons of indigenous glass-workers in technical schools.

POTTERY AND CERAMICS.

The antiquity of the craft in India.—Its age in Egypt and China.—The artistic treatment of Grecian pottery.—The indigenous pottery of India.—Its mode of manufacture.—The preparation of clay.—'Throwing' on the wheel.—The firing process.—Decorated pottery.—Glazed pottery.—The ceramic industry, a development of the potter's art.—Its manifold use at the present day.—The principles of the ceramic art.—Its system of manufacture.—The reduction of clay.—Churning the clay.—The treatment of flint.—Mixing the ingredients.—Evaporating the mixture.—Its maturation.—The old 'wedging' operation.—Kneading the paste.—The 'throwing' process.—Finishing the shape.—The baking process.—The application of glaze.—Porcelain.—The modern industry in India.—An improvement in the indigenous industry.

The antiquity of the craft in India.

THE people of India, reputed for their industrial activity in ancient times, are believed to have been one of the earliest workers in pottery. Although the early history of the craft in this country is entirely lost in the mist of ages, it may be reasonably surmised, that in a crude and rudimentary form, it originated within our own shores, for evidence is not wanting of its existence here in the days of remote antiquity. Frequent allusions are to be found in the Vedas, more especially in the Rig-Veda, to earthen vessels used by the Hindus, and the water-pots represented in the sculpture of Buddhistic monuments testify to the age of the craft. Since no evidence is obtainable of its introduction into India from extraneous sources and its existence here is so ancient, it may be regarded, until some better light is thrown on this subject, as a natural growth of the inventive faculty of the Indian people. Yet it must not be supposed that India is the only country in which this industry is indigenous. It is believed, upon no slender grounds, that the art of making earthenware was of native origin among the peoples of ancient China and Egypt, and that the age of the craft in those countries is more ancient than it is in India.

While it may be conjectured that this industry was indigenous in more countries than one, it is almost certain, that of all the crafts now pursued in the industrial world, there is none which has an origin of such remote antiquity as the art of making pottery. Relics of the fictile craft, in the shape of rude urns, vases and vessels, are said to have been excavated from the tombs of prehistoric men. "On the walls of the tombs of the Beni-Hassan," says Bourry, "pictures have been discovered, pourtraying scenes from the life of Egyptian potters, modelling vases and firing them in an oven, at a time corresponding to the Theban period (B. C. 3000-1700)."* In the earliest period of Egyptian civilisation, vases of baked clay appear to have been used, and glazed tiles have been discovered which are traced to the epoch of Rameses III (B. C. 1200). The most remarkable pottery made by the early Egyptians was a kind of earthenware formed of fine sand or frit and covered over with a thick glaze, blue, green, or purple in colour. It belonged to a period about 1600 years before the Christian era. According to their

Its age in Egypt and China.

* Bourry's "Treatise on the Ceramic Industries," p. 15.

own records, the ancient Chinese also manufactured a species of glazed ware in the reign of their Emperor Hwang-Ti, about 2700 B. C. This ware is sometimes erroneously referred to as porcelain. Although the idea is accepted, and it is quite probable, that when the Greeks were making terra-cotta vases the Chinese were manufacturing porcelain, it is difficult to believe that this substance was prepared by them at such an early stage of the craft as in the 27th century before Christ. There is no doubt that the Chinese were the inventors of porcelain, but it is unlikely that in the reign of the Emperor Hwang-Ti, their glazed ware was of the same composition and translucency as the latter-day porcelain.

The artistic treatment of Grecian pottery.

But the most beautiful pottery belonging to antiquity is known to have been made in Greece, that cradle of European refinement and culture. This pottery was made usually of burnt earth or *terra cotta*, a mixture of fine clay and powdered sand, air-dried at first and then baked. The body was sometimes covered over with a coating of very fine clay, on which figures were either painted or raised. The painter and the sculptor thus joined in beautifying the potter's art. Their combined efforts helped to produce perhaps the finest specimens of industrial art that the world has ever seen. Drawing their inspirations, as it were, from the Greek gods, the work of these artists, usually most delicate and refined, was at times quite spirited. Among the subjects pourtrayed were the olympic games and various heroic exploits. Perhaps no page of Grecian history has been able to chronicle the social life of Greece more gloriously than the figures and paintings on her pottery. It was thus that these people displayed a desire to complete their social entity. Where deeds were heroic and the arts and letters cherished, industries had to be fostered to form the fullness of a national life.

The indigenous pottery of India.

It is a noteworthy fact that the class of earthenware now generally prepared by the Indian potter bears a striking resemblance to the old Grecian terra-cotta pottery. It is also believed that this type of earthenware has been made in India since the earliest times. The resemblance may therefore be explained by the very possible assumption that the followers of Alexander conveyed this particular type of pottery from India into Greece. It could not have been introduced into this country by the Grecians, as the craft in *terra cotta* was in evidence in ancient India prior to its appearance in Greece. It would not, therefore, be too fanciful an inference to draw that the indigenous worker of to-day produces the selfsame article that his ancestors and their Grecian contemporaries were manufacturing 2000 years ago. In India, almost every village has its potter or *kumhar*, who generally makes cooking utensils or *kapala*, water-vessels or *kalasi*, plates or *pathra*, saucers or *malsha*, cups or *khuli*, goblets or *sorahi*, bowls or *gumlah*, tobacco pipes or *kolka* and curved tiles or *kholah*. This class of ware is not durable being made of ordinary clay; and, according to a well-known Hindu practice, has to be rejected on certain occasions. The potter is therefore ever busy.

The most elegant process in any handicraft is that of the potter moulding a vessel on his wheel. Unlike other crafts where the article formed needs a succession of tedious work, here the vessel appears on the wheel as it were by the magic handling of the potter. The facility with which the plastic clay answers to his touch, as though instilled with his thought and wish, rises and falls taking a succession of elegant shapes, makes this art singular and beautiful above others. The wheel he uses is always a rustic implement. It is known in Upper India as the *rota* and in Bengal as the *chak*. The former is a flat circular stone revolving on a pivot; the latter, a heavy earthen ring attached to a central hub by means of spokes, also spins on a pivot. The potter shapes his vessel in the centre of the wheel which is always flat. An illustration of the wheel known as the *chak* is given in Plate VIII.

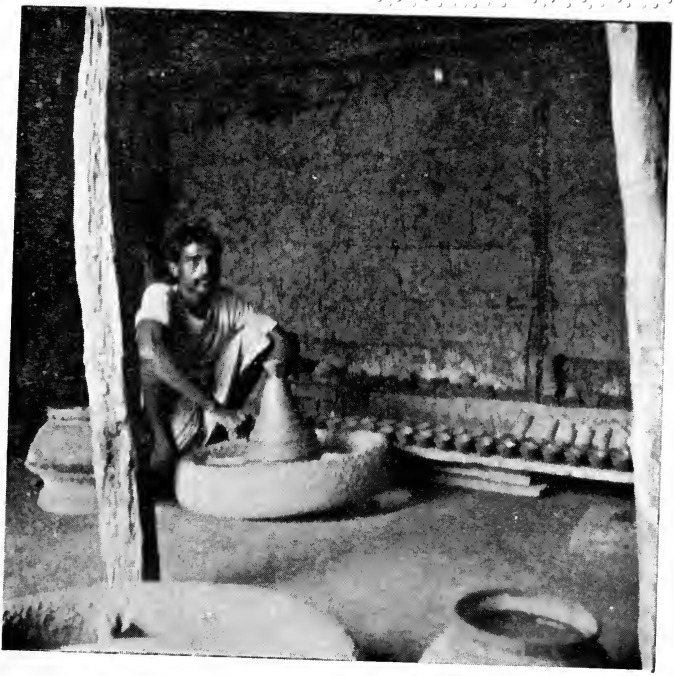
Its mode of manufacture.

The potter cannot make his vessel unless he has first prepared the clay for it, which is a very simple process with the indigenous worker. The clay is prepared in Upper India from *kali mitti*, and in Bengal from *atel mati*; either of them is a pasty mud which is obtained from the banks of a river or the side of

The preparation of clay.

Plate VIII.

[To face p. 78.



POTTERY-MAKING.

The indigenous potter and the wheel used by him in Bengal.

From a photo taken by the author.]

a pond, wherever it is more easily available. The potter takes a few lumps of it and sits next to a bowl which holds some water. He sprinkles a little of the water on the mud and breaks up the lumps between his fingers. He wets the mud every now and again to make it soft and slippery. As he proceeds in this manner, all bits of stone or stick that strike his fingers, he throws aside. When he clears the moist mud of all foreign substances, he begins to press and squeeze the clay with both his hands as a baker kneads his dough. Having thus obtained a pure, soft, and well-mixed mass, he proceeds to mould his vessel on the wheel.

'Throwing' on the wheel.

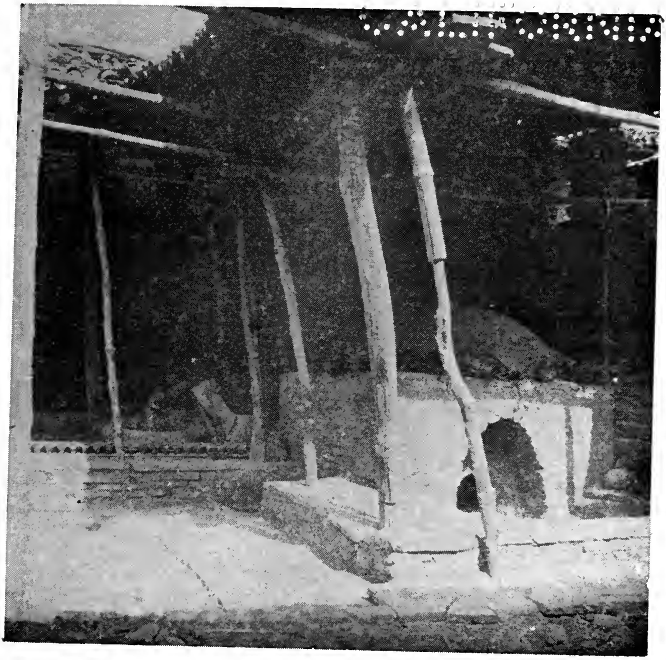
He takes a big lump of clay, puts it in the centre of the wheel and shapes it roughly like a cone. This he does to facilitate the working upwards of his clay during the process of moulding. This process is technically known as 'throwing.' He turns the wheel with his hands, and then with a small rod placed between its spokes, he gives it a good, long spin. Immediately after, he puts his hands round the lump of clay, and, by pressing it upwards, raises a portion of it which he gradually shapes into a vessel between his fore-finger and his thumb. He is greatly assisted in this action by the rotation of the wheel. As he forms a vessel, he cuts it off from the body of the clay by means of a piece of thread. He then wets his fingers in the bowl of water placed near him, so that they may work smoothly over the clay, and proceeds to form the next vessel. This he does in a manner similar to the first. The wheel has to be spun at regular intervals of about 4½ minutes, and a fresh lump of clay put on it when the former one is used up. Thus he gets on until a sufficient number of pots are made to fill his kiln, which is known as *awan* in Upper India and *poan* in Bengal. Before baking, however, he puts these pots in the sun to dry, and when after some hours they are quite hard, he arranges them over the kiln.

The kiln in the villages is a circular chamber made of mud, but in the towns it is a square oven built of bricks as shown in Plate IX. The latter has the better construction of the two. About half way down this kiln is a floor of iron-grating, below which is the hearth. There is a semi-circular opening down the front wall through which the hearth is fed with fuel. The vessels are arranged on the grating in layers, one above another. Each layer is made up of regular rows of cups or pots. When the pile is completed, the potter scatters bits of coal over it, especially filling up with them the crevices between the pots. The mass is then covered in first with straw and then with cow-dung, through which holes are made here and there for the escape of smoke and the passage of draft. When this is done, faggots of wood are placed below the grating of the kiln and fired. In a little while the flames spread to the coal above the grating and the pots begin to bake. The fuel is fed for about

The firing process.

Plate IX.

[To face p. 80.



POTTERY-MAKING.

The kiln used by an indigenous potter in Bengal.

From a photo taken by the author.]

four or five hours, after which the fire is left standing for the same length of time when the baking is supposed to be complete. On the following morning, when the vessels have cooled down, they are removed from the *poan.*

Decorated pottery.

On this class of terra cotta or unglazed ware, which is most largely produced in India, decorations are sometimes painted or printed. The places noted for this kind of art pottery are Sewan and Khulna in Bengal; Azamgarh, Agra, Chunar, Lucknow and Meerut in the United Provinces and Oudh; Salem and Madura in the Madras Presidency; and Hallah and Bombay in the Bombay Presidency.

Glazed pottery.

There is also a class of glazed pottery produced in this country which resembles old Persian ware. Such pottery is made at Delhi, Peshawar, Lahore, Multan and a few other places in North-Western India. The body of the ware made in Delhi is prepared from a composition of powdered felspar and gum. The vessel is cast in a mould, as the paste does not possess the elasticity of clay and cannot be shaped on the wheel. A slight glaze appears on the ware owing to a partial vitrification of the felspar in the process of firing, but in some of the best pieces, the body is semi-translucent. In Multan and Peshawar, the glaze—a lucent coating, turquoise, dark-green or dark-purple in colour—is applied on the vessel before the process of baking. The art of making this glazed pottery is supposed to have been introduced into India from Persia by the Mahommedans, but the date of its advent is not known. Sir George Birdwood, the well-known writer on the industrial arts of this country, states that the glazed pottery of Sindh and the Punjab is probably not older than the time of Chingiz Khan (1206-1227 A. D.) "In all the imperial Mogul cities of India," he writes, "where the art is practised, especially in Lahore and Delhi, the tradition is that it was introduced from China through Persia by the Afghan Moguls, through the influence of Tamerlane's Chinese wife."* As it is supposed that, in the middle ages, the route from China to India lay through the north-east of Persia, it is quite possible that the art originally came from China.†

The ceramic industry—a development of the potter's art.

In the modern world, the potter's art has developed into a vast and varied industry known in Western countries as ceramics. The old art producing a few kinds of ware, often artistic in treatment, has given place to a new system of manufacture, which turns out with scientific and economic efficiency, various classes of goods with a wide range of usefulness. It also retains, though to a very limited extent, its old function of creating decorative pieces. Owing to the extensive appli-

* Birdwood's "Industrial Arts of India," p. 320.

† Describing the route by which the Chinese traveller Houen Tsang came to India, Mr. R. C. Dutt, the Indian historian, says—"He left China in 629 A.D. and came through Ferganah, Sumarkand, Bokhara, and Balk to India." (*Vide* R. C. Dutt's "Civilisation in Ancient India," Vol. II. p. 134.)

cation of this art to present-day requirements, its development has become imperative in a country like India, as seen by the increasing imports of foreign ceramic ware. This industry has thus become as important as that of glass or the metals. Although it may be urged, that in an Indian household terra-cotta ware together with stone, brass, and copper utensils take the place of glazed crockery, as used in the European home, it must not be forgotten that there are needs other than the purely domestic, which a progressive community has to be provided with. The ceramic industry affords agriculture a convenient means of drainage and irrigation. It helps to procure in the cities a supply of water. In the fitting and decoration of buildings, its products come in as necessary factors; to the cause of sanitation its goods render invaluable service. But even as articles of domestic use, the ordinary terra-cotta ware of the indigenous potter is neither so clean nor so durable as the glazed pottery manufactured by the modern system, and for this reason, the use of the former has been abandoned to a large extent by the middle and upper classes of modern Indian society.

Its manifold use at the present day.

There are a few substances found in nature which, when submitted to special treatment, become plastic bodies and can be readily shaped. Among these substances may be named clay, sand, felspar and flint, which are generally used as ingredients in the preparation of the 'potter's paste.' Clay always forms the

The principles of the ceramic art.

body of the paste, while the others are used either separately or in combination to impart firmness to it. Their use prevents the body from shrinking or cracking in the baking process. Each ingredient is at first prepared by itself, two or more of them are then blended together, and the mixture is finally converted into paste by undergoing certain operations. To enable the paste, when moulded, to retain its shape, it is first dried and then baked.

Its system of manufacture.

Such a diversity of goods are produced in the modern industry that the details of their working must necessarily vary. Yet there are certain main processes which are common to the manufacture of ceramic ware. The preparation of the potter's paste is the first, the formation of the article the next, and its baking the last process.

The reduction of clay.

The clay is put into a chopping machine which consists of a cylindrical vessel containing a series of fixed and revolving knives. One series is fixed to the walls of the vessel, the flat sides of their blades being in the line of a spiral curve; the other is attached to a vertical shaft, the knives being arranged in the same line as those on the walls. The edges of the knives in the one series are, however, in a direction opposite to the edges of those in the other. The cylinder being stationary, the action of the revolving shaft on the clay is to reduce it to an extreme degree of comminution, while the spiral movement of the knives, operating like

Plate X.

[To face p. 85.

THE CERAMIC INDUSTRY.

The preparation of clay in the 'slip-house' of a modern pottery in India.

From a photo taken by the author.]

a screw, forces the clay downwards in the direction of an outlet, at the bottom of the vessel, through which it is finally expelled.

Churning the clay.

The clay is then thrown into a vat where it is mixed with water and thoroughly stirred. This is done by a machine called the 'blunger' which consists of an upright revolving shaft with arms extending at right angles to it, the extremities of the arms being joined by vertical bars. When the fine, wet clay is churned by this machine, it acquires the consistency of cream. It is then run off into cisterns through a set of wire and silk sieves, where it is dissolved in water until it attains a certain degree of liquefaction.

The treatment of flint.

The other ingredient most generally used in the preparation of the potter's paste is flint. This substance is reduced to powder in a disintegrating machine. The ground flint is then treated much in the same manner as the clay, so that it is ultimately directed in a liquified condition to another set of cisterns.

Mixing the ingredients.

The two liquids are then mixed together in such measure that the flint bears to the clay the proportion of one-sixth or one-fifth or even more, according to the quality of the clay and the kind of ware to be manufactured.

The mixture is next run into shallow vats called 'slip-kilns,' below which are arranged a number of hot pipes that cause evaporation in the vats. When the water in the mixture. is thus dried up, there remains in the vats a uniform inelastic mass which is cut into cubical lumps.

Evaporating the mixture.

These lumps are then removed to a damp cellar where they remain for several months. During this period, a certain amount of fermentation and disintegration takes place, which renders the paste finer in grain and less liable to crack in course of baking.

Its maturation.

This process of maturing cannot sometimes be resorted to or accomplished. But invariably after the evaporation in the slip-kilns, the paste is 'slapped' or 'wedged' to reduce it to an extremely fine texture and intimately incorporate its ingredients. In the operation of wedging, each lump is taken up in succession by a workman and broken across by a sudden twist of his hands. The two halves are then struck together in another direction and dashed down on a board. This operation is repeated more than a score of times when the paste becomes ready for the potter.

The old 'wedging' operation.

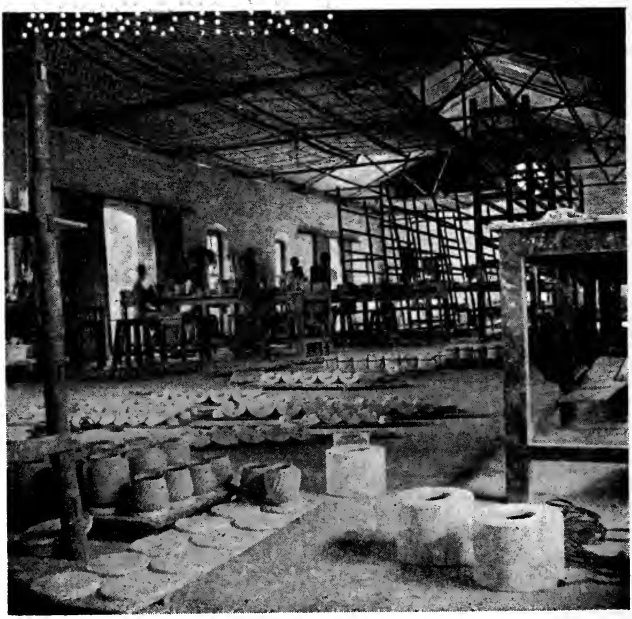
This final process of incorporation and comminution is now-a-days generally performed, not in the way just described, but in a kneading machine similar in principle to that by which the clay is first operated on, where the paste is kneaded in much the same fashion as the baker's dough.

Kneading the paste.

If vessels of a circular form have to be made, they

Plate XI.

[To face p. 87.



THE CERAMIC INDUSTRY.

The moulding operation in a modern pottery in India.

From a photo taken by the author.]

are 'thrown' or turned on a wheel which is a development of the original potter's wheel; it is lighter in construction and driven by steam power. This modern wheel is an apparatus resembling an ordinary turning lathe, except that its disc, called the 'chuck,' is horizontal instead of vertical. In the centre of this wooden revolving chuck a lump of clay is placed, which the potter shapes with his hands into a vessel in the same manner as in the hand industry. The rotary motion of the chuck gives the ware a circular form. When the vessels are obtained, they are put up on shelves and dried, after which they are taken to a lathe and turned to an accurate shape.

The throwing process.

At this stage of the manufacture, handles and other attachments are fixed on, which is done with a thin paste called 'slip.' The articles are then removed to a room and there dried more thoroughly. They now reach a stage when they are called by the ceramist 'green-ware.' These are again taken to a turning lathe where they are more truly shaped as well as smoothed. If the articles are not to be of a circular form and accordingly cannot be thrown on the wheel, they are cast in moulds, a process which is also adopted in the hand industry.

Finishing the shape.

After being thrown or moulded, the vessels go from the hands of the potter into the firing room, where they are baked in the kiln until they acquire a certain degree cf hardness. The composition of the ware is then called 'bisque' or 'biscuit.' Before undergoing this course of baking, the articles are enclosed in crucibles called 'saggers' and then put into the kiln. They are enclosed in saggers to protect them from the smoke and to enable the baking to be uniform. According to the size of the kiln, the firing lasts from 12 to 45 hours. At the beginning of the course, the kiln is subjected to a moderate heat which is gradually raised to a very high temperature. After the kiln has been allowed to cool, the vessels are taken out.

The baking process.

If they are not to be printed with a coloured pattern—sometimes also when they are—the articles are immersed in a composition called 'glaze cream.' They are then subjected to heat for the second time, when the cream vitrifies into a glazed coating which renders the vessels impermeable to water. Without being taken to the bisque stage, green ware can also be immersed in a glazing mixture, directly after they are formed, and then fired.

The application of glaze.

Porcelain or chinaware, which is the finest kind of pottery, is made out of argillaceous minerals of great delicacy mixed with siliceous earths capable of imparting to them a certain amount of translucency by their vitrification. The substances generally used in its manufacture are kaolin or China clay and felspar, with chalk sometimes added as an admixture.

Porcelain.

Among the pioneers of manufacturing industries in India, it is difficult to find any that have struggled with so much patience and fortitude as the founders of the ceramic industry. The inception of this manufacture has been a dismal and unprofitable task for those engaged in it. But it is well-known that the pioneers of every industry with all their originality, labour, and resource, merely pave the way for others, if they are not provided with a sufficiency of capital to pursue the work they have with difficulty inaugurated. Such was the case with the precursor of the ceramic industry in India, a retired engineer by the name of George Macdonald, the son of a Caithness minister. In 1866, he founded the Ranigunge Pottery Works, as far as possible, upon the improved methods then adoped in the ceramic manufacture. After struggling for a few years with the arduous labours of constructing his factory, organising the resources for his raw materials, and manufacturing samples for the market, he found himself in financial difficulty. In consequence of this unfortunate situation, his works were sold in 1870 to Messrs. Burn & Co. of Calcutta. This incident apparently prevented Macdonald from being reduced to penury in his old age. But at the commencement, the pottery proved by no means promising to its new owners, for they found in the market a deep-rooted prejudice against country-made ceramic ware. They perfected their methods and turned out the best varieties of bricks,

The modern industry in India.

pipes, tiles, and sanitary ware. Yet the building trade and Government engineers would not have their goods. Gradually they extended their operations to the manufacture of terra cotta ware for domestic use and clay figures of no mean finish. Some of their glazed and coloured tiles are excellent pieces of art pottery. A new factory was also established by them, in the meanwhile, at Jubbulpore. With all these useful and decorative productions they struggled for many years. In 1894, however, their pipes were put to a most crucial test by the Government of India and found far superior to imported English pipes. This proved a triumph to their patient toil and exquisite skill, at the same time, an awkward disclosure to the decriers of country-made ceramic ware. Since then these manufacturers have flourished, and now employ a staff of about 1400 Indian workmen, a portion of which consists of modellers and potters of great ingenuity. Although they manufacture a fairly wide range of ceramic goods, they make a speciality of pipes and tiles, probably on the economic principle that high industrial efficiency can only be attained by specialising in a few lines.

In 1907, the Calcutta Pottery Works were started by Maharajah Maninder Chander Nundy of Cassimbazar and Babu Boykonto Nath Sen of Berhampore, with the aid of an able ceramist, Mr. Satyasundara Deb, who had studied his art at the Higher Technological Institute of Tokio. This establishment is the premier factory in this country for the manufacture of glazed pottery of the superior grade. Mr. Deb has already prepared silicious porcelain, and essays with a very fair prospect to produce the best qualities of chinaware from kaolin and felspar, which he procures from Rajmehal and Modhupur in Bengal. The factory is equipped with machinery and kilns of the most modern type. Illustrations are given in Plates X and XI of the 'slip-house' and of a moulding room of the factory. The former is that portion of the works where nearly all the processes for the preparation of the potter's paste are carried on; the latter is the room in which only the throwing operation is conducted. The casting and pressing methods of moulding, which the factory also adopts, are done in other rooms. The factory is now turning out very fair qualities of glazed ware consisting of cups, saucers, plates, ink-pots, gallipots, insulators, dolls and figures.

An improvement in the indigenous industry.

Of the indigenous industries still existing in India, the potter's craft is perhaps the only one which has not been visibly affected by foreign competition; and the reason for it is, that the poorer classes of people in this country cannot afford to pay the high prices of imported pottery. Improvements in this craft are, therefore, not essential to its preservation; but they would materially assist the potter by reducing his labour as well as his cost of production. The only reform, immediately possible, appears to be the introduction of an improved type of wheel, mounted on a table and worked by foot, leaving the hands entirely free for the purpose of moulding. In the present process, the potter has to stop his moulding after every 4 or 5 minutes to turn the wheel, and before he can resume work, nearly half this time is wasted. With a machine like this, the potter should be able to increase his daily outturn by nearly half of what he moulds at present.* If an improved wheel of the aforesaid type were devised in India, it would not only prove a boon to the potters, but a source of income to its patentee. The introduction of such a wheel in this industry may be a question of time, but it must ultimately appear.

* The writer had occasion to discuss this question with some intelligent potters of Kumurtuli in Calcutta, who were of opinion that an improved wheel of this pattern would be of considerable advantage to them.

THE MANUFACTURE OF SUGAR.

The vicissitudes of industry.—Early accounts of the sugar industry.—Its extension into western countries.—The rival of cane-sugar.—The indigenous system of sugar-making.—Extracting the juice.—The process of boiling.—Recent attempts towards improvement.—Centres of the indigenous industry.—Mr. Hadi's method of cane-crushing.—His process of manufacture.—His method of making white sugar.—Prospects of the industry.—The modern system of manufacture.—The process of extraction.—Clarification.—Evaporation.—Concentration.—The 'centrifugal' treatment.—Sugar-refining.—The modern industry in India.—Difficulties of indigenous workers.—Prospects of date and palm sugar.

The vicissitudes of industry.

An insight into the history of sugar manufacture in India, as may be gleaned from facts now obtainable, reveals the early existence of a great industry, which has apparently passed through many vicissitudes of fortune, and ultimately sunk in the natural order of industrial decline. There is every indication, that, of all the countries in which cane-sugar is now being manufactured, Bengal was the first to grow the cane and prepare sugar from it. It is also believed that this industry attained a developed stage in the early centuries of this era, and that, in the middle ages, it passed through more or less a languid career ; but in modern times, owing to the rivalry of other countries, it is known to have declined. Its early growth may be attributed to the richness of the Indian soil no less than to the advanced stage of industry in the country, its long career of langour to the natural resources of the land, and its ultimate decline to the want of efforts towards improvement. Yet such a career is not uncommon in the economic history of men. In regions where nature has been too lavish, the races of man have been inclined to lead a listless and torpid existence. If such people are not brought into conflict with competing forces, their material position often continues unimpaired. But when competition sets in, and they still rest secure on their past pre-eminence, rivals gradually grow stronger and finally oust these weaker people from their former economic situation. The natural law of growth and decline thus asserts itself even in industrial life.

The sugar-cane is believed to have been cultivated in the country extending from Cochin China to Bengal long before it was known in any other part of the world, but its original home has not been traced. Allusions are made to this plant in the 'Atherva Veda', and by the classical writers of Greece and Italy, who speak of "the sweet sap of the Indian reed", and "the Indian reed yielding honey." But no proper preparation of sugar is recorded before the fifth century of the Christian era, when it is said that white sugar was shipped to Europe from this country. It is also stated by some writers on sugar-cane, that, during the early part of the seventh century, a Chinese Emperor sent an agent to learn the art of sugar-making in Gangetic India, in which country this industry was then supposed to have been in a developed condition. The art thus appears to have been

Early accounts of the sugar industry.

carried into China. About this period Fa Hian, Houen Tsang, and other Chinese pilgrims are known to have travelled through this country, and it would not be a matter of surprise if it comes to be found that one of these travellers was sent on this special mission.

Its extension into western countries.

The cultivation of the sugar-cane appears to have spread from India into Arabia, and it has been reasonably conjectured that the Arabians introduced it into Persia, Egypt, Syria, Sicily, and Spain. It took, however, several centuries to reach Europe. The Spaniards in their turn disseminated the cultivation of the sugar-cane in the farther West. After the expeditions of Columbus, they transplanted it to their Empire in the West Indies and South America, where the industry rapidly extended and flourished. In the middle ages, Venice was known to have been the great European centre of the sugar trade, but the cultivation of the sugar-cane apparently did not thrive in Europe. The history of this trade during the seventeenth century, indicates that raw sugar, manufactured in the Spanish colonies of America, was sent over to Europe to be refined.

The rival of cane-sugar.

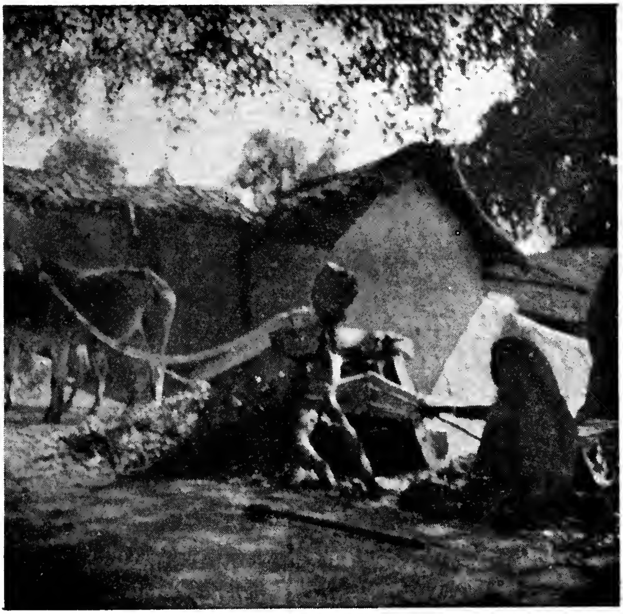
In 1747, Andreas Marggraf, a physicist of Berlin, discovered sugar in the beet-root, but the first beet-sugar factory was not established until 1801. It took over half a century to devise means and make the new product a commercial success. This was done in Silisia by Franz Achard, a pupil of the discoverer. Its manfuacture naturally attained a developed condition in Germany during the latter half of the last century, where this industry is now conducted on the most scientific and economic basis. Feeling the pressure of competition from beet-sugar, the cane-sugar planters of Java and Mauritius have in recent years also improved their methods of cultivation and manufacture. The result of the development of both these sugar industries has been, that cane sugar from Java and Mauritius, and beet-sugar from Germany, are at the present day largely imported into India, while the indigenous industry is still carried on in its original and rudimentary manner.

The indigenous method of preparing cane-sugar is simple but inefficient. The cane is crushed between two wooden rollers which express only about 60% of the juice that it contains; this juice is then boiled down, sometimes to merely a thick liquid called *rab*, but generally to a coarse sugar or jaggery known as *gur*. In the United Provinces, where the manufacture of sugar is more extensively carried on than in any other part of India, there are two methods of extracting the juice from the cane. By the old system, which has probably been practised since the earliest days of sugar preparation in India, the cane is cut into small pieces, and then bruised by a large mortar and pestle called the *desi kohlu* or country mill. The mortar is made generally of chunar stone and the pestle of *babul* wood. The pestle

The indigenous system of sugar-making.

Plate XII.

[To face p. 97.



INDIGENOUS SUGAR-MAKING.

The 'churki' engaged in sugar-cane crushing in the United Provinces.

From a photo taken by the author.]

rotates inside the mortar which contains the cane and thus presses out the juice from it. Two bullocks are yoked to an attachment of the pestle which turns by the circular walk of the animals round the mortar. The *desi kohlu* is still in use in the eastern districts of the provinces such as Jaunpur, Azamgarh and Mirzapur, probably because the cost of stone is very little in these localities. According to the recent method, large pieces of cane are crushed between the iron rollers of a mill, called the *lohi kohlu*, which is also known as the *churki*.

An illustration of the *churki* engaged in this system of cane-crushing, which was witnessed by the writer at Burdaha, a village 16 miles south-east of Allahabad, is given in Plate XII. The *churki* consisted of two upright iron-rollers, so fixed in a heavy wooden frame that there was a space of less than an inch between them, into

Extracting the juice.

which pieces of cane, about two feet in length, were inserted through the perforations of a triangular plank. This plank formed the breast of the wooden frame. The rollers, about 18 inches long and 5 inches in diameter, were topped with cogged wheels working into each other so that their revolutions were simultaneous. Into one of these rollers was fixed a spindle which was attached to a wooden bar. A pair of bullocks were yoked to this bar. The circling of these animals round and round the *churki* caused the rollers to revolve. As the mill was fed with pieces of cane, the

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juice being expressed, kept trickling down to an earthen tub sunk in the ground, known as the *nand.* A network of bamboo twigs, called the *channah*, was placed over the tub which prevented stray pieces of *pata* or crushed cane from falling into the liquid. This *pata*, known technically as the 'bagasse,' regularly worked its way out from the back of the rollers and collected in a heap on the ground. It was subsequently dried and used as fuel for boiling the juice.

When a sufficient quantity of juice was extracted, it was taken to the boiling shed shown in Plate XIII. Under this rustic roof, the *bhatti* or boiling process was carried on. At one end of the shed was a large earthen stove where a fire had been kindled. A big iron bowl called the *karahi* was then placed on the stove, and into this the *khandsari* or sugar-maker poured the cane-juice through a cloth-strainer. The juice was thus filtered. After feeding the stove with wood-fuel for about half an hour, the juice commenced to simmer. While this proceeded, a scum appeared from time to time on the surface of the liquid, its appearance becoming more frequent as the liquid began to boil. This scum, which the *khandsari* referred to as the *shira*, was collected with a broad ladle and put into a vessel. The process of boiling and skimming was continued till the juice was partially purified. A handful of *sujji* (impure carbonate of soda) was then thrown into the bowl and thoroughly mixed with the juice. This was

The process of boiling.

Plate XIII. [To face p. 98.

INDIGENOUS SUGAR-MAKING.

The boiling-shed of the 'khandsari' in the United Provinces.

From a photo taken by the author.]

done to further purify it. As the liquid gradually thickened, it was kept in constant motion with a wooden stirrer called the *pharuhi.* At this stage the juice was converted into a thick syrup known as *rab.* As there is, however, a very small demand for *rab* in the market, being a substance bought only by sugar-refiners, the *khandsari* proceeded to make *gur,* which is the sugar of the poor people and is most readily saleable. He continued the boiling till the water in the syrup almost entirely dried up. After a while the syrup went quite thick and assumed a dark brown colour. It was then taken off the fire and poured into a circular platform in the middle of the shed. Here it was stirred with a *khurpi* or club-shaped rod, till it became cool and partially grainy. It was finally made up into balls of the size of a closed fist, and dried in the sun. The *gur* was thus made ready for the market.

Recent attempts towards improvement.

Within the last two or three decades, the competition of foreign sugar has tended to lower the price of the indigenous product; and, in consequence, some well-to-do cultivators of the United Provinces have sought to effect a reduction in their cost of manufacture by the introduction of improved types of the *lohi kohlu.* The 2 and 3-roller Behea mill, and the 3-roller Nahan mill have been adopted by them; the latter being better known in the district of Meerut than elsewhere. But their use is yet so scarce that cane-crushing generally in the country may still be regarded in an elementary stage. During this period also, no corresponding attempt was made to improve the mode of sugar preparation. In recent years, however, the Government of the United Provinces have made strenuous efforts to place the sugar industry of these provinces on a better footing. Sir John Hewett, himself a researcher of indigenous industries, has taken up the work of industrial reform with an earnestness for which he will ever be remembered. An agricultural officer, Mr. Syed Mahommed Hadi, has been specially deputed by his government to make a study of the cultivation and manufacture of sugar in his provinces, and to devise means for their improvement. Mr. Hadi has already applied to the indigenous process some of the modern methods of sugar manufacture. He has also very rightly attached the utmost importance to the development of its system of cultivation, for it is well-known that the yield of sugar per acre of crop in India is small compared to that of Java or Mauritius.

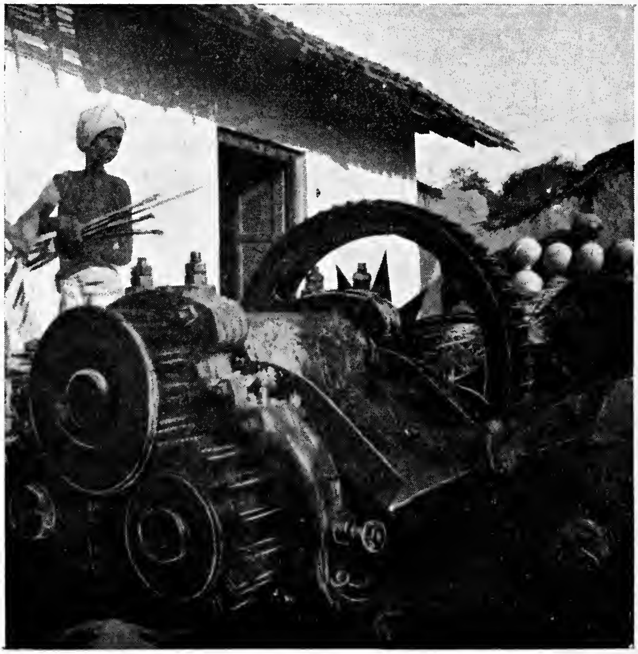
The sugar-cane is cultivated in various parts of India, but the largest areas under this crop, according to the "Agricultural Statistics of India" for 1905-06, are given below. The average of five years ending in 1904-05 shows that the area in the United Provinces was about 49 per cent of the total area under sugar-cane cultivation in British India.

Centres of the indigenous industry.

In Bengal—Patna, 166,000 acres ; Bhagalpur, 95,000

Plate XIV.

[To face p. 101.



IMPROVED SUGAR MANUFACTURE.

The cane-crusher introduced by Mr. S. M. Hadi working at an experimental factory.

From a photo taken by the author.]

acres; Rajshahi, 92,000 acres; Dacca, 83,000 acres; Burdwan, 79,000 acres; and Chota Nagpur, 53,000 acres.

In the United Provinces—Meerut, 108,000 acres; Gorakpur, 93,000 acres; Bijnor, 77,000 acres; Azamgarh, 69,000 acres; Mozaffarnagar, 56,000 acres; Basti, 55,000 acres; and Barelli 51,000 acres.

In the Punjab—Gurdaspur, 51,000 acres.

It must here be stated that a portion of the crop in almost every district in India is consumed in the cane, without being converted into *gur* or sugar. Such is perhaps the case in the Punjab and in certain districts of Bengal, more than in the other parts of India. For this reason, the official average of sugar out-turn in this country (1 ton of sugar per acre of crop) is generally misunderstood. It would be impossible, from agricultural and trade statistics merely, to show the average quantity of sugar (raw and refined) obtained from the acre of the Indian crop.

The system of manufacture adopted by Mr. Hadi was exhibited in four experimental factories, which were working last winter at different centres in the United Provinces. The writer had the opportunity of visiting the factory at Baraon, a few miles south of Naini Junction near Allahabad.* An illustration of the cane-crushing process is given in Plate XIV. The crusher, which was made in England in accordance with Mr.

Mr. Hadi's method of cane-crushing.

* The writer is indebted to Mr. S. M. Hadi for explaining to him the system of manufacture and taking him round the works.

Hadi's directions, consisted of three steel rollers mounted in a heavy iron frame. It was driven by an oil engine of about 6 horse-power. Entire pieces of cane, as they came from the fields, were fed into the crusher by a labourer who inserted the pieces between the rollers. As the juice was extracted, it poured into a drain and thence ran into a vat placed beside the machine. Although this machine worked on the same principle as the *churki*, being heavier in construction and having an additional roller, it extracted more juice from the cane than does the latter. In the *churki*, a good quantity of juice is left in the bagasse, which is a loss to the *khândsari*. There is, moreover, a great saving of time and labour in this crusher, as it worked much faster than the *churki*.

An illustration of Mr. Hadi's boiling plant is shown in Plate XV. The cane-juice was brought from the vat near the crushing machine and collected into a high reservoir on the right wing of the plant. A wooden frame suspending a cloth strainer was next placed on the raised tank in the left. One end of a long zinc shoot was then connected to an outlet in the reservoir, and the other placed over the cloth strainer. The outlet cock in the reservoir was opened and the juice flowed through the shoot into the strainer. Here it filtered through the cloth and dripped into the tank below. From the tank, the clean juice entered the *clarifying* vat in the middle of the plant. In this vat, the juice

His process of manufacture.

Plate XV.

[*To face p. 102.*

IMPROVED SUGAR-MANUFACTURE.

The boiling-plant used by Mr. Hadi at an experimental factory.

From a photo taken by the author.]

The worst book ever written on this theme.

was heated and some *sujji* put into it. Gradually a scum of impurities rose to the surface and was removed. The process of skimming continued till the juice was sufficiently clarified, when it was drained into the *evaporating* pans placed below the clarifier. Here the boiling commenced and a good portion of the water in the juice was evaporated. Scums which again rose to the surface were removed. The juice then entered the *concentrating* pans, where it boiled more fully than before and concentrated into a syrup. It finally entered the *rab* pan where, boiling over great heat, the syrup reached the granulating point. The pans were all made of copper, but the reservoir and the tank were built of zinc. Under these different vessels, there was a large furnace in which the heat was regulated from the first to the last vessel; the heat under the clarifying vat was the lowest and that under the *rab* pan the highest. Adjoining the *rab* pan, but sunk in the ground, were two *nands* or bowls into which the *rab* was finally collected, stirred, and cooled.

During the course of sugar manufacture, that portion of the juice which is converted into molasses and does not crystallise, has to be separated from the sugar proper before marketable sugar is obtained. To effect this purpose, the concentrated substance of cane-syrup is put through the 'centrifugal machine,' in the modern practice of this manufacture. Mr. Hadi similarly utilises a small centrifugal machine, specially made for him

His method of making white sugar.

in England, for the purpose of converting *rab* into white sugar. An illustration of this machine is given in Plate XVI. It consists of a drum-shaped vessel inside of which spins a meshed basket. The *rab* was poured into the basket, which was then spun at a high velocity by the turning of a wheel on the side of the machine. During the rotation of the basket, a preparation of soda was put into the *rab* to clarify it. Owing to the action of centrifugal force caused by this rotation, the *rab* flew from the centre to the sides of the basket, a circular wall which was meshed. The *rab* was composed of grainy sugar and molasses. Of these components, the former being unable to pass through the meshes adhered to the wall, but the latter went through them and ran down the machine. The sugar being thus separated from the molasses, assumed a lighter and lighter colour as the basket went on spinning, till it became perfectly white. The white sugar was finally scraped off the wall of the vessel and dried. It was thus made ready for the market. The molasses which had run out of a spout at the bottom of the machine, had in the meanwhile collected in an earthen vessel.

Prospects of the industry.

The work which has been initiated by Mr. Hadi, with the support of his Government, is likely to place the sugar industry of the United Provinces on a much sounder footing than it has been before. It is the intention of this Government to have a larger number of factories working on Mr. Hadi's system

Plate XVI.

[To face p. 104.

IMPROVED SUGAR MANUFACTURE.

The 'centrifugal machine' used by Mr. Hadi for making white sugar.

From a photo taken by the author.]

during the coming season.* The establishment of these factories is also within the reach of small capitalists or joint-stock companies that could induce cultivators to sell their crops to them, as is often done in the jute industry in Bengal. In such cases, as the buyers advance money to the growers at the time of sowing, which is a great help to them, they are sometimes only too willing to sell their crops in advance. Mr. A. C. Chatterjee, of the United Provinces Civil Service, who has recently written an exhaustive report on the industries of his provinces, is of opinion that Mr. Hadi's system could be adopted by zemindars who sow large areas of cane in *sir* or who could persuade their tenants to bring their juice to them.†

The modern system of manufacture.

The modern system of cane-sugar manufacture, as adopted in Java and Mauritius, may here be briefly described, as a section of it—that relating to refinery—has been introduced in India by a few factories set up during the latter half of the last century. Attempts are also being made now to introduce the entire system of manufacture in this country. In passing it may be observed, that the processes adopted by the sugar-makers of the southern islands are, to a large extent,

* The writer was informed by Mr. Hadi that the price of the centrifugal machine was Rs. 400, and he believes that the cost of the complete plant could not have been more than Rs. 5000. Detailed information on these points may be had from Mr. S. M. Hadi at Pertabgarh.

† *Vide* Chatterjee's "Notes on the Industries of the United Provinces," p. 96.

similar to those employed by the manufacturers of beet-sugar in Central Europe.

The process of extraction.

The juice is extracted from the cane by passing it through three roller-mills in succession. A roller-mill consists of a set of three steel cylinders which are driven by steam-power. In the first mill, about 50% of the juice is extracted, in the second, nearly 75%, and in the third, about 90%. In certain factories, a 'cane-cutter' and a 'cane-shredder' are used, before the cane is put through the mills. The former cuts the cane into four-inch pieces, and divides them into thin slices; whilst the latter reduces them into shreds between two rows of teeth, and carries them to the mill. This system of triple crushing is now met with in every up-to-date factory. Some planters resort to even a more thorough method of extraction called the "imbibition process." During the process of extraction, the bagasse often gets so dry that it refuses to yield any more juice, although a certain quantity of sucrose or sugary substance is still contained in it. At this stage, the bagasse is saturated in water and crushed, by which operation all the sugary substance is extracted from it. The extracted juice flows between the cylinders into a gutter placed below the mill, and the bagasse is thrown out by the rotation of the cylinders. The bagasse is used as fuel in the furnaces of the factory, and the ash from it is returned to the soil. This ash is considered a very good manure for sugar plantations.

The juice being thus obtained, is passed without delay through a set of sieves and run into the 'clarifiers.' The sieves remove all foreign substances that get mixed up with the juice during the crushing of the cane; the clarifiers are a series of iron vessels in which the clarification of the juice takes place. The vessels are heated and milk of lime is put into the juice. Lime is not only the indispensable agent of clarification, but it is used for the purpose of neutralising or rendering inoperative the acidity of the juice. For the latter purpose, however, soda is now considered more suitable. After lime is put into the clarifier, the juice is heated to just below boiling point, when gradually a scum of impurities rises to its surface, and some heavy substance falls below. Between them is found the clarified cane-juice of a pale straw colour. If white sugar is required, the juice is bleached with sulphurous acid gas, which is obtained by burning sulphur in a small furnace. The heavy substance that settles at the bottom of the clarifier is known as molasses or inverted sugar, which is caused by the fermentation of the juice. Fermentation, which is caused chiefly by access of air to the juice and its exposure to heat, sets up the moment the juice is extracted. It is sustained by the heat necessary for carrying on the manufacture, augmenting as the time is prolonged and the heat increased. Acids also provoke fermentation. Hence arises the importance, in this manufacture,

Clarification.

of the prevention of acidity, and of rapid treatment of the juice at low temperatures and with the least possible exposure. These safeguards reduce the formation of molasses to a minimum. The scums that form on the top of the clarifier are used as manure in the plantation.

Evaporation.

After clarification the water in the juice is evaporated until the liquid thickens into a syrup. This is effected by drawing off the clear juice from the clarifiers into a range of copper vessels, called the 'evaporators,' which are heated by direct fire for a time, when the juice comes to the syrup point.

Concentration.

The syrup then passes into the 'vacuum pans,' where it is heated in vacuum by means of steam, till increasing in density, it forms into a grainy substance mixed with a thick fluid. Having thus reached the granulating point, the concentrated mass is removed to a shallow tank and allowed to cool, where the bulk forms into crystals and the fluid remains as 'treacle' or fine molasses. This is known as the process of concentration and crystallisation.

The 'centrifugal' treatment.

The mass is then fed into the drum or basket of the 'centrifugal machine,' which is made to spin at a very high speed, being driven by steam-power. Owing to its rapid rotation, the machine separates the crystal sugar from the treacle, driving the latter through the meshed wall of the basket, as we have already seen. The crystal sugar, being thus set free from the treacle, assumes a white colour and is made ready for the market. By the modern system of manufacture, a maximum amount of sugar and a minimum of molasses are obtained from the cane-juice.

Sugar-refining.

In a refinery, raw sugar or jaggery is first dissolved into a syrup by the addition of water. When *rab* is treated, this preliminary process is, of course, unnecessary. The syrup is then passed through filtering bags to remove all the mechanical impurities that it holds in suspension. It is then filtered through burnt bones or 'animal charcoal' to remove all traces of colouring matter and lime that are in it. This produces a perfectly white syrup, which is finally cooked in the vacuum pan and crystallised, as above described. It thus becomes the refined sugar of commerce. It has been observed before, that when white sugar is made direct from the cane-juice, animal-char filtration is not required, but that the juice is bleached with sulphurous acid gas. The disuse of animal charcoal in the manufacture of sugar has now become almost essential to the success of sugar-works in this country.

The modern industry in India.

It appears from the accounts of the modern industry in India, which may be gathered from the proceedings of the East India Company and subsequent official records, that the improved system of sugar manufacture was introduced into this country over a century ago. In the aforesaid proceedings may be found some facts relating to the earliest efforts made for its introduction. The first entries appear in connection with the name of Lieutenant John Paterson. This pioneer is stated to have applied in 1787 for permission to come to India for the purpose of growing sugar-cane. In his application he showed how the industry could be carried on in this country with greater advantages and at a lower cost than in the West Indies. A concession was accordingly made for him to settle here and take up land in Behar, which he could obtain from the people. There was a clear stipulation in the grant to the effect that the enterprise should be at his own risk, the Company merely agreeing to purchase all the sugar he might produce at a certain price. After his arrival, he appears to have preferred Benares to Behar, and obtained leave to alter the location of his industry. He is later on reported to have succeeded in procuring land in Birbhum. It is evident that he encountered difficulties which he did not anticipate. The next entry speaks of the Company giving him a loan of Rs 25,000 for the purpose of obtaining machinery from England. It is then said that his assistant, Mr. W. Fitzmaurice whom he had brought over with him, left his service and applied for permission to take up land on the same terms as were allowed to his employer. Paterson is then reported to have died on the 26th of September 1794, and directions were issued by the Company to recover the loan from his estate.

The next enterprise recorded was that of Mr. William Fitzmaurice, a Jamaica planter, apparently the assistant of Paterson. Fitzmaurice is reported to have submitted, in February 1793, a detailed account of the benefits that would be derived by the introduction of West Indian methods of cultivating cane and manufacturing sugar. We are led to believe, from the various entries against his name, that he managed to work up a plantation and factory, for he is subsequently reported to have sold sugar to the Company. No further records are, however, obtainable of this concern. In 1794, there appears an entry stating that a Mr. James Keene, an experienced sugar manufacturer, was given permission to proceed to Bengal for the purpose of starting a sugar concern. Reports of these ventures, not merely in Bengal but in other parts of the country, continue to be found in these proceedings. It is, therefore, evident, that in the days of the East India Company, there were plantations and factories in India, owned and worked by Europeans on the modern system. But it also appears that these undertakings, within a few years of their establishment, were either converted into indigo concerns, or continued to work merely as sugar refineries, for the purpose of refining the indigenous product. Some of them were not nearly so fortunate and stopped work entirely, leaving behind dismal ruins as marks of their unsuccessful efforts. With reference to these early attempts, it is stated in a report of the Famine Commissioners, that "the chief mistake appears to have been the concentration of operations in large central establishments, which led to the deterioration and evaporation of cane-juice during the carriage of canes to the factory, for, it is now well-known that juice ought to be expressed and boiled as soon as possible after the canes are cut." While cultivation and the actual process of manufacture have proved very difficult undertakings for Europeans in India, it has been found easier by them to refine the raw sugar of the country. During the last century, they are said to have supplied, from their refineries, the Indian market with a fairly good quality of white sugar; and it is also known that they created, and actually held for many years, an export trade in this product, till the competition of beet-sugar set in. The principal factories still carrying on this work are the Rosa Sugar Refinery of Shahjahanpur, the Cawnpur Sugar Works of Cawnpur, and the Cossipore Sugar Works near Calcutta. The oldest of these factories is the Rosa Sugar Refinery, which was established at the commencement of the last century. Some new factories have also been recently erected in the United Provinces and in Bengal, on the modern system, amongst which the largest is perhaps the Pryag Sugar Works near Allahabad.

It is apparent, from a study of the circumstances surrounding the indigenous industry, that its backward condition is due to three principal causes—the poor yield of sugar-cane per acre of cultivation, the low percentage of juice extracted by the imperfect method of cane-crushing, and the loss sustained by the conversion of juice into molasses, owing to the crude process of manufacture. These defects stand out prominently when the conditions here are compared to those of the industry in Java or Mauritius. In these islands, the average out-turn of sugar per acre is reported to be nearly three and a half tons, whereas the normal out-turn of sugar in this country is calculated by the Agricultural Department to be not more than a ton per acre. These out-turns represent, in sugar, the net results of both cultivation and manufacture, and would not be reliable if the yield of cane per acre of crop were considered. But that there is a difference in favour of the islands even in this latter respect, is well-known. As the remedy on this point is a subject of endeavour with the Agricultural Department, it may be excluded from our present enquiry.

Difficulties of indigenous workers.

With regard to the next cause, we have already seen that the country mills crush on an average only 60% of the juice from the cane, and that the triple crushers used in the southern islands extract about 90% of the juice. The comparative loss in the home industry is quite obvious. The only remedy in this regard would be a much larger introduction in the indigenous industry of improved mills such as the three-roller Nahan mill, the three-roller Behea mill, the four-roller Babu mill and the mill used by Mr. Hadi. Regarding the last difficulty, it may not be possible to obtain figures showing the comparative loss, in the countries considered, by inverted sugar or molasses ; but, it is well-known that in the home industry there is a greater formation of molasses than in the factories of Java or Mauritius. If the indigenous *khandsari* could at least be taught the use of proper soda to neutralise the acidity of the juice during the process of manufacture, there would be a smaller loss sustained by inversion.

Besides cane-juice, raw sugar is prepared in this country from the juice of the date tree *(phœnix sylvestris)* and of the palm tree *(borassus flabellifer)*. The date tree is said to be indigenous in various parts of India, and is found in abundance in Bengal, Bihar, Gujerat, and on the Coromandel Coast. It is also grown in Eastern Bengal and Mysore. The tree is tapped between November and March, the yield of a single tree being from three to five seers of juice each morning. A good quantity of the juice, at the present day, is consumed either as a beverage when fresh, or as an intoxicant when fermented. In the former condition it is known as *khejoor ras*, and in the latter as *tari.* A small portion of the juice is, however, converted into jaggery or *gur*, exactly by the same process as cane-juice. The palm tree or the palmyra palm is also found in various parts of India and Burma, but it grows most abundantly in Southern India, particularly in Tinnevelly. This tree also is tapped for its juice, which is very largely consumed as a fermented liquor

Prospects of date and palm sugar.

(*tari*), and to a lesser extent as a fresh beverage (*tal ras*); a small proportion of it only is converted into *gur*, and also into sugar-candy, known as *tal misri*. Yet large numbers of these trees in almost every part of India have not been touched at all. While attempts are being made to improve the manufacture of cane-sugar in this country, it appears somewhat unfortunate that a comparitively simple industry, such as could be built up from the produce of these trees, should be left undeveloped. Precisely the same process of manufacture as in cane-sugar may be adopted for date and palm sugar, but the great advantage in the latter would be the absence of cultivation with all its attendant outlay of capital, time, and labour. Moreover, the tapping of these trees, as compared to the extraction of cane-juice, is a less expensive and arduous process. There would, of course, be an initial expense in devising some means for the rapid conveyance of the juice from the trees to the factory, such as by overhead trolleys or some other quick mode of carriage. But a corresponding arrangement is also necessary in a well-conducted sugar-plantation. In Mauritius, for instance, special trains known as 'cane-specials' are run in the sugar-cane season for the purpose of conveying cane to the factory. The initial outlay in a date or palm sugar manufacturing plant, would also be much less than in a cane-sugar factory, as a portion of the premises with the crushing machines, driving engines, and a part of the clarifying plant could be dispensed with. Such being the prospects of this undeveloped industry, it may be reasonably expected that the manufacture of sugar from the date and the palm will attract the attention of people living in the vicinity of these trees. With these resources for raw product in addition to sugar-cane, there is no reason why the sugar industry of India, if developed, should not be in a position to supply a very large portion of the demands of the local market.

PAPER-MAKING.

The art is the result of intellectual advancement.—Its origin and growth in foreign countries.—Its late arrival in India.—The materials used for paper by the earliest makers.—The materials used in India.—The hand-industry.—Indian hand-workers.—Their mode of pulp-preparation.—The pulp-dhaki.—Treading and washing.—Their process of paper-making.—Forming sheets from pulp.—Drying, sizing, and glazing.—Pulp-making in the Indian mills.—The manufacture of wood-pulp.—Invention of the paper-machine.—The modern system of manufacture.—The 'wire-cloth.'—The 'felt-cloth.'—The 'calenders.'—The modern industry in India.—Suggestions for improvement of the Indian hand-industry.—Prospects of the modern industry in India.

THE causes which hasten or retard the advent of manufacturing industries in any country are those which also determine the material welfare of its people. The development of almost all these industries has been associated with the growth of material civilisation. But in the case of paper-making, its invention has apparently been the result of intellectual advancement.

The art is the result of intellectual advancement.

Unlike the industries which provide for our bodily wants, it is reasonable to infer that this art commenced at a period when civilisation attained an advanced stage. As primitive man extended his observations from the material to the intellectual life, he began to be enlightened and to cultivate letters. In the gradual pursuit of science and letters, a necessity arose for recording the literature of the time on some convenient material. The material used for writing, now known as paper, therefore appears to have been devised when the ordinary handicrafts were being already practised. So long as the knowledge of the world was confined to a few, it was mostly committed to memory and thus transmitted from father to son. We find, accordingly, that the gospels of Christ and the verses of Homer were rendered from memory to succeeding generations. In our own country, the Vedas which were composed in verse or *sloka*, were thus handed down for many centuries by the Brahmans. But when science and literature extended, this process of transmission was not sufficient and writing came into usage. The inhabitants of India were, at this juncture, more fortunate than the peoples of other countries. They used palm leaf for this purpose which they obtained in the country. Hence it is easy to understand how the art of paper-making was unknown in India even during the middle ages, notwithstanding the early origin of poetry and literature in the country.

Its origin and growth in foreign countries.

The fabrication of paper is supposed to have originated in Egypt, but the period at which it began is unknown. The origins of almost all the crafts, which have contributed so largely to the advancement of the human race, are shrouded in such obscurity that their history has been made up mostly of intelligent conjecture. Egyptian paper was prepared out of the bark of a reed that grew in the delta of the Nile, and was called by the ancient writers the *cyperus papyrus*. At the commencement of the Christian era, paper was also made by the Chinese from some unknown material, and its preparation from the cotton fibre appears to have been devised by them sometime during the second century. A knowledge of this manufacture was, moreover, believed to have been acquired by the Japanese at an early period. The art of paper-making gradually spread to the northern coast of Africa, apparently from Egypt, and in course of time was introduced into Europe. Paper made in Egypt from the papyrus was in general use in that continent up to the 9th century, when it began to be substituted for paper manufactured from cotton and other fibres. It has been surmised that paper so made was introduced into Europe by the Moors. After the Moorish invasion of Spain, the first European paper-mills are said to have been set up in that country, where water-mills were already in existence. In these mills paper was manufactured from cotton rags, and the industry spread from Spain, during the 13th and 14th centuries, to Italy, France, and Germany. At a later period, it was carried over to England. The first English paper factory is said to have been set up in Hertfordshire by John Tate in 1495.

In olden times, the materials upon which writing was conducted in India were palm leaf and birch-bark. The former was used by the people of the plains, and the latter by the hill-tribes. The use of palm leaf is continued in certain parts of the country even to the present day. The period at which the art of paper-making appeared amongst her inhabitants

Its late arrival in India.

is not known, but it may be reasonably surmised, from the direction in which it reached this country, that it was brought from China. The people of the Eastern Himalayas are believed to have practised this art anterior to its spread in Europe, for paper was known to have been made in Nepal before the middle ages. Authentic records of the industry in India, however, begin from the reign of Emperor Akbar, when the manufacture of this material is said to have been introduced into Cashmere. It subsequently spread to other parts of the country.

The materials from which paper has been manufactured in various parts of the world, have formed an important factor in the development of this industry. A large variety of raw and waste products have been used for this purpose in different countries, among which may be mentioned straw, hemp, flax, bamboo-shoot, jute-cuttings, esparto and other kinds of grass, pine-wood, waste-paper and cotton-rags. The Chinese, who have from the earliest times made paper of excellent quality, use different materials in different parts of their country. Hemp and rags are used in certain provinces, and the inner bark of the mulberry, bamboo and straw in others. In Japan, where much of the paper made is noted for its strength and softness, the bark of the mulberry is principally used. In Europe, cotton rags were used so largely in the middle ages that vegetable fibres were for a long period almost entirely forgotten. These rags, besides being admirably

The materials used for paper by the earliest makers.

adapted for the purpose of paper making, were perhaps found cheaper than any other material. It was only during the 18th century, that the attention of paper-makers was again drawn to the use of vegetable fibres, and they reverted to their use. In the 19th century, straw, wood, esparto, and other varieties of grass have been extensively used by European manufacturers, but esparto grass and pine-wood have found most favour with them in recent years. These two products, which are obtained chiefly from Spain and Norway, have been found most suitable to the requirements of modern paper-makers whose productions must be cheap and abundant.

The materials used in India

The materials used by paper-makers in India have been numerous. In the last century, hand-made paper appears to have been made chiefly from cotton rags; but, at the present day, waste paper is used most largely for this purpose. The mills make use of various species of grass, straw, hemp, jute cuttings and rejections, cotton rags, old ropes, waste-paper and rejected gunny bags. But the cheapest and most suitable raw products for the power industry, have been found in three species of grass known as *sabai*, *munj* and *bhabar*, as well as in jute cuttings and rejections. *Sabai*, which is used by the mills of Bengal, comes principally from Sahebgunj in the Rajmahal District. *Munj* is largely utilised by a mill near Lucknow, and is said to be common in the country extending from Bengal to Northern

India. *Bhabar* is converted into paper by a mill in Bengal, and is the most plentiful of these three species of grass. According to Sir George Watt, this grass is met with throughout the central table-land of India from Bengal to Madras, in the United Provinces, and in Central India. In some parts of the country it is said to be extremely abundant.

The hand-industry.

Up to the close of the 18th century, when the paper-making machine was unknown, paper was prepared entirely by hand. The hand-industry is still continued in certain countries, because it turns out fabrics that are peculiarly strong and lasting which the machine cannot be made to produce, so that although the processes in the industry are laborious and expensive, the prices obtained for hand-made paper are exceptionally high and readily support its manufacturers. At the present day, of all countries in the world, England is perhaps the largest producer of this class of paper.

Indian hand-workers.

In India, the preparation of hand-made paper appears to have been carried on in various parts of the country during the 17th and 18th centuries, but it is now becoming extinct. This industry was known to have been formerly conducted in several districts of Bengal, but it is at present confined to a few villages only in the districts of Hugli and Howrah, among which may be named Shahbazar, Moyanin and Mahanad. In the United provinces, the industry has had a similar career. Referring to it, Mr. A. C. Chatterjee gives the following account. "At one time," he relates, "an extensive hand industry in paper flourished in these provinces. Muttra, Lucknow, Jaunpur and Kara in the Allahabad district were the principal centres * * * The industry is now practically extinct in the three last-named places. Some paper is manufactured by hand in the interior of the Almora district from the fibre of the *boru* plant * * * In the town of Muttra, the hand industry still manages to survive. Old paper is purchased from the Aligarh postal press and elsewhere and thoroughly soaked in water. It is then converted into thin pulp by treading and kneading. The pulp is again washed (the water of the Jumna being considered particularly suitable) and then steeped in a solution of *sujji* for some days. The workman then lifts out some of this paste on a framework covered with a reed mat. This on being drained forms into a sheet, is dried by exposure to the sun, treated with flour paste and again dried. The paper is then glazed by hand rubbing and sold to local dealers.*

Their mode of pulp-preparation.

The material selected for the manufacture of paper is first reduced to pulp, which is the primary process in paper-making. The method followed by Indian hand-workers is crude and laborious. A worker whose operations the writer had the opportunity of watching at Shahbazar, a village about six miles north-east

* A. C. Chatterjee's "Notes on the Industries of the United Provinces," p. 82.

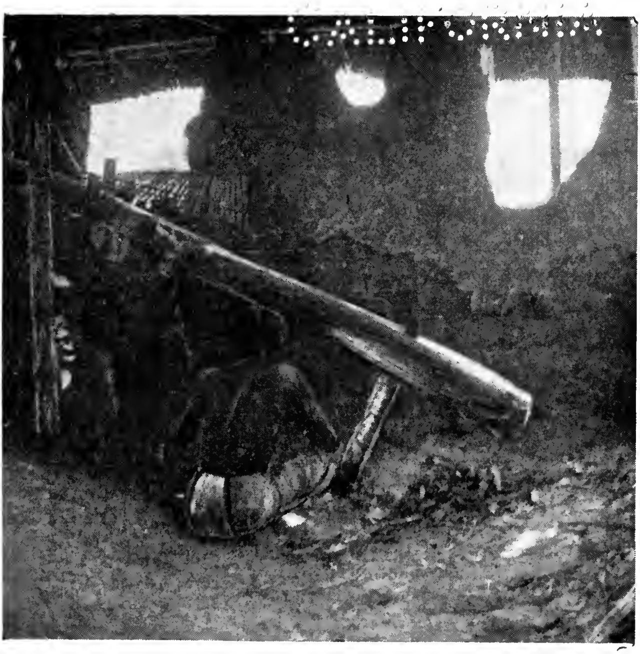
of Tarkeswar in Bengal is illustrated in Plate XVII. The raw material used was waste-paper (*chat*), which the paper-maker or *kagji* said had been first separated from all its admixtures, such as card-board, coloured paper, bits of string and stone. It had then been dusted over a sieve and put into a tub of water mixed with lime, where it had been soaked for six or seven days. This, he said, was done to clean and soften the paper. The soaked paper was then beaten in the *dhaki* or tread-beam, which is shown in the illustration.

The 'pulp-dhaki.'

This implement was very much like the 'rice-dhaki' but heavier in construction. It consisted of a long wooden beam, having at one end a wooden pestle projecting downwards, the extremity of which was capped with an iron ring. The beam was about 9½ ft. in length, 8 in. in diameter at the thinner end, and 13 in. across at the thicker end. The pestle was about 2½ ft. in length and 5 in. in diameter. Through the body of the beam and about the middle of it was pierced an iron rod which rested on two props, one on either side of the beam. The props were planted into a raised earthen platform. The *dhaki* being thus mounted, two workmen standing at the head of the platform treaded its thinner end. Below the pestle was a flat heavy stone sunk in the ground which acted as a mortar. In principle, the *dhaki* is a lever, the support in the middle on which it turns being its fulcrum, the pestle at the heavier extremity

Plate XVII

[To face p. 124.



HAND-PAPER MAKING.

The 'dhaki' employed in the preparation of pulp.

From a photo taken by the author.]

the resistance, and the treading of the workmen at the thinner end being its power. As the labourers treaded the beam, it worked up and down somewhat like a see-saw, and the *kagji* placed small quantities of the wet paper on the stone. When the wet paper was beaten into shreds it was put into a tub, some lime and *sujji* mixed with it and water added to the mixture.

A lad then went into the tub and commenced to tread on the soft stuff, bringing up a scum of impurities to the surface of the water. It was next put on a large piece of cloth and washed in a pond adjoining which the paper-maker resided. The cloth was dipped into the water, its ends being tied to the waists of two craftsmen, who agitated the stuff to and fro till it looked like butter. The stuff was thus converted into pulp or *saj*, and was finally ready to be made into paper.

Treading and washing.

Although the system by which pulp is prepared by the Indian craftsman is crude and laborious, the method he adopts in the manufacture of paper is comparitively simple and similar to the process followed by the hand-workers of this industry in England. An illustration of the *kagji* engaged in paper-making is given in Plate XVIII. This process was witnessed by the writer also at Shahbazar. The principal implements used by the craftsman were the *chowkat*, an oblong wooden frame with battens fixed across, and the *jal*, a screen made of very fine strips of bamboo bound with horse-hair in parallel

Their process of paper-making.

lines. The top and bottom edges of the latter consisted of two thin pieces of bamboo-shoot. The screen fitted into the frame and was kept taut by two sticks placed between its edges, one on either side. Over this screen, which was placed on the frame, paper was formed out of pulp, one sheet at a time, the size of each sheet depending upon the inner measurement of the screen. Beside a pond, which the *kagji* considers indispensable owing to its supply of water, a round earthen vat called the *hodh* was sunk in the ground. Near it stood two small tubs containing water purified with alum. Pulp was put into the vat and water from the tubs poured over it. The mass was then stirred for a few minutes with a rod until it resembled butter-milk. This was done to diffuse the pulp throughout the vat.

The *kagji* then sat beside the vat and proceeded to make paper. He placed the screen over the frame and on either side of it fixed a stick. The frame containing the screen was then dipped into the vat and some pulp drawn over it with a few smart pulls. Having done so, he brought the frame to a horizontal position over the vat and gently shook it from side to side, thus spreading the pulp evenly along the screen and making its fibres cohere by a rough process of intertwining. While he did so, the water escaped through the interstices of the screen, leaving upon it a film of pulp in the form of a sheet. He then deftly lifted the screen, the sheet adhering to it, and placed it, face downwards, on a plank beside him.

Forming sheets from pulp.

Plate XVIII.

[To face p. 176.

HAND-PAPER MAKING.

A 'kagji' engaged in making paper.

From a photo taken by the author.]

The sheet was pressed to the plank by a quick movement of the hands over the back of the screen, which was thereby separated from the sheet. The screen was again placed over the frame, the sticks fixed, the frame dipped into the vat and raised with another layer of pulp on it. A second sheet was thus formed and placed on the plank. He continued this operation, occasionally stirring the pulp in the vat with a rod, till he completed a pile of sheets near him which he covered with another plank. Over this plank, he placed some heavy boulders.

After some hours when through the pressure of the boulders the water was squeezed out of the paper, the sheets were taken out one by one and placed over bamboo mats or *durmah.* The mats were then put out in the sun.

Drying, sizing and glazing.

When the sheets were thus dried, a liquid size which was prepared by boiling sun-dried rice, was applied on them with a brush. One side only of each sheet was thus treated at a time, the intervening period being occupied in drying. The freedom with which the sheets are allowed to contract by this manner of drying, as against the quick drying process in the paper machine, is in the opinion of paper-makers what imparts strength and firmness to hand-made paper. The dried sheets were then exposed to the evening dew, by which treatment the paper-maker said the sheets were softened, and thereby made fit for the final process. This process consisted in glazing the sheets over a plate of iron with a *norah* or stone roller. They were thus finished and made ready for the market.*

Pulp is prepared by the Indian mills from *sabai* and other varieties of Indian grass on the following system, which is similar to that adopted by the mills in Europe for the pulping of esparto. Weeds, mud, and all other foreign substances are picked and removed from the grass, which is put into a boiler. In this vessel, the grass is boiled in high-pressure steam. When the boiling is over the steam is turned off, and the liquid, almost black with matter extracted from the grass, is run out. Clean water is now run in and the steam turned on. The boiled grass is thus washed. It is then taken to the breaking machine, where it is reduced to pulp by the revolution of rollers fitted with knives. The pulp is finally bleached by admixture with chloride of lime (prepared by the action of chlorine gas upon slaked lime), or, with certain other chemicals. This makes the pulp almost snow-white and fit for the production of white paper. An illustration showing the pulping process of a mill in Bengal is given in Plate XIX. Waste products such as cotton-rags and old paper, which are reduced to pulp in a somewhat similar manner, require a smaller proportion of chemicals in the bleaching process than any grass.

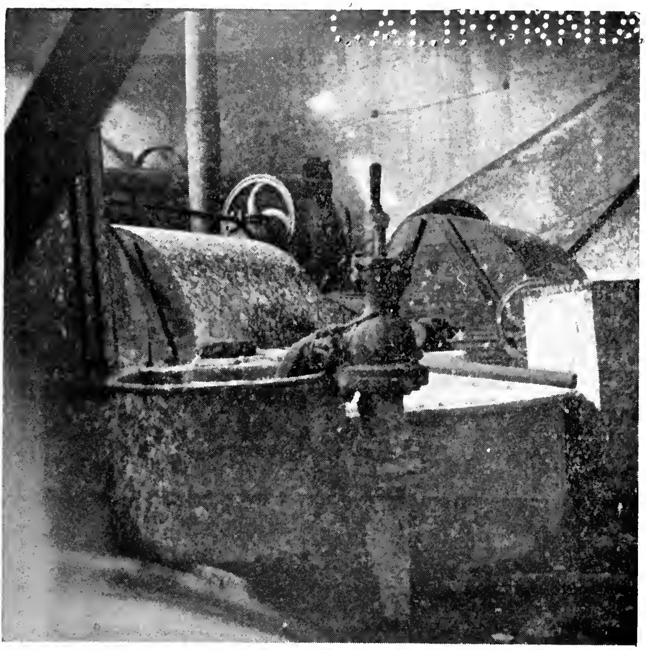
Pulp-making in the Indian mills.

The system by which pine and other varieties of wood

* A similar method of making a species of paper-board was also witnessed by the writer at Moorali Bagan in Ultadingi, a village in the northern suburbs of Calcutta.

Plate XIX.

[To face p. 128.



MACHINE PAPER-MAKING.

The pulping section of a paper-mill in Bengal.

From a photo taken by the author.]

are converted into pulp in Norway and more recently in North America, may here be alluded to. It is so simple that its economy is apparent when compared to the processes just described. The pulp is prepared either by a *mechanical* or a *chemical* process. By the former method the wood, after being cut into slabs, is disintegrated in a grinding machine. In this machine, the slabs are pressed against the face of a mill-stone which revolves at a high speed, while a flow of water conveys the fibres of wood away as they are separated from the blocks. The fibres are then sieved according to fineness and finally pressed into pulp. In the latter process, the wood after being cut into thin slices is boiled with caustic soda. By this treatment the wood is said to be digested. When the boiling is complete, the wood is discharged with considerable force into a large iron chamber placed below the boiler. The digested wood is thus reduced to pulp. Mechanical wood-pulp is, however, inferior to chemical wood-pulp as a material for paper-making. The fibres in the former being disintegrated become short, whereas those in the latter being merely digested remain their normal size. But either kind of wood-pulp is inferior to grass-pulp. It will be seen later why short fibres make weak paper. Here it may be observed that a similarity exists between the construction of paper and of the cotton fabric. Long stapled cotton is known to spin strong yarn and short stapled cotton weak yarn.

The manufacture of wood-pulp.

The closing years of the 18th century witnessed an important event in the annals of this industry. A Frenchman by the name of Louis Robert, a machinist in Leger Didot's paper-mill at Essonnes, invented a paper-making machine and obtained a patent for it in 1799. This machine was taken over to England by Didot in 1801, where it was improved upon by an Englishman named John Gamble who was assisted by the skill of Didot and of Bryan Donkin another English machinist. The patent for it ultimately passed into the hands of Henry Fourdrinier, a naturalised Frenchman, in 1804. Since that time, no material change has been made in this machine.

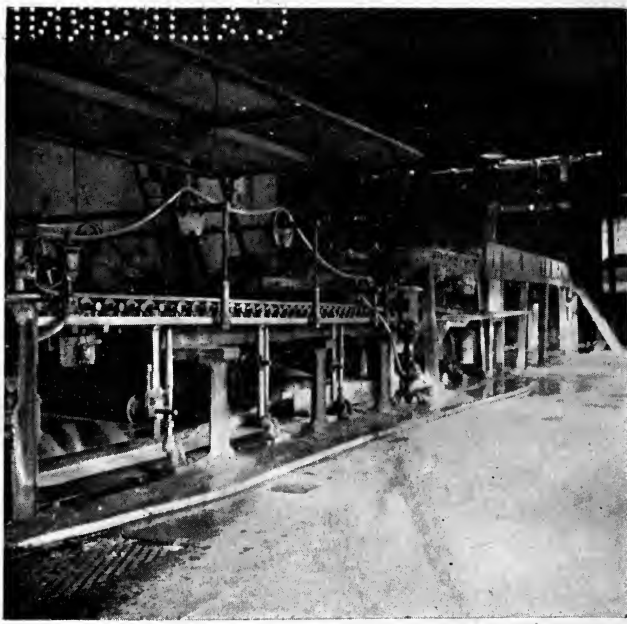
Invention of the paper-machine.

Paper is now manufactured in Europe and America according to the system established by the introduction of the Fourdrinier machine, which is still considered the most effective and economic in this manufacture. This system is also adopted by paper-mills in India with a slight alteration sometimes in the process of preparing pulp, as this product is made out of materials different to those used in Western countries. After the pulp is prepared, it is taken to paper-making machines of the Fourdrinier type, illustrations of which are given in Plates XX and XXI. At the right end of the machine, shown in Plate XX, the pulp or 'half-stuff,' as it is technically called, is contained in iron-vessels known as 'stuff-chests,' where it is constantly agitated by arms

The modern system of manufacture.

Plate XX.

[*To face p. 131.*



MACHINE PAPER-MAKING.

Fourdrinier machines at work in a Bengal mill, showing the 'wire-cloth' in the left half of the illustration.

From a photo taken by the author.]

attached to a revolving spindle. This keeps the particles of fibre evenly diffused throughout the chests. From these chests the pulp passes through the 'sand-catchers' and 'strainers where it is cleared of all sand, dirt, knots, and lumps that it may contain. On leaving the strainers, it goes into the 'pulp-regulator' which regulates the supply of pulp to the paper-machine.

The 'wire-cloth.'

The pulp now reaches the 'wire-cloth' of the machine which is somewhat similar to and corresponds with the screen used in the hand-industry. It consists of a very fine net of brass wires long enough to travel over several rollers in the machine and return below them to its starting point. By reason of its ends being joined, the cloth is said to be endless. Portions of the cloth are seen below the rollers in the left half of Plate XX. During its revolution, when the cloth moves forward in the direction away from the regulator, a vibratory motion from side to side is given to it, which has the same effect as shaking the screen in the hand process. As the pulp flows from the regulators and spreads itself out in a thin film, covering the surface of the wire-cloth, the water drains off through the interstices of the web. The pulp is prevented from flowing over the sides of the wire by the 'deckle' or boundary straps made of india-rubber. The vibratory motion gives regularity to the layer of pulp and also imparts strength to it by intertwining its fibres. In the wire-cloth, the pulp fabric passes under the 'dandy-roll' which impresses it with any water-mark that may be desired. This roller is placed above two air-boxes from which the air is partially exhausted, so that atmospheric pressure comes in here to aid in compacting the fabric.

The half-made paper is now received by the 'felt-cloth' or 'felts' which like the wire-cloth is also an endless piece.

The 'felt-cloth.'

While passing through this portion of the machine, shown in the middle of Plate XXI, it undergoes the pressure of five consecutive rollers which express any water that it may still contain. After being smoothed by the action of two press-rollers, the paper is dried by being carried over a set of steam-heated cylinders, the heat in which gradually increases from the first to the last cylinder.

The web of paper is then glazed by friction between

The 'calenders.'

cast-iron rollers called 'calenders.' It is finally submitted to the action of the cutters in another department, by which it is cut into the required size.

In the manufacture of printing paper, the sizing is done while the material is in a state of pulp. This also helps the fibres to combine readily. A mixture of rosin and alum is used in this size. Writing paper is generally sized when the fabric is formed but has not reached the drying cylinders. It is passed through the sizing-tub and led round a series of large skeleton drums. The paper is then dried by the action of fans revolving inside these

Plate XXI.

[To face p. 332.

MACHINE PAPER-MAKING.

Fourdrinier machines at work in a Bengal mill, showing the 'felts' and the 'calenders' in the right half of the illustration.

From a photo taken by the author.]

drums. It is finally glazed in the same way as printing paper. The lower grades of 'writings' are, however, sometimes treated in the same way as 'printings.' Paper-makers are of opinion that sizing in the pulp state does not produce so strong a fabric as when the finished paper is sized. This is probably another reason why the hand-made fabric is superior in strength to the machine-made product.

Although the art of paper-making, as we have already seen, reached India long after its origin and development in other parts of the world, the modern system of manufacture was introduced here shortly after its initiation in Europe. We are indebted for the advent of this industry to a great and generous spirit, one who was a pioneer of useful work in various directions. Those who have read the life of John Clark Marshman the historian of India, know with what devotion and self-sacrifice he worked for the cause of education in Bengal, how he spent every penny of his salary of £1000 a year as the Official Translator for this purpose, unknown even to his own family till after his death, while the native press was writing of him as a hireling of the Government. He is known to have spent at least £30,000 on the Serampore College, an institution kept up exclusively for the education of Indians. Along with his father Joshua Marshman the eminent missionary, he founded the first Bengali newspaper the "Samachar Durpun" in 1818, and the

The modern industry in India.

"Friend of India" in 1821. But the Christian missionaries, have ever been in the forefront of educational and other useful work in this country. This great pioneer appears to have imported from England, probably during the third or fourth decade of the last century, a paper-making machine worked by steam-power. He set up this machine in Serampore and from it manufactured an ordinary quality of white paper known as 'Serampore paper.' After some years this little factory is said to have been taken over by a joint-stock company, formed under the name of the Bally Paper Mills Co. Ld., of which Messrs. George Henderson & Co. of Calcutta were the managing agents. This company gradually extended the plant and produced the well-known *badami* or almond-coloured paper. It subsequently erected a large mill on the foundation laid by Marshman and worked successfully for many years. Owing, however, to its plant becoming unsuitable to present requirements and its machinery wearing out, it was unable to compete against new mills set up in Bengal and went into liquidation in 1905.

In July 1882, Messrs. Reinhold & Co. of Calcutta founded the well-known Titaghur Paper Mills Co. Ld., and set up an up-to-date factory at Titaghur near Calcutta. After a time its managing agency passed into the hands of Messrs. F. W. Heilgers and Co. This mill had a very hard struggle for some years against cheap paper imported in the Indian market from Central Europe, but has now overcome that competition and is turning out paper superior in quality yet at a similar price to that of the ordinary imported material. About the year 1890, a new syndicate was formed under the name of the Imperial Paper Mills Co. Ld. by Messrs. Jardine Skinner & Co. of Calcutta, who located its works at Kankinara on the Eastern Bengal State Railway line. This mill employed a very able paper-maker by the name of Booth who produced some very good qualities of paper, but was unable to understand the needs of the local market. After a brief though strenuous career, the company went into liquidation in 1903. Its plant and machinery, as well as those of the Bally Mills, were taken over by the Titaghur Paper Mills, which is now the largest paper-factory in India. In 1890 yet another company came into existence under the name of the Bengal Paper Mills Co. Ld., with Messrs. Balmer Lawrie & Co. of Calcutta as its managing agents, which located its factory at Raniguuge on the East Indian Railway line. This concern is still working successfully. The modern system of paper manufacture has also attained some success in other parts of India. Several paper-mills are now scattered over the country, the chief among them being the Upper India Paper Mills at Lucknow, the Girgaum Paper Mills at Bombay, the Scindia Paper Mills at Gwalior, and the Reay Paper Mills at Poona.

It is quite evident, from an examination of the processes followed in the Indian hand-industry, that some material changes and improvements have to be introduced in its system of manufacture. These improvements, as we shall presently see, may be based upon the system adopted in the English hand-paper industry. Hand-made papers being used for valuable deeds, bank-notes and drawing purposes, must be made stronger and more durable than machine-made papers, else, they have no chance of existing against the competition of the latter. A change has therefore to be effected in the raw material, and, instead of waste-paper some other materials with longer fibre, such as cotton-rags and jute cuttings, have to be used. The *kagjis* admit that in former days paper used to be made from rags, and stronger stuff was produced. This is obvious, as the longer the fibre the greater is the intertwining in the formation process. At the same time it may be stated, that with the aforesaid products, the pulping operation could not be done with economy in the *dhaki*, but in some hand-machine devised on the principle of the breaking machine. This would not be a difficult task either for the Government or some technical or industrial institution. If such a machine were constructed and its working shown in the centres of this industry, the *kagjis* would probably adopt the machine.

Suggestions for improvement of the Indian hand-industry.

Besides a change in the raw material, some of the processes of the hand manufacture might be improved. In the bleaching process the use of cleaner water and purer lime is essential. After the paper is made, the Indian workman subjects the sheets to the pressure of boulders which merely squeezes out the water ; the English craftsman puts them between intervening felts in a press, which not only draws out the water but consolidates the fibres. The sheets come out of the press in a thin, compact form. In fact, for the best qualities of paper, the process of pressing is repeated several times. A wooden hot-press, such as book-binders use in this country, would not be expensive and may with advantage be used for this purpose. The native process of sizing may also be conducted in a more efficient and labour-saving manner, as sizing is an important process in paper-making and should be done effectively. It increases the strength of the paper, and by filling its interstices prevents the ink from spreading among the fibres by capillary attraction. Instead of size being applied with a brush on one side of the sheet at a time, the sheets should be dipped into a tub containing size as done by the English hand-worker. By the latter process, the liquid enters the interstices more thoroughly and both the sides are sized in one operation. The sheets may then be hung up on lines to be dried. It may here be observed that the sizing process of the *kagji* is as tedious as the method followed by hand-weavers in England, during the 17th and 18th centuries, who brushed their warp with size on the loom and also dried it there, during intervals of weaving taken for these operations, until William Radcliffe, the Stockport inventor, suggested the idea of mechanical sizing.

Prospects of the modern industry in India.

If we were to consider the advanced stage which certain Western countries have attained in the manufacture of paper by taking advantage of natural resources which their soil affords, such as India also offers us, the reflection is suggested either that we should profit by their example and adopt their methods, or that if we neglect to do so, we shall have to face at no distant date their crushing competition. The economic methods of some of these manufacturers is well-known. In Scandinavia and North America paper is manufactured from wood-pulp prepared from the timber of the white pine, the poplar, the fir, the aspen, and the hemlock. In the latter country, water-power, which costs much less than steam-power, is often utilised in this manufacture. Wood-pulp is, moreover, prepared by a simpler process and needs a smaller quantity of the bleaching agent than grass-pulp. A comparison of the two processes would clearly show the economy of the former. While such are the conditions under which the industry is conducted in those countries, its resources and prospects here are not less favourable. Most of the above-named trees are to be found in abundance in the forests of the Himalayan ranges where water-power may also be obtained. The use of turbines worked by waterfalls is also known in these regions. At the present day, a number of tea factories are being worked in this manner in the Darjeeling Himalayas, and it is well-known that the electric-dynamo which lights the town of Darjeeling is worked by a powerful turbine. With such facilities for timber and motive power, it is certainly worth our while to find out where these two can be found side by side. It may be said that these localities being away from the paper markets, mills situated therein would generally pay more for freight on the manufactured commodity than do the mills now existing in the country; but, on the other hand, they would save almost entirely the cost of carriage on the raw material which is the heavier item of the two. At the present day, the mills in Bengal pay not only freight on grass from Sahebgunge and other grass-growing districts, but are liable for freight on their manufactured goods to Northern India. If a few mills were situated in the lower Himalayan ranges of Upper India, practically no freight would be borne by them either way. It is therefore apparent that the success of such undertakings would be assured if convenient sites could be selected.

HAND-LOOM WEAVING.

The special sphere of hand-weaving.—Its early origin and slow development.—Invention of the 'fly-shuttle.'—Its effect on the cotton industry.—Its introduction into India.—The progress of hand-weaving.—The yarn used by Indian hand-weavers.—Its method of manufacture.—Hand and machine spinning.—The present position of hand-weaving.—In Bengal.—In Madras and the United Provinces.—Methods of the indigenous weaver.—Single-sizing.—Drying and winding.—The 'tanah' process.—The older method.—The later method.—Excellence of indigenous warp.—Beaming.—Drawing.—Twisting.—Indigenous looms.—The Serampur Loom.—The process of weaving.—Improved looms.—Salvation Army Loom.—Mr. P. N. De's Slay.—The improvement of hand-warping.—Development of hand-warping in England.—Mr. P. N. De's Warping Mill.—The process of warping.—Suggestions for development of this industry.

The special sphere of hand-weaving.

SINCE the introduction of steam-power and electricity into the industrial world, there can be no doubt that industries which continue to be worked by hand are of service to us only in special fields. Their spheres of usefulness have been narrowed down to limits wherein the application of motive power has been considered unsuitable. In the departments of industry where manual labour was largely employed, power-driven machines have been found most suitable. But in those occupations in which human skill is required more than manual labour, such as the skilful artisan can provide, it is doubtful how far the introduction of the intricate and so-called 'intelligent' machine driven by motive power has been economic. In the weaving of fancy fabrics, for instance, so much skill and so little power is needed that the hand-loom is able to complete with the power-loom. It is therefore necessary to recognise the limits to which steam-power can with advantage be applied, and to remember the services which skilful labour has rendered to humanity. These are considerations which in a scientific age are likely to be forgotten.

Its early origin and slow development.

Human ingenuity has devised no craft which ministers so essentially to the wants of civilised men as the art of cotton weaving. It may, in truth, be said that civilisation did not exist when the cotton fabric was not known, and that the crucial test of the culture of man was the thought and endeavour which led to his invention of this art. If a curve were drawn depicting the origin and growth of weaving, it would strongly resemble the wave line as might be traced of the course of civilisation, for the history of this industry is concurrent with the history of human refinement. But all trace of the inventor of this art or of the period at which it began, has been lost by the distance of time. Speaking on the origin of cotton weaving, Richard Marsden, one of the greatest writers on this subject, states that "the best historical evidence obtainable points to India as the birthplace of cotton manufacturing."* Our earliest notion of weaving in this country was when it attained more or less a stage of development. This developed stage of the industry is inferred from the references made to the woven fabric by Manu the great Hindu lawgiver in his Institutes,

* Marsden's "Cotton Weaving," p. 1.

and from the accounts given by the followers of Alexander of the cotton garments worn by the people of this country, at the time of the Macedonian invasion. The people of ancient Egypt were also acquainted with the art of weaving. From these two countries, the industry appears to have spread to other lands—to Persia, Greece, and Rome before the Christian era and to the north-west of Europe at a later period.

The Chinese, who cultivated the cotton plant at an early age, began its manufacture into cloth during the thirteenth century. The cotton textile had become an article of trade between India and the Mediterranean ports in the centuries preceding the Christian era, but its commercial utility began to be extended in the middle ages. During the sixteenth century, certain improvements were made in its manufacture by French and English weavers. Up to that period Indian fabrics were extensively used in European countries, but after their progress these French and English manufacturers were able to sell their fabrics at prices lower than those of cotton goods exported from India. Yet the machine used for weaving, known as the 'loom,' was of a crude type and needed much time and labour to operate.

A decided improvement was, however, made in this machine in 1733 by John Kaye, a Lancashire manufacturer, who invented the 'fly-shuttle' and applied it to the loom. His invention consisted of an improved arrangement for picking. He placed a box at either end of the slay for the reception of the shuttle. In each of these shuttle-boxes, a shuttle-driver called the 'picker' was fitted in such a manner that it could slide along the length of the box, backwards and forwards. The two pickers were attached to each other by a string slung before the slay. In the middle of the string was a handle by which the shuttle was jerked from one box to the other. In the older looms the picking had to be done by the use of both hands, or in the case of wide cloths by the help of a second operator; here the use of one hand alone, jerking the handle to and fro, served the same purpose. This appliance naturally rendered the weaving process less laborious and more expeditious.

Invention of the 'fly-shuttle.'

The invention of Kaye, insignificant as it appeared in his time, really changed the destiny of cotton weaving. The production of the loom was so much increased by his invention that sufficient yarn was not obtainable to meet the demand of weavers. Yarn was then spun on a piece of mechanism called the 'spindle', a reproduction of the Indian *charka*, which yielded a very poor out-turn. Machinists naturally endeavoured to increase the output of the spindle. The invention of the 'spinning-jenny' by Hargreaves in 1764, of the 'water-frame' by Arkwright in 1769, and of the 'mule-jenny' by Crompton in 1779 brought about the desired effect. With these improvements in the spinning process, there began to be

Its effect on the cotton industry.

produced an abundance of yarn, where formerly it was comparatively scarce. To use up the larger out-turn, the need for faster looms soon began to be felt again. Up to that time, the loom was worked by manual power and was a reproduction of the Indian hand-loom, with the fly-shuttle attachment. Attempts were then made to work it by steam-power. It was thought that the process of weaving could not be shortened nor the mechanism of the loom made more simple, so that the only means of increasing its capacity was to drive it more rapidly.

Its introduction into India.

The fly-shuttle proved so great an improvement to the hand-loom that in a short time it found its way into Europe and was thence brought into India. About the end of the eighteenth century and probably during the days of Warren Hastings, it was introduced into Serampore in Bengal by the Danish settlers of the town, but political causes prevented its spread in the country.

In 1785, Dr. Cartwright devised the first power-loom in England. Various machinists followed up his idea with developments ; yet for over fifty years the power-loom was not a success in practical weaving. Cartwright and his followers had not provided for any means of feeding the loom with weft-thread as fast as it could be consumed, so that the machine had to be stopped every now and again for the thread to be replenished. Moreover this thread used to break off frequently, and to join it the loom had also to be stopped. These two defects rendered the working of the power-loom barely faster than that of the hand-loom. While these attempts were being made to improve the former machine, the hand-loom benefited considerably. Certain improvements which were applicable to the latter were adopted by hand-loom workers. Improvements were not only introduced in the weaving machine but in the processes preparatory to weaving, such as the 'sizing' and 'warping' of yarn. It thus happened that in the period of interval between Kaye's invention and the construction of the power-loom the hand-loom industry was considerably developed. In 1841, two English machinists, Bullough and Kenworthy, invented the 'weft-fork,' an attachment for automatically stopping the power-loom on the breakage or exhaustion of weft. This prevented long stoppages in the machine thus making its progress much faster than before. A signal service was thereby rendered to the power-loom, which has since become a commercial success. The success of the power-machine did not, however, stop the progress of the hand-loom entirely, for further improvements in the former have since been applied to the latter. There is, consequently, a similarity now between the two machines, the power-loom differing from the hand-loom in those points only which enable it to work at a higher speed, to use a longer warp, and to handle a larger quantity of cloth. This similarity arises from the fact that the construction of the

The progress of hand-weaving.

hand-loom served as the foundation upon which the power-machine was built.

It is evident, that for a proper development of this industry, there must be special facilities for yarn. At the present day, the bulk of the cloth produced by Indian hand-weavers is woven of yarn of above 30's counts, which is mostly imported from Lancashire; and the lesser portion is woven of yarn of below 30's counts, which is chiefly the produce of Indian mills. A very small fraction of this coarse yarn is, however, spun in the *charka* or hand-spindle in this country. There are certain recesses in this continent where the primitive methods of spinning and weaving are still carried on from cotton grown and ginned on the spot. As the hand-loom industry depends almost entirely for its yarn on the spinning mill, the manner in which this raw product is manufactured may here be briefly described.

The yarn used by Indian hand-weavers.

After the harvesting of the cotton crop, the produce which is obtained from the pods of the plant cannot be sent from the fields direct to the manufacturers. It has seeds adhering to it, and is therefore taken to a ginning factory which is usually situated in the cotton-growing district. Here the seeds are removed from the fibre. In the *ginning* process, the produce is also cleaned of all foreign substances that are found mixed with it. The raw cotton is then baled for convenience of transport and brought into the market; from here

Its method of manufacture.

it goes into the hands of the manufacturers. When brought into a cotton mill, the raw stuff is taken to the spinning division and there the first process it undergoes is *mixing*. Different qualities of raw cotton are mixed or blended to minimise the cost of production and to obtain particular qualities of yarn. The mixed stuff is then subjected to an operation called *scutching* in which further impurities are extracted from it, and a lap or sheet is formed of the cotton. In this lap, the fibres lie in all directions. The next process is known as *carding*. Individual fibres are taken from the lap, further cleaned and laid in a position more or less parallel to each other. They are thus formed into a thin film which is finally condensed into a 'sliver,' a soft and round strand of cotton. The two foregoing operations roughly resemble the cleaning, combing, and dressing of a lady's head of hair. The operation that follows is termed *drawing*. Several slivers are taken together and extended or drawn out to the thinness of an original sliver, with the result that the new sliver is more uniform in body than the old ones and the fibres in it are placed more perfectly in parallel order. The succeeding operation of *slubbing* is merely a continuation of the former process, the new slivers being combined and attenuated to such a degree that it becomes necessary to twist it slightly in order to preserve its cohesion and rounded form. The next process known as *roving* is also a continuation of the preceding action, its object being to still further attenuate the sliver which also receives some additional twist. The final treatment is the process of *spinning*. The sliver is here attenuated to the required fineness, and is given the twist by which the strand of cotton, known as yarn, is formed.

It has been found impossible to discover any new principle in the art of spinning. For centuries hand-spinning is known to have been conducted on precisely the same principle, in whatever part of the world the handicraft was pursued; and the introduction of machine-spinning merely continued the essential methods of the hand worker. The same principle is also adopted in every form of the spinning industry—whether the fibre treated is cotton, jute, wool or flax. Although nearly a hundred and fifty years have elapsed since the spinning-jenny was invented, and despite the fact that driven by the severest competition spinners have continually endeavoured to develop their craft, it is remarkable how no change has yet been found possible in the theory of spinning. In the Industrial Museum at Bolton in Lancashire, a singular remnant of mechanical invention is preserved. It is the head-stock of the 'mule-jenny' made and worked by Samuel Crompton himself. The most significant fact about this jenny is that all the motions produced by the intricate 'self-acting mule' of to-day are found in the old head stock. It is true that the great inventor produced some of his motions by the hand or by

Hand and machine spinning.

the knee which he could not get automatically, but none of the modern spinning machinists have been able to deviate from the essential movements of the mule-jenny. The only result of constant endeavour towards the development of this art has been an increase of speed in the present-day spindle.

Although the condition of hand-loom weaving in this country a few years ago might rightly have been described as languishing, it is certainly not so at the present day, for clear indications of a renewed life have appeared since the movement of 1905. Reviewing the industry in Bengal, Mr. J. G. Cumming of the Indian Civil Service made the following statements in 1908. "The hand-loom weaving industry has existed, as Mr. Collin said in 1890, more or less in every district. The yearly accounts from 1892 were rather dispiriting. In the monograph for 1898, it was stated 'that large numbers of weavers have abandoned their looms and have taken to other pursuits,' or that the cotton weaving industry was in a decaying condition. In 1899 the industry was stated to be on the decline, but there was no change in the fine muslin of Golnagar and in the coarse cotton cloth in Orissa. By 1901 it was stated that the competition of European piece-goods was lowering the indigenous industry in the Burdwan, Presidency, and Patna Divisions, but that the fly-shuttle loom was coming into use in the two former areas. In 1905 it was stated that the coarse country-made

The present position of hand-weaving.

cloths were preferred in the Orissa and Chota Nagpur Divisions and in the Sonthal Parganas. By 1906-1907, the industry had recovered. In Burdwan district there was an increase in out-turn of one-half over that of the previous year. From Bankura there was an export trade. At Bolpur in Birbhum there was considerable manufacture. In Hooghly district the manufactures in Arambagh subdivision rose from 11 lakhs to 14 lakhs. In Howrah the mill out-turn decreased; and the hand out-turn increased. In Midnapore, Ghatal was the centre of weaving. In the 24-Parganas the mill market was dull, the hand out-turn smartened in Basirhat subdivision. In Jessore there was a considerable manufacture in both coarse and fine cloth; so also in Khulna. In Nadia coarse cloths, bed-sheets, and towels were made at Kushtia, Meherpur, and Shikarpur. Fine cloths with silk borders were made at Santipur for export. In Patna, both cotton and mixed fabrics were manufactured in Bihar. In Saran district, the *jolahas* wove a coarse cloth for winter use. There was some spinning in the Gopalganj subdivision. In Gaya, there was coarse cloth manufactured. In Darbhanga district there was the special *kokti* cloth woven near Madhubani, and *kanti* cloth at Bharwara and Pandaul. In Shahabad coarse cloth was woven all over the district. In Bhagalpur coarse cloth was made, but an improvement in texture was made; so also in Monghyr. In the Sonthal Parganas, both *jolahas*, *tantis* and aboriginals did coarse weaving. At Kishanganj

In Bengal.

in Purnea district, *lungis* and *patanis* were made. Throughout Orissa and Chota Nagpur Divisions coarse cloths were woven, principally for local consumption. A comparison between this account and the earlier accounts shows what a revolution for the time being has been made in the industry by the new factor of an increased local demand. How far this factor will be permanent, it is impossible to say. The contrast is shortly as follows:—Country cloth will last over a year, and imported cloth seven or eight months. The cost of the latter is Re. 0-11 to Re. 1-3, of the former Rs. 1-12 to Rs. 3-0. * * * What has happened in Bengal is that in parts of Jessore district and most of Howrah district, in the Sadar and Serampur subdivisions, but not in the Arambagh subdivision of the Hooghly district, and in the Raniganj side of the Burdwan district, the Serampur pattern of hand loom has extended. But I believe that it was due more to intercommunication among the people themselves than to official efforts to popularize the Serampur fly-shuttle loom. On the other hand, the ordinary weaver throughout the Burdwan and Presidency Divisions has, whether a fly-shuttle worker or not, received a special demand for his wares on account of the movement in favour of local manufactures."*

Owing to the remarkable development of the industry in Bengal, the Government of that province has recently established a Central Weaving Institute at Serampur. Its

* Cumming's "Review of the Industrial Position and Prospects in Bengal." p. 7-9.

inauguration was most opportune, for the need of such an establishment was making itself felt very greatly. This institute serves as a centre for the diffusion of knowledge and training requisite for the improvement of hand-loom weaving. Here, students recruited from the literate classes, undergo a course of training, both theoretical and practical, on the improved methods of the industry. On completion of their course, they are provided with looms and preparatory appliances, for which payment is recovered from them by small annual instalments.

In Madras and the United Provinces.

In the Madras Presidency, the industry has also improved considerably in recent years. Although no official report has lately been published on hand-weaving, it is apparent from a perusal of the proceedings of the Conference held in connection with the *All India Weaving Competition* at Madras in 1908, that a large number of weaving factories, working on the improved system, have been started throughout the presidency. A central weaving factory has also been established under Government auspices at Salem. Regarding the position of hand-loom weaving in the United Provinces, Mr. A. C. Chaterjee makes the following observations in 1908. "The hand-weaving industry is widely distributed throughout the provinces. There is no town and hardly a large village where a few *julahas* or *koris* are not found plying their hereditary trade. The coarser fabrics (known ordinarily as *garha* and *gazi*) made of yarn of counts lower than twenty are to be met with in all plains districts. The finer cloths are manufactured mostly, but not altogether, in the eastern districts."* It is evident, from the facts above recorded, that owing to the adoption of improved methods and the increased demand for hand-made fabrics, the industry has received a new lease of life.

Methods of the indigenous weaver.

The indigenous weaver pursues methods which have apparently been practised in this country for many centuries. They are tedious and laborious, and, in some instances quite primitive, but they help to produce fabrics which are known to be more lasting than mill-made cloths. When the *tanti* or the *jolah* (the Hindu or the Mahommedan weaver) gets yarn for his loom, he steeps it in fresh water for a day or two, which is done to strengthen it. When yarn comes from the spinning mill, it is composed more or less of loose fibres and has little strength or firmness. It has, therefore, to undergo certain operations known as the 'preparatory processes' before it can be fit for the weaving operation. The most important of these processes is the operation of sizing. This consists in squeezing or slashing the yarn in a size composed of starch and other ingredients which consolidates the fibres and thereby imparts strength to the yarn. Sizing also includes dressing which consists in laying down the fibres so as to glaze the surface of the yarn. Apart from its value in the woven cloth, this process renders the yarn

* Chaterjee's "Notes on the Industries of the United Provinces," p. 13.

fit to stand the strain and friction on the loom. It may here be observed that yarn for the warp is invariably sized but yarn for the weft is usually not sized, as much unlike the former, it is subjected to very little strain and friction during the process of weaving.

The yarn required for the warp is taken by the weaver, hank by hank, and squeezed in a size till the threads are thoroughly permeated with it. In Bengal, the size is made usually of roasted paddy (*khoi*) and tamarind, and in Madras, of rice flour and gingelly, boiled in water. The wet hank is next taken and placed round a swift (*charki*).

Single-sizing.

From the swift, the threads of the hank are passed between two grains of wet *khoi*, or through a gelatine made of the last-named size, pressed between two fingers, and then wound on small reels (*natai*). This method of single thread sizing is a very perfect process, as it sizes every side of the yarn and thoroughly smoothens it. The excellence of single or hand sizing consists in the treatment of threads individually between the fingers of a hand, which act intelligently and press it just enough to glaze its surface, yet not so much as to stretch or break it. Any system, therefore, that does not possess this particular virtue cannot be as perfect.

The hanks, after being thus treated, are dried on reels in an open place. They are then taken out of the reels from their tapering ends, which are thus constructed to facilitate this quick mode of transference, and put round small swifts. They are thus transferred, as it would be inconvenient to unwind the yarn from the reels, which are fixed to their central rods. The unsized yarn is also mounted on swifts. The weft yarn is then wound on pirns, and the warp yarn on bobbins, when it is to be warped according to the modern system of peg warping; but if it is to be warped on sticks in the ground, or according to the old system of peg warping, the warp yarn remains in the swifts. The winding on bobbins and pirns is done in the spinning wheel (*charka*). The bobbin or pirn is fixed into the spindle of the wheel. The swift, with the hank of yarn round it, is placed on a dry lump of earth beside the spinning wheel, and the end of the yarn is fastened to the bobbin or pirn. The spindle, being connected to the wheel by an endless cord, revolves as the handle is turned, and so winds the yarn on the bobbin or pirn fixed into it. The weaver turns the wheel with one hand and guides the thread along the bobbin or pirn with the other. Where the modern system of peg warping is adopted, the bobbins when filled are put into a bobbin-frame.

Drying and winding.

The warp yarn is then divided into the number and length of warp threads required for the cloth, in either of the two following ways known to Indian weavers as the *tanah* process. (*a*) Sticks about 3 ft. long are fixed into the ground in couples and usually in two rows. The sticks at the ends of the rows

The 'tanah' process.

are stronger than the intermediary ones, so as to bear the strain of the warp. They are about 3 in. apart in each couple, and the distance between two couples varies between 6 to 8 ft. The warper holds the swift in his hand, fastens the end of the thread to an end stick and takes the thread along from stick to stick in succession, placing it outside one and inside another. When he comes to the last stick, he passes the thread around it and retraces his steps to the first stick repeating the process. Thus he goes to and fro from the first to the last stick laying out his yarn. The distance all round the sticks forms the length of the warp, and the rows of thread along the sticks, from top to bottom, form the number of warp ends. The use of the intermediary sticks is to form leases and so prevent the threads from getting entangled. These warp threads are then collectively wound on an end stick together with the other sticks which are finally pulled out of the ground. (*b*) Instead of sticks in the ground, pegs are driven into a wall, about 4 feet apart, all in a line. In the olden days, the yarn was then warped in the pegs, precisely in the manner done for the sticks in the ground. In later years, however, the idea struck the warper that the labour of treading over a space equivalent to the length of all the threads of the warp combined together, might be obviated by carrying more than one thread at a time. A new method was then adopted in peg warping with the help of a lease-taker called

The older method.

bahr. The *bahr* is a small, wooden, rectangular frame containing ribs made of bamboo strips which have holes in the middle.

The later method.

By the later method, the ends of the threads are drawn out collectively from, say, 40 bobbins placed in a bobbin-frame, and passed alternately through the eyes and between the ribs of the lease-taker. The alternate series of threads are then separated, thus forming a lease. The two alternate halves are next taken in two bunches, knotted together, and slipped through the first peg, so that one bunch of thread goes over and the other goes under the peg. Two men generally work at this process—the warper and the carrier. The former carrying the *bahr* takes leases and does the warping, the latter carries the bobbin-frame. The bobbin-frame is placed beyond the second peg, so that one extremity of the threads is in the frame and the other at the first peg. The frame is then carried beyond the third peg, when the bunch that was under the first peg is put over the second, and the one over the first put under the second. The alternate bunches are then similarly taken over and under the succeeding pegs, knotted together, and slipped through the last peg. This first section of the warp is then shoved right into the pegs, nearest to the wall. Similarly, as many sections as would make up the required number of ends for the width of the cloth, are then one after another warped and fixed into the pegs. If, for instance, 1200 ends are required 30 sections are taken. The distance between the first and the last peg forms the length of the warp required. All the sections from the first peg are then taken out one by one and slipped through a rod held in the hand which thereby protects the leases; the warp is finally wrapped round this rod. The leases of the succeeding pegs are transferred to other lease rods, which are then rolled up with the warp, as in the case of the sticks from the ground. This later method is also adopted for warping with sticks in the ground, as shown in Plate XXII, which is as largely practised at the present day as the method of peg warping just described.

The aforesaid methods show that the indigenous weaver sizes his yarn previous to warping it, which is a more efficient system of yarn preparation than the reverse method followed in the power industry. Sized yarn possesses strength sufficient to resist the stretching and breakage which it is subjected to in the warping process; but unsized yarn gets its elasticity drawn upon in the warping process and breaks by the slightest undue strain in the loom. In the power industry, sizing is never done before warping, as to make the former process expeditious many stands of yarn are sized together, and when a large number of threads are to be arranged as a preparatory process to sizing, it is more economical to warp them than to merely arrange them. But it is this warping of unsized yarn that destroys a portion of

Excellence of indigenous warp.

Plate XXII.

[To face p. 158.

HAND-LOOM WEAVING.

The 'tanah' or indigenous process of warping.

From a photo taken by the author.]

its strength. This is another reason why the preparatory processes of the hand-weaver produce a stronger warp than the system adopted in the mills.

This perfect process of hand-sizing, and of weaving on a diminutive loom, rendered it possible in former years for weavers in Bengal to weave Dacca muslins, known as 'running water' and 'dew drops,' from yarn equivalent to 524's counts, which far exceeds the finest yarn spun at the present day. It was possible to spin such fine yarn, owing to the special quality of cotton used, and to the particular care bestowed in its manufacture.

When the warp is prepared by the several processes just described, the indigenous weaver proceeds to wind it round the warp-beam of his loom. The weaver places the beam over trestles in the gound. He then takes the ends of the warp from their situation in the sticks, passes them between the dents of a coarse, open reed and wraps them round the beam. Having thus led and fixed all the ends to the beam, he winds them collectively on it, in such a manner that the threads lie parallel to each other and are distributed evenly along the beam. During this operation, the first two sticks being held in the hand before the reed retain the leases, which travel up from one end of the warp to the other by the winding of the threads. These two sticks finally become the lease-rods seen in his loom. The rest of the sticks are drawn out of the warp as they approach the first two

Beaming.

sticks. In this process, the warp is also examined, broken threads pieced, and knots in the warp cleared.

The warp being thus transferred to the warp-beam, the indigenous weaver takes its ends and draws them through the healds and the reed, and fixes them on to the cloth-beam. The ends of the warp are taken from the beam, and entered through the healds and the reed in regular succession, from one end of the beam to the other. Two operators are required for this purpose, one on either side of the healds. These operators are known in weaving mills as the 'reacher-in' and the 'drawer-in.' The reacher-in takes two contiguous threads from the warp and reaches them to a double hook, which the drawer-in draws, first through two healds and then through one space in the reed. The draft or order in which the threads are passed through the healds, in plain weaving, is as follows:—

Drawing.

The ends of the odd numbers are drawn *through* the eyes of the first series of healds, and *between* the healds of the second series; the ends of the even numbers are drawn *between* the healds of the first series, and *through* the eyes of the second series. Thus, the two shafts of healds contain the alternate threads of the warp.

The order in which the threads are entered through the reed in plain weaving is two contiguous threads through each space. The operators are very careful and see that the threads do not cross or get entangled. Having passed the threads of the warp through the reed, they are finally fixed on to the cloth-beam, and wrapped round it two or three times. The fixing on the cloth-beam is done by putting the ends of the threads into a channel cut along the side of the beam, and then by inserting a long narrow batten over them. The threads are similarly fixed on to the warp-beam.

Certain weavers vary the drawing process in the following manner. During the operation of beaming, they use the loom reed instead of a coarse, open reed to pass the warp threads through, which are entered in the same order as in the drawing process. When the beaming is done, the ends of the warp are fixed on to the cloth-beam. The weavers then raise a complete series of healds between the reed and the warp-beam. The replacing of healds, the loops of which wear out after about a dozen pairs of *dhooties* are woven, is also thereby effected. This passing of the warp through the loom reed in the beaming process and the formation of healds on the loom, are reckoned by these weavers (who are adepts in heald-making) to be less laborious than the passing of the warp through the coarse, open reed and the ordinary drawing process.

Twisting.

A repetition of the drawing process for separate pieces of warp is obviated by a simple device, if the same web is to be continued. After a warp is woven, its extremity is kept filled in the reed and the healds. This portion is then cut off from the cloth-beam and the warp-beam, and knotted at opposite ends to prevent it from coming out of the healds and the reed. When a new warp is to be drawn in, its ends have merely to be twisted to the old ends, and carefully pulled through the healds and the reed. As drawing is a slow and tedious process, this device saves a deal of time and labour to the weaver.

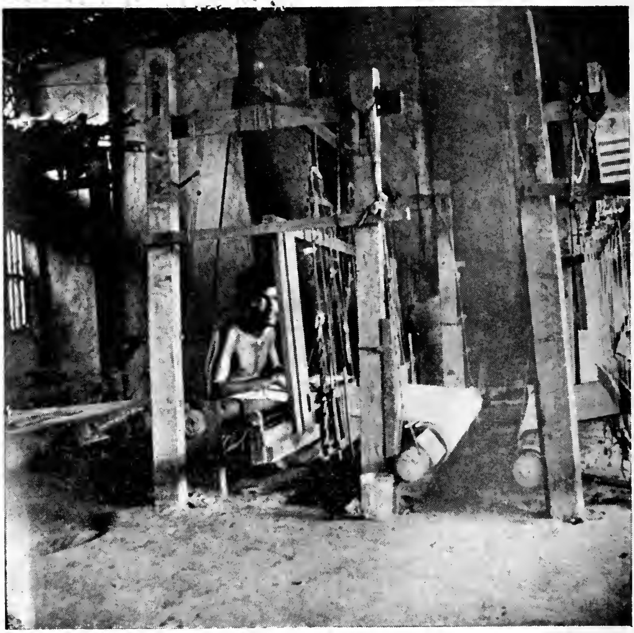
When the warp has been arranged on the loom by the beaming and drawing operations, it is ready to be woven into cloth. The loom generally used by the indigenous weaver is of the old type in which the 'fiy-shuttle' does not come into play. Here, the ancient method of picking, by which the shuttle was thrown by hand, is still followed.

Indigenous looms.

Among the poorer classes of weavers, the loom has not even a frame and its construction is crude. The warp-beam and the cloth-beam rest on stout pegs driven in the ground. On either side the warp is a thin post, also driven in the ground. A rod is mounted on these posts and over it are slung a set of strings suspending the leaves of healds, which are connected to the toes of the weaver by a pair of cords. The reed which is made of bamboo strips, is enclosed in a rough wooden lay hanging from two other posts. A pit is dug under the warp so that damp air from it may reduce the breakage of warp threads. The weaver sits in front of the cloth-beam with his feet inside the pit and weaves his cloth. Among weavers that are well-to-do, the loom is fitted

Plate XXIII.

[*To face p. 163.*



HAND-LOOM WEAVING.

The indigenous weaver at work in a pit-loom.

From a photo taken by the author.]

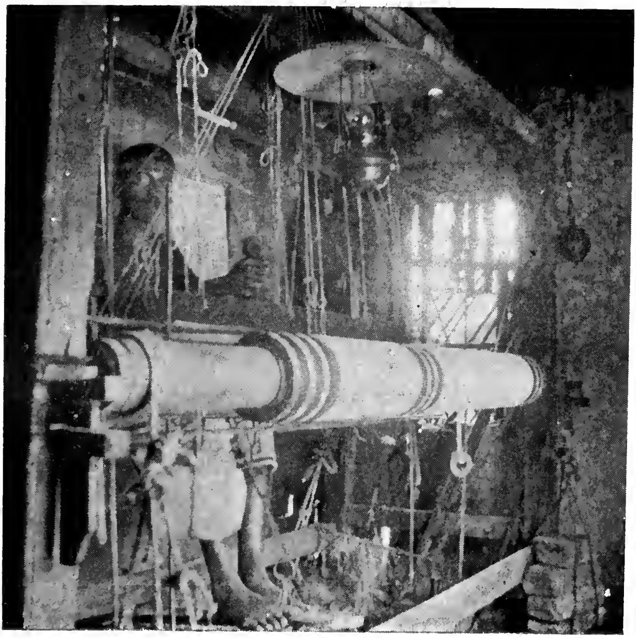
inside a rectangular frame. Sometimes, though rarely, this frame is movable, having no parts buried in the ground, when the pit even is not dug under the warp. The weaver sits in front of the cloth-beam, opposite to which is the warp-beam at the back of the loom. The warp is arranged between these two beams. The shafts of healds are suspended from a top bar across the loom by means of cords running round pulleys. These shafts again are connected by strings to two treadles fixed at the bottom of the machine. The reed is carried in a lay pendant from the top of the loom. The shuttle is thrown along the lay from hand to hand. The weaver sheds the warp by means of the treadles with his feet; he next throws the shuttle with one hand and receives it with the other; then he beats up the weft; and with all these movements completes only one pick in the web. Moreover, if the cloth woven be wider than the stretch of his arms, another operator is required at one side of the loom to receive the shuttle and throw it back. These looms naturally require great labour and skill to manipulate, yet work very slowly. Such was the construction of looms used by French and English weavers during the 16th century, according to accounts given by the earliest writers on weaving. In recent years, however, certain indigenous weavers, having perceived the economy of the 'fly-shuttle' and possessing means to afford it, have attached it to their looms. Such looms are known in Bengal as the 'Serampore Loom,' the name being derived from the town in which they were first used. In Southern India similar looms, known as the 'Madras Frame Loom,' have also been recently introduced. Although the 'fly-shuttle' was at first applied to looms having a movable frame, they have recently been adopted in pit looms in which portions of the frame are driven in the ground. An illustration of such a loom is given in Plate XXIII.

The Serampore Loom, illustrated in Plate XXIV, is fitted in an upright rectangular frame. The lay or slay (*docthee*) is suspended from the top of the loom by means of two small iron pegs which project one on either side of the top bar of the slay. These pegs rest on grooves in cross-rails on either side of the loom, so that the slay may swing backwards and forwards. The lower portion of the slay carries the reed (*shanah*) and the shuttle-boxes. The reed is fitted into grooves cut in the upper and lower battens. At either end of the lower batten are placed the shuttle-boxes, and the surface of the batten slanting towards the reed forms the shuttle-race. On this runs the shuttle (*makoo*) to and fro. At the top of each box is fitted an iron rod, which runs through and thereby guides a wooden block sliding along a groove in the bottom of the box. These blocks (*marrah*) form the pickers, that is, they do the picking in the loom by driving the shuttle. Along the top of the loom runs lengthwise a rope, the middle of which rests on a string hanging from above the machine. Two strings attached to

The Serampore Loom.

Plate XXIV.

[To face, p. 264.



HAND-LOOM WEAVING.

The Serampore Loom being worked by an indigenous weaver.

From a photo taken by the author.]

this rope are tied to a handle in the centre of the slay and the two pickers on either side.

Along the top of the loom is fixed lengthwise a hexagonal roller, from which hang two strings being wrapped round it. The ends of these strings are tied to the two shafts of healds (*jhap*), the two ends in front to the front shaft and the two at the back to the rear shaft, so that when one shaft rises the other falls and *vice versa*. This is an improvement on the old loom, where in place of the roller there was a bamboo or a rod, from which hung levers (*nutchnees*) or pulleys (*kopees*) three or more in number, from which again were pendant the two shafts of healds. In each lever or pulley, one side string was attached to one heald-shaft, and the other side string to the other heald-shaft. The defect in this arrangement was that several levers or pulleys would not always act uniformly, and, in consequence, the healds seldom worked in a line. A single roller, which must always work uniformly is, therefore, a better means of suspending the heald-shafts. When the heald-laths are made of flexible wood, such as bamboo, three or more strings suspend each shaft ; but if they are made of some rigid wood, such as teak, one string at either end of each lath is used. Below each heald-shaft is tied a thick cord. These two cords are again tied to two treadles which have their fulcrum in front of the machine. The treadles work the healds up and down and thereby cause the *shedding* of the warp.

The *picking* is effected with one hand by jerking the handle to and fro, and the *beating* with the other by working the slay backwards and forwards holding it by its upper batten. In front of the loom is the cloth-beam. At one end of this beam is a thin ratchet-wheel against which is fixed a click, which prevents the beam from unwinding. The winding which forms the taking-up motion in the loom has to be done by hand.

At the back of the loom is the warp-beam. This beam is detachable for convenience of the beaming operation. The ends of the beam are narrower than its body, and are put inside of two brackets, fitted at opposite sides of the loom frame. When the ends are put into the brackets, the openings in the latter are closed up by wedges. Weights are suspended by ropes which are wound round the warp-beam in a direction opposite to that of the warp. These weights, which are not allowed to touch the ground, prevent the warp from unwinding, except at the letting-off motion; yet they enable it to yield slightly at any undue strain, thus minimising the breakage in warp threads. This system of weighting the warp-beam has apparently been in existence for many centuries in this country, and has been adopted in almost every kind of loom.

Having arranged the warp on the loom, as we have already seen, the indigenous weaver takes a number of pirns containing weft yarn. He fixes a pirn in his shuttle and commences the weaving operation. He sends forward the slay with his left hand, and works the treadles with his feet, thus producing a shed in the warp. He then jerks the handle to one side with his right hand, and thereby sends the shuttle through the shed. This leaves a thread of weft in the track of the shuttle. The treadles are again worked and the shed closed. Next, he brings back the slay, with the weft thread in it, to a few inches off the cloth-beam, and secures the thread there by reversing the shed by the action of the treadles. Having thus completed a pick, the weaver takes back the slay, sends the shuttle through the reversed shed with the weft thread behind it, closes the shed, beats up the thread to the weft near the cloth-beam, and produces a shed again. He continues these movements, rolling up the cloth every now and again, as it is being formed. All these movements constitute weaving in this loom, in which the shedding motion is effected by the feet, and the picking and beating motions by the two hands.

The process of weaving.

To keep the length of weft thread taken at each pick uniform throughout the fabric, two sticks measuring slightly longer than the width of the cloth are joined together, and fixed into the edges of the fabric by means of pins at their extremities. By this device the cloth is stretched to its proper width and the selvage ends are also kept in. These sticks, which assume the form of a bow over the cloth, are called by weavers in Bengal the *mothee*, and serve the function that 'temples' do in power-looms.

Since the beginning of the movement for the revival of hand-weaving, quite a number of improved looms have been devised. In most of these machines, attempts were made to quicken the process of weaving, by combining two out of the three principal motions of the loom into a single automatic movement, which would thereby also economise the labour of the weaver. Some machinists sought to combine the shedding and the picking, while others the picking and the beating motions. Among looms constructed on the former principle, the best-known were the Simplex Automatic Loom made in Calcutta, and the looms constructed in Ludhiana on the Japanese model, in which by the depression of the pedals in the shedding motion, the picking was also effected by a picking stick placed on either side of the loom. These looms are no longer manufactured. Of those that were devised on the latter principle and are still being constructed, may be mentioned the Sayajee Cottage Loom of Baroda, Churchill's Loom of Ahmednagar, and the Salvation Army Loom of Bombay, in which by the movement of the slay in the beating operation, the picking is also effected by a set of levers.*

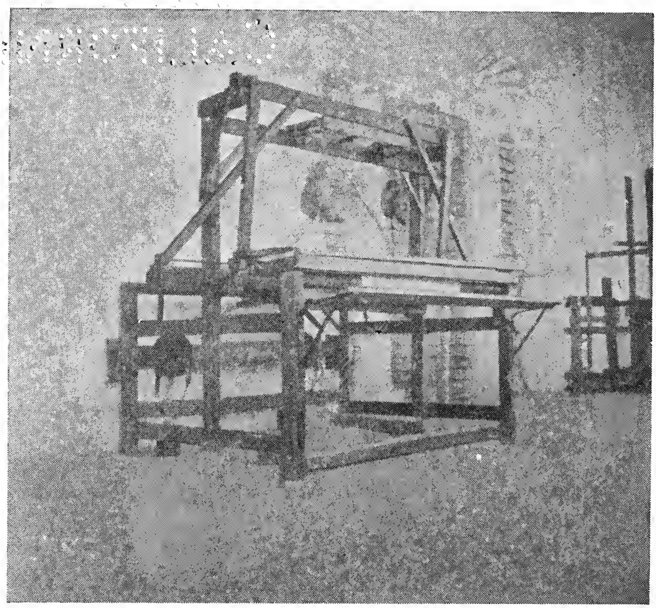
Improved looms.

An illustration of the Salvation Army Loom used in the Government Weaving Institute at Serampore is given in Plate XXV. The loom is fitted into a frame which is

* A description of the Sayajee Cottage Loom and Churchill's Loom may be found in the writer's "Hand-Loom Weaving," (Edition of 1906) pp. 34 and 99.

Plate XXV.

[To face p. 169.



IMPROVED HAND-WEAVING.

The loom constructed by the Salvation Army in Bombay.

From a photo taken by the author.]

rectangular if the top portion be neglected. This portion consists of a head-piece supported on two posts which run up the middle of the loom, one on either side. The slay is pendant from this head-piece. In front of the loom is the cloth-beam and below it are four treadles which work the shafts of healds.

Salvation Army Loom.

The picking is effected by an arm placed in front of each shuttle-box. These arms are actuated by a long lever which is fixed above the cloth-beam and is set in motion by pulling the slay forward to beat up the weft. The picking and the beating of the weft are thus effected by one hand, while the shedding of the warp is caused in the usual way by the action of the feet on the treadles. The loom has an automatic take-up motion actuated also by the movement of the slay. Although coarse counts of yarn up to 30's only can be woven in this machine, it is suitable for a variety of work, and its speed exceeds that of any constructed in the country.* The makers now claim that a practised worker can turn out at least 20 yards of coarse cloth on this loom in a day. Its price (Rs 90) is, however, high for the indigenous weaver and its use, for this reason, is yet confined to weaving factories.

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* This was the finding of the Committee of Judges who awarded the first prize to this loom in the Indian Industrial Exhibition held at Calcutta in 1906. The writer who was in this Committee believes that the present model, which he examined at the Government Weaving Institute at Serampore, is an improvement upon the old one which was displayed at the Exhibition.

The varied experience acquired by the hand-loom movement teaches us that one of the most feasible schemes for the improvement of this industry at present is to place within the reach of indigenous weavers an appliance which they could readily adopt both by virtue of its price and adaptability. Such an appliance has been devised by Mr. P. N. De of the Weaving Institute at Serampore. What must now be done is to get it known to weavers and introduced among them. This implement consists of a slay with the fly-shuttle arrangement which can be attached to any country loom. It is simple in construction and is made entirely of wood having no iron rods to guide the pickers as in the Serampore Loom. These rods have been dispensed with by Mr. De to enable the slay to be repaired in any part of the country where there may be no blacksmith.*

Mr. P. N. De's Slay.

We have already seen that the indigenous system of yarn preparation, though excellent in its method of sizing, is extremely slow and laborious in the warping process and yet produces a short warp. This has always been a great drawback with the Indian weaver. The labour and delay occasioned by the sizing process are little compared to the time and trouble he spends over the warping of his yarn. What, therefore, calls for immediate reform in the preparatory processes is in this direction. A warping mill similar in principle to that

The improvement of hand-warping.

* The price of this Slay complete with reed and shuttle is Rs 20/-.

used by the English hand-weaver is of the utmost necessity to him.

In England a system of peg-warping very similar to the Indian process prevailed up to the latter half of the 18th century. Ball-warping was then introduced. The appliances for this new process consisted of a large vertical reel with a coarse comb attached to its side, and a driving pulley connected to it by an endless cord. A bobbin-frame, otherwise called a creel, with about forty bobbins of yarn completed the plant. The warper took the ends of yarn collectively from the bobbins, passed them between the teeth of the comb, and tied them together to a peg in the reel. The threads were next taken under and over lease pegs as in peg-warping. The reel was then revolved. The length of the warp was calculated by the number of its revolutions and the number of threads by the ends of yarn taken at a time. The warper then severed the threads from the creel and wrapped the warp round his arm making it into a ball. This style of doffing the warp gave the name of 'ball-warping' to the process. This system of warping was an improvement on the laborious method of peg-warping and so came into vogue.

Development of hand-warping in England.

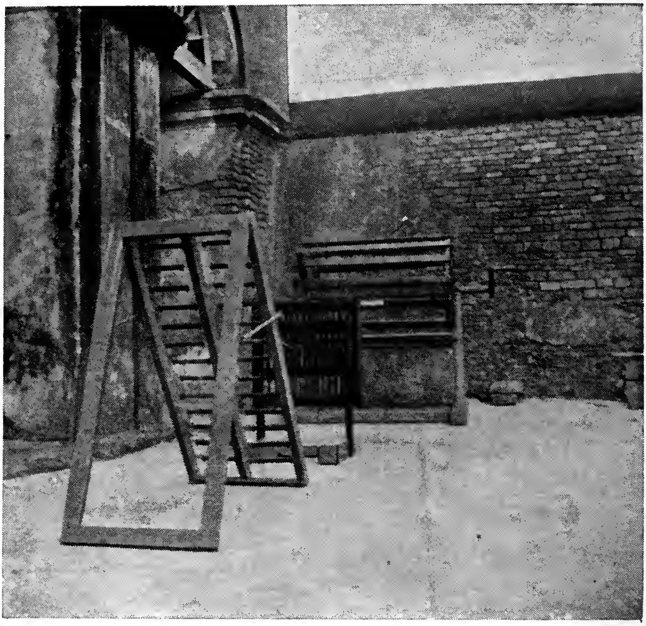
About the year 1875, a process more convenient than ball-warping, particularly for coloured fabrics, was introduced in England. To obtain small warps of different colours, it was necessary to prepare the warp in sections of yarn, each section representing a colour and all the sections making up the width of the cloth. The process was, therefore, called 'section-warping' and it prevails up to the present day. The section-warping mill consists of a large creel, usually semicircular in shape and containing about 250 bobbins, a wide reed, a contracting reed, a diminutive beam called the section-block, and attachments for winding, compressing, marking, and doffing. From these bobbins, as many strands as will form the section of yarn are taken and passed through the wide reed. They are next taken through the contracting reed, which reduces their width to that of the section-block, on which they are then wound. This process is continued till as many sections as are required for the width of the cloth are warped.

A warping mill, heck, and creel similar to the plant used for this purpose in the English hand-industry has been constructed by Mr. P. N. De. An illustration of his plant is given in Plate XXVI. It consists of a drum-shaped frame mounted on a stand, called the warping mill, a heck or lease-taker, and a creel or bobbin-stand. In the top batten of the mill are fixed two rows of pins. One row stands upright on the surface of the batten and the other lies along the outer side of it. There are about 50 pins in each row, fixed one inch apart. The position of each side pin is exactly between two top pins, so that if a section of yarn be tied to the former, it will wrap between the latter. The circumference of the

Mr. P. N. De's Warping Mill.

Plate XXVI.

[*To face p. 173.*



IMPROVED HAND-WARPING.

The warping mill, heck, and creel devised by Mr. P. N. De.

From a photo taken by the author.]

frame is 3 yards. The number and length of warp threads are calculated and wrapped round this mill. The heck consists of two small frames having vertical ribs. In the middle of each rib is a perforation which is called the 'eye' of the heck. The frames slide to and fro along grooves in the heck. The creel holds 26 bobbins of yarn.

The process of warping.

From the left half of the creel ends of yarn are taken, passed through the eyes of the front heck-frame and between the ribs of the rear heck-frame. From the right half of the creel ends of yarn are also taken, passed between the ribs of the front heck-frame and through the eyes of the rear heck-frame. If 26 threads are calculated per inch of cloth, 13 ends from each half of the creel are taken. The 26 ends are then collected together and tied to the side pin at one end of the frame. The lease is now formed by sliding the rear heck-frame to one side, till the threads from one half of the creel cross the threads from the other half, thus forming an end lease. The lease is preserved by a loose knot tied round it with coloured thread. The frame is then revolved and the section of thread falls between the 1st and the 2nd top pin, that is, the first inch space. If the length calculated for the warp be 96 yards, the revolutions of the frame must be 32. After 16 revolutions, that is, at the middle of the warp, another lease is formed and protected as aforesaid. This is the beer lease. After 32 revolutions, another end lease is similarly taken, and the tail of the section tied to the side pin where the head was also secured. Having warped a creel of yarn, threads from another 26 bobbins, replaced in the creel, are now leased and wound on the next inch space of the frame; and so on, till as many inch spaces are filled with sections of warp as the inch width calculated for the cloth; for instance, if 46 inch width be calculated, 46 inch spaces are to be filled.

Some years ago when a sufficient knowledge of indigenous weaving had not been acquired, it was considered a hopeless task to improve its position. At the present day, however, from the investigations which have been made into the conditions of this industry, we are at least able to locate the causes of its decline. It seems rather evident that the removal of these causes would resuscitate the industry. The task before us is great and will require years of strenuous effort, as all work of this nature does, but it is by no means hopeless. In this regard it is apparent that the work of development and reform must lie in the three following principal directions:—

Suggestions for development of this industry.

(*a*) The improvement of looms and preparatory processes so as to render the work of the weaver less laborious and more expeditious.

(*b*) The diffusion of knowledge and training in improved methods to the sons of indigenous weavers, who along with technical training should receive an elementary education, such as will raise their poor standard of intelligence.

(*c*) The relief of the weaving classes from their present indebtedness to the *mahajans* by the organisation of co-operative credit in the centres of this industry.

The improvement of looms and preparatory processes in recent years has been instrumental in producing some useful machines and appliances which must be more largely brought to the notice of weavers through the agency of provincial exhibitions. The use of some of these machines is being already taught in weaving schools of which a few have been formed in the country. Besides the Government Weaving Institute at Serampore, the establishment of the Hewett Weaving School at Bara Banki in 1907, and of three demonstration schools at Tanda, Saharanpur, and Moradabad, respectively, in 1908 by the Government of the United Provinces, should prove most useful in the dissemination of improved knowledge. The formation of the Salem Weaving Factory by the Government of Madras, and the establishment of hand-loom factories in Southern India by private enterprise are also steps towards the development of this industry. But yet there is need for a larger number of schools and factories, particularly in Bengal.

There can be no question that one of the principal causes for the decline of this industry has been the ignorance and insularity of the weaving classes. This is evident from their unwillingness to join the weaving schools, which in some cases out of sheer ignorance they appear to look upon with fear and suspicion. It is quite possible that such weavers would regard an improved loom with much respect, deck the machine with flowers, take it in procession to the nearest temple, and worship it there from time to time, as was done in the case of an improved plough in Western India which Sir George Birdwood talks about. Hence it is obvious that an elementary system of education should be imparted to the sons of weavers along with the technical training which these schools provide. Without such education, it seems evident that the best attempts to make them improve their position will in many cases prove futile.

The indebtedness of the weaving classes is also an impediment in their way in adopting improved appliances. Mr. A. C. Chaterjee, I. C. S., who appears to have made an enquiry into the financial position of weavers in the United Provinces, makes the following observation on this point:—"At present almost every where cotton-weavers are to a great extent dependent on mahajans or middlemen. In most centres of the industry the yarn dealer is different from the mahajan or dealer who takes over the manufactured cloth at a price or on commission sale."* The Salvation Army in India, whose labours in connection with the development of this industry are well-known, has had similar

* Chaterjee's "Notes on the Industries of the United Provinces," p. 29.

experience with regard to the condition of hand-weavers. Commissioner Booth-Tucker, writing in the "War Cry" of October 1909, says, "the placing of our looms in the hands of the weavers is rendered difficult owing to the fact that during the hard times of the past few years, the poor people have become deeply indebted to the money-lenders, who naturally have no desire to see them liberated." The organisation of co-operative credit in weaving centres therefore seems essential to the development of this industry.

THE RICE INDUSTRY.

The economics of industry.—Extent of the rice industry.—Varieties of paddy.—The conditions of labour in paddy cultivation.—The 'dhaki' and the 'hath-musuli.'—Cleaning, boiling and drying.—The method of husking.—Improved system of rice-milling.—Separation of refraction.—Grading.—The two systems of conditioning.—The soaking process.—Cleaning by specific gravity.—The boiling process.—Sun-drying.—Machine-drying.—Mallinson's Dryer.—The whizzer.—Khan's Dryer.—The necessity of drying.—Efficient husking.—The Engelberg Huller.—Cowie's Huller.—The process of cleaning.—The White Rice Cone.—The polishing process.—Varieties of rice.—The modern industry in India.—Export trade in rice.—Cost in the indigenous and in the modern system.

The economics of industry.

If industries are to be organised in India on the wealth-productive basis, it is evident that they must adopt the most approved methods of economy and efficiency. Economic industry now requires that motive power should be utilised where manual labour was formerly employed, so that such labour may find more suitable and productive employment in the various fields of skilful manufacture. But in place of this well-adjusted system, there is a very different type of economic constitution in India. The main features of this type are easily discernable. While the production of wealth in the country is insufficient for her population, a large section of her labour is wastefully employed. Under these circumstances, there appears to be a need for economic re-construction by setting free the misused labour for the extension of her industries. In the manufacturing section of the rice industry, an enormous amount of labour is expended in the pursuit of crude and primitive methods. It is certain that these methods must sooner or later be improved. Apart from the absence of economy in this craft, there is no division of labour and consequently no efficiency. It is most desirable that in an extensive industry, there should be a separation of the agricultural from the manufacturing section, so that the methods of each may be able to attain excellence. This system has been introduced in India both in the jute and wheat industries, and there is no reason why it should not be extended to the rice industry.

Extent of the rice industry.

Of the various rice-producing countries in the world, India is by far the most extensive, her average annual crop being obtained from nearly 64 million acres of paddy.* Burma comes next as a rice-producer with an average annual cultivation of about 8 million acres of the raw produce; Japan, Siam, the United States of America, China, Egypt, and Mexico then follow in respective order with smaller productions. Within the soil of this country, rice holds the premier position of all agricultural products. Sir George Watt, whose investigations into the economic resources of India are invaluable, states that "rice occupies the foremost place amongst the food-crops of India; it takes up nearly three times the area devoted to wheat and twice that which yields millets."† There is hardly a province in the country where the

* *Vide* "Agricultural Statistics of India" since 1900-01.
† Watt's "Economic Products of India," Vol. V, p. 521.

cultivation of paddy is not carried on to a greater or less extent as the table given below will show. The figures indicate the average of acres annually sown with this produce.*

	Acreage.		Acreage.
Bengal ...	37,093,000	Punjab	606,000
Madras ...	7,735,000	Ajmere and Coorg ...	81,000
The United Provinces ...	6,980,000	Berar ...	37,000
Central Provinces ...	4,553,000	N-W. Frontier Province ...	25,000
Assam ...	3,961,000	Native States (Mysore, Hyderabad, Nepal, etc.)	787,000
Bombay ...	1,441,000		
Sind ...	787,000		

The yield of rice in India varies with the crop (winter, autumn or summer) and with the district, but over twelve maunds per acre have been considered the average of production for all India. On the basis of this official average, the aforesaid areas would yield annually an aggregate of nearly 29 millon tons of rice. At the opening of the Imperial Research Institute at Pusa, the late Sir Denzil Ibbetson, then the Revenue and Agricultural Member of the Government of India, declared that he estimated the total value of the agricultural produce of this country to be £349 millions sterling. It may also be approximately calculated, on the basis of average prices, that the total value of the rice produced in India is £190 millions sterling. The value of this product, therefore, exceeds the value of all the other agricultural products of this country taken together.

* Calculated from the "Agricultural Statistics of India" 1900-01 to 1907-08.

Varieties of paddy.

The varieties of paddy grown in India are believed to be extensive. A certain writer has estimated that their number exceeds four thousand. It is possible that many of these are hybrids, but some of the principal commercial varieties obtainable in Bengal, which is the largest paddy-growing province in the country, are as follows :—

FINE QUALITIES.	WHERE GROWN.
Tulopanjee	Northern Bengal.
Kalanuniah, Dansnuniah	Ditto.
Akundih	Southern Bengal.
Banktoolshi	Ditto.
Dudhkolma	Ditto.
Durgabhog	Ditto.
Kamalbhog	Ditto.
Gopalbhog	Ditto.
Dulpi	Ditto.
Bansfool	Ditto.
Hemthorongini	Ditto.
Goyabally	Ditto.
Indurshal	East and Central Bengal.

MEDIUM QUALITIES.	WHERE GROWN.
Kukurjali	Northern Bengal.
Patna	South and East Bengal.
Nagra	South and Central Bengal.
Ballam	Backergunge District.
Jhingayshal	East and Central Bengal.

MEDIUM QUALITIES—(*contd.*)	Where grown.
Sitashal, Ramshal	East and Central Bengal.
Kabuli Manshara, Talah Do.	Northern Bengal.
Paynath, Hili, Joypur	Northern Bengal.
Khulna	Central Bengal.
Panathi, Sonakowri	Northern Bengal.
Cuttack, Balasore	Southern Bengal.

COARSE QUALITIES.	Where grown.
Colom, Dhumshi	Northern Bengal.
Mushakani	Southern Bengal.
Joroh Motah, Sadah Do., Ghoonshi, Gaytee	Ditto.
Bochi	Northern Bengal.
Orashal	Eastern Bengal.
Chandbally	Southern Bengal.

Although agricultural land is held in this country under various systems of land-tenure, there are particular economic conditions under which labour is applied to land in the cultivation of paddy. Perhaps the most frequent of these is the one in which the cultivator, holding land on a lease, works with his own hands assisted by the labour of his family. Another is that in which he sows on a landlord's soil in co-partnership with him, with the help of certain members of his household. This is known as the *adhi* or half-share basis. Yet another is where the peasant-proprietor cultivates on his own soil almost entirely with hired labour. These conditions vary sometimes in certain localities. While in the agricultural section such development is observed, the manufacturing side of the industry is still found in a rudimentary stage.

The conditions of labour in paddy cultivation.

In almost every village home in Bengal and in certain parts of Southern India, rice is prepared from paddy by a crude and laborious method which has probably been practised since the days of antiquity. The principal implements used in this preparation are the *dhaki*, a heavy wooden lever worked by foot, and the *hath-musuli*, a wooden mortar and pestle worked by hand. The former is employed in almost every part of the country while the latter is used only by certain hill-tribes, such as those of North-Eastern Bengal. The *dhaki* is usually fashioned in the form of a beam and is about 7 ft. in

The 'dhaki' and the 'hath-musuli.'

length and 7 in. in diameter. An illustration of the *dhaki* in the operation of paddy-husking is given in Plate XXVII. Through the body of the beam and about the middle of it runs an iron pivot, which is fixed against two props planted in the ground, one on either side of the beam whereby it is supported. From one end of the beam, a trunk projects downwards which drops into a cavity in the ground when the *dhaki* is worked. This trunk, the extremity of which is capped with an iron ring, acts as a pestle and the cavity as a mortar.

The first process in the indigenous system of rice preparation is the cleaning of paddy. This is done by two men. One of them pours the grain from a certain height upon a mat on the ground, while the other fans it vigorously thus blowing away all dust and light substances that are mixed with it. The cleaned paddy is next soaked in water for a day or two. It is then partially boiled over fire and then dried in the sun, if *ushna* or par-boiled rice is wanted. If on the other hand, *attab* or sun-dried rice is required, the paddy is merely dried in the sun. Boiling inflates and drying contracts the grain, the result is that the husk gets loosened from the body. Drying alone has this effect to a certain extent by mere contraction.

Cleaning, boiling and drying.

The dried paddy is then put into the cavity below the trunk of the *dhaki*. At the opposite end, two women with all their weight alternately tread on and off the

Plate XXVII.

[*To face p. 184.*

INDIGENOUS RICE-MAKING.

The 'dhaki' used for paddy-husking and rice clearing in Bengal.

From a photo taken by Mr. C. O. Barker.]

dhaki, thus dropping the trunk continually on the paddy. A third woman sits near the cavity and feeds it with the grain which is husked by pressure and friction, the former being caused by the fall of the trunk and the latter by the grains being rubbed against each other. This woman besides feeding the *dhaki* removes the husked stuff, and by tossing it up repeatedly in a *chalni* or flat, matted, receptacle in a very deft manner, sifts the husk from the rice. When the paddy is husked and the shells thus sifted, the brown rice is again put into the cavity and the *dhaki* worked, till the brown coating is removed from the rice and it is cleaned. The husking process entails great manual labour and expenditure of time, yet does not yield a very clean produce. Three women working at the *dhaki* for over five hours or two for eight hours do not husk, sift, and clean more than sixty seers of paddy which yields about a maund of rice.

The method of husking.

In Burma, Japan, Siam and the United States of America, rice is made from paddy by an improved system in which economy and efficiency have been attained by the division of labour and the application of motive power. Although there is some variation of process in the United States of America, owing to the peculiar qualities of paddy and conditions of work in that country, in principle the American system is the same as that adopted in the East. During the last 50 or 60 years, attempts have been made in

The improved system of rice-milling.

Bengal, from time to time, to mill rice on the improved system which may here be described.*

When paddy is purchased in Bengal, it is cleaned of dust and light refraction by the process of fanning described in the indigenous method. There is however a certain percentage of admixture, technically known as refraction, (such as balls of mud, bits of stick and stone), which remains in the paddy and is separated from the grain in the mill. When par-boiled rice is to be prepared, this separation is effected by specific gravity in the soaking process which will be presently described. But when unboiled rice is required, the paddy not being subjected to a course of soaking, the separation is done by a 'circular-motion separator' as used in the Rangoon mills. This apparatus consists of two sieves and a tray bound in a wooden frame. The top sieve has perforations which allow the paddy to pass through but retain larger substances such as balls of mud, bits of stone and stick. The lower sieve has perforations which allow smaller substances such as husk and dust to pass through into the tray below, but retain the paddy. The entire frame circulates in a horizontal plane being fitted to the curve of a spindle which revolves vertically. The refraction from the top sieve and the tray are carried away by shoots into a bin; the cleaned paddy from the lower sieve

Separation of refraction.

* An experiment on the modern system of rice-milling was conducted by the writer at Salbari in Northern Bengal during 1904 and 1905.

goes into a grader or direct to the drying platform as may be found necessary.

Grading.

Breakage of rice in the huller and defective hulling may be minimised by grading paddy as a preparatory process to the husking operation. In the same quality of paddy, grains of more or less two sizes are often found. This is most noticeable in the paddy of Lower Bengal. If such paddy is allowed in the huller, the regulation of pressure being uniform in the machine, there is a perceptible breakage in the finer grains. The paddy is therefore graded or sorted into two different sizes and husked separately. This is done by a grader or 'shaking screen.' This apparatus consists of a screen with meshes which allow the smaller grains to pass into a tray below, while the screen retains the larger grains. The screen and tray are mounted in a frame which is lower at the side which has the two outlets. The crank below the frame gives it a backward and forward motion. Both the circular-motion separator and the shaking screen require very little power to drive.

The two systems of conditioning.

When par-boiled rice is required, the paddy is not subjected to the two aforesaid processes but is soaked in water and slightly boiled in steam. While by the former processes paddy required for the preparation of *attab* rice is conditioned, by the latter methods paddy required for the preparation of *ushna* rice is so treated. In the latter paddy, the separation of refraction is effected in the soaking process, and the grading is dispensed with as par-boiled grain is easy to husk, not requiring much pressure in the husking operation; so that, even if grains of different sizes are let into the huller, there is little or no breakage in the smaller grains.

The soaking process.

Paddy is soaked in vats built of masonry and covered over with portland cement. Two vats similar in size are usually constructed. Each vat has a tap overhead which supplies it with fresh water and a netted drain below which draws away the dirty water. The vats are situated outside the mill building, and their size depends on the amount of paddy required to be soaked. These vats usually contain two days' consumption of paddy for the mill, a day's in each vat. If 150 maunds of grain are required daily, the capacity of each vat should be 750 cubic feet.* The vats are shallow, but their length and breadth extensive. The method of soaking is simple. The grain is put into the vat and water let in until the former is completely submerged. It is then well stirred with a wooden oar until the light admixture that is in it (such as husk, bits of stick and straw) rises to the surface of the water. This admixture is then taken out and the paddy allowed to soak

* The space occupied by a maund of paddy is approximately $1\frac{1}{2}$ ft. $\times 1\frac{1}{2}$ ft. $\times 1\frac{1}{2}$ ft. or $3\frac{3}{8}$ cub. ft. The space required for 150 mds. would, therefore, be $3\frac{3}{8}$ cub. ft. $\times 150$ or $506\frac{1}{4}$ cub. ft. Allowing about half of this space for water, the contents of each vat would be 750 cub. ft. The inner dimensions may be 15 ft. $\times$ 10 ft. $\times$ 5 ft. in each vat.

for at least 24 hours. While paddy is in the vat, there must always be a good quantity of water above the surface of the grain, so as to prevent it from rising above water-level in the course of soaking. This would set in decomposition in the grain. Although paddy can be kept in water for some days without injury, provided the water is changed every day, drenched paddy cannot be exposed to air for any length of time with safety.

When the soaking is over and the grain taken out of the water, all mud and dirt that have been washed away from it, is found settled at the bottom of the vat. In the soaking process, the paddy is therefore first separated from its admixture and then rid of all its impurities. This is technically called 'cleaning by specific gravity.' Two vats are essential for paddy-soaking. A single vat however large it may be would not suffice, as this process along with the steeping, cleaning, and raising of grain occupies each vat for atleast 30 hours, and soaked grain must be provided for each day's work.

Cleaning by specific gravity.

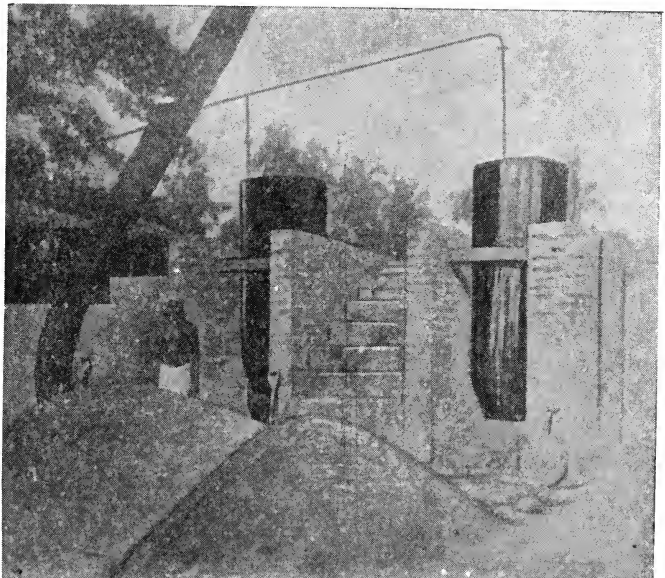
Immediately after it is taken out of the vats, the drenched paddy is put into a pair of boiling vessels, as shown in Plate XXVIII, and there boiled in steam. The vessels are torpedo-shaped and made of zinc or steel. At the top of each vessel is a round aperture to which is hinged a heavy lid. The grain is let in through this opening. At the bottom of the vessel is a

The boiling process.

square aperture with a sliding-door. This door lets out the paddy. The vessels are connected to a boiler in the engine room by means of a steam pipe, which has a wheel-cock near the vessels and another near the boiler. The size of each vessel depends on the quantity of grain required. If 150 maunds of paddy are to be boiled daily, two vessels are necessary and the capacity of each should be 24 cubic feet. To feed the vessels, a boiler distinct from the one that drives the engine is needed. This boiler should contain a large quantity of steam at a low pressure. For the vessels above described a 20 n. h. p. boiler having steam at 30 to 60 lbs. pressure would suffice. The operation of boiling is conducted in the following manner. The soaked paddy being put into the vessel through the upper aperture, the top-lid is closed. The wheel-cocks are then opened and steam let in. When the steam permeates every portion of the vessel, it commences to boil the grain. During this process, as it exhausts itself on the produce, it keeps escaping through the upper and lower apertures, the top-lid and sliding-door not being steam tight. All the water in the grain oozes out from the lower aperture. After about five or six minutes when an odour of boiled paddy emanates from the vessel, the steam is shut off by closing the wheel-cocks, and the paddy drained out by the lower aperture. It is then conveyed to the drying platform or apparatus, whichever is used. The advantages of steam-boiling over boiling on fire, as in the indigenous system, are many.

Plate XXVIII.

[*To face p. 190.*



IMPROVED RICE-MILLING.

The boiling vessels of a rice-mill in Bengal.

From a photo taken by Mr. C. O. Barker.

The operation becomes very much quicker, far less laborious, and more easy to regulate. By this process the shell of the grain is loosened and the operation of husking is rendered easy.

Sun-drying.

Paddy is dried in the sun on a large platform constructed in the open, and raised from the ground about a foot at the sides and a foot-and-a-half at the centre. Its size should be about 6000 square feet to dry 150 maunds of paddy, and proportionately for larger quantities.* The grain is spread out in a layer about an inch thick and turned over in cross lines every now and again. This frequent stirring helps to dry it rapidly. Paddy so spread would require from three to five hours to dry depending on its condition, whether unboiled or boiled. It may here be observed that unboiled paddy required for *attab* rice has also to be dried in the sun before being husked, which is done on this platform.

Machine-drying.

Although sun-drying is more suitable for *attab* rice—and probably also for *ushna* rice—than artificial drying, it becomes difficult during the monsoons to carry on the husking operation unless the latter process is resorted to, or a large quantity of sun-dried stock is held in reserve. It may, of course, be possible to keep the mill going during this period with cleaning work only. Artificial drying is adopted in tea, coffee, and

* One maund of paddy spread out in a layer one inch thick would require 1½ ft. × 1½ ft. × 18 or 40½ sq. ft. of space.

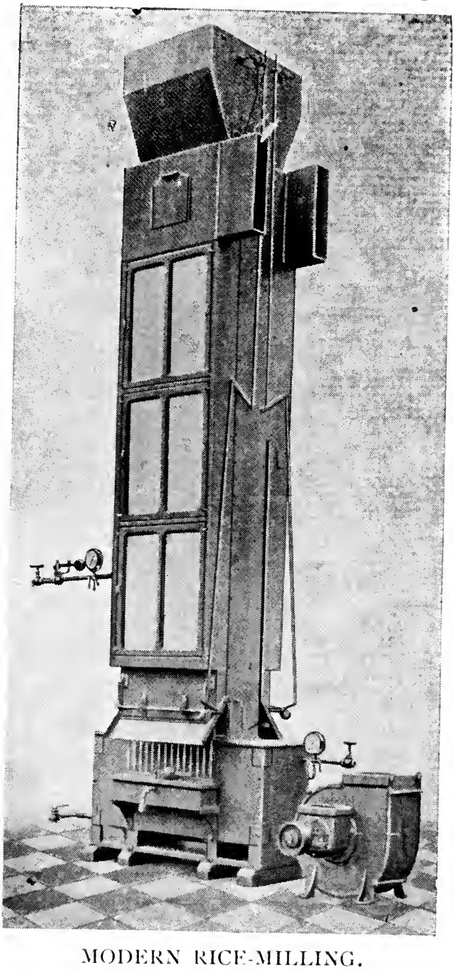
flour manufacture, and there are some well-known grain-dryers in the market. Among these may be named Gibbs' Dryer for tea, paddy, and other produce which has rendered valuable service to Rangoon millers, and the Ramos Dryer which is largely used in America for drying coffee and paddy. But a well-designed machine for this purpose appears to be the Mallinson Dryer made and sold by Messrs. Thos. Robinson & Son, of Rochdale, England.

Mallinson's Dryer.

This apparatus, an illustration of which is given in Plate XXIX, consists of two vertical steel casings. Inside the right-hand casing and running parallel to it is a row of steam pipes which are connected with and drain into a steam-trap set in a convenient place. The space between the two casings consists of a hot-air chamber, the heat in which is supplied by a steam-chest placed below the casings. In the left-hand casing is an exhaust trunk connected to the exhaust fan shown at foot of the illustration, which may be placed in any suitable position. The grain flows slowly down the casings and is checked in its fall and turned over at intervals by louvres or slats. After every few inches along the casings are inlets and outlets through which the hot-air enters and leaves the apparatus and so is exhausted through the grain. The Dryer is said to work in an easy and effective manner. The grain is fed into a hopper at the top of the right casing and falls on an adjustable feed tray which is connected to an outlet gate below by the

Plate XXIX.

[*To face p. 192.*



MODERN RICE-MILLING.

Mallinson's Dryer used in American mills.

rods seen outside the machine. If the feed coming into the hopper increases, it causes the tray to open by its additional weight, and being connected by the rods to the outlet valve, the latter opens at the same time allowing more grain to escape, thus rendering its action perfectly automatic. As the grain enters the casing, it feels the effect of the steam pipes which cause it to perspire, that is, to bring the moisture from within the grain to its surface. At the same time, the grain is subjected to currents of hot-air, passing through the inlets and outlets, which dry up this moisture. During this treatment the louvres, inlets, and outlets are continually breaking the fall of the grain and exposing every side of it. The hopper is always kept fully charged with grain which runs down the machine in a continuous stream.

After passing down the right casing, the grain is elevated to the hopper of the left casing. It then flows down this casing, again going through a similar treatment, with this important difference that there are no steam pipes in this casing, the grain being simply treated with hot-air currents until it comes to the cooling stage. As better results are obtained by gradual cooling rather than by bringing the grain from the one extreme to the other, the last half of this casing is separated from the hot-air chamber by an open space. This is to allow a current of cool air to be exhausted through the grain before it finally leaves the apparatus. The heat is under perfect control and can be instantly regulated to suit any variety or condition of grain.

The same makers also manufacture a 'whizzer,' which is a machine for drying the moisture on the surface of the grain by air. This is effected by the construction of an internal drum which is so arranged as to induce a very strong current of air to pass through the grain as it ascends the casing. This machine would be useful during the monsoons to small millers who are unable to afford an expensive apparatus and depend entirely on sun-drying.

The whizzer.

It may here be mentioned that a rice-huller maker of Salkea near Calcutta, Mr. Rakhal Das Khan, constructs a paddy-dryer which has been worked with a certain amount of success by a miller in Chetlah, south of Calcutta. The machine is small and treats only forty maunds of grain in a day of eight hours, four coolies being engaged in it at the same time. Its working is, therefore, not more economical than the sun-drying process, but it would be useful in wet weather when the latter is not possible.

Khan's Dryer.

The necessity of paddy-drying has been exaggerated in this country. Owing to both boiled and unboiled paddy being dried in the sun before being husked by the indigenous method, there is a notion that drying is essential for all variety and conditions of paddy, even if husked in the machine. But such is not

The necessity of drying.

the case in every country. In Burma, Siam, and in the United States of America, unboiled paddy is husked in the mills without any previous course of drying. Certain qualities of Bengal paddy can also be husked satisfactorily in the Engelberg and Cowie's Hullers without any such special course. It is, of course, always understood that only matured and air-dried paddy has to be put into a huller. The only question with us, therefore, is the drying of boiled paddy and this can be conducted under a tropical sun for the greater part of the year. Daily a hundred or two hundred maunds of grain can be conveniently dried in an open platform if there is sufficient ground for this purpose. But the treatment of larger quantities in this way would become rather cumbrous. Machine drying would, therefore, be necessary only in some cases in this country.

After treatment by the aforesaid processes, the paddy is brought to a condition fit to be husked. The miller now adopts the most efficient and economic method, on which depends the quality of his rice and the return for his labour. He must turn out perfectly white and entire grains, free from any admixture of unhulled rice. These results must at the same time be obtained on the most economic basis. The method of husking therefore depends upon the quality of rice required and the price that may be expected for it. There are a number of hullers that could be used for the husking of boiled paddy which is a comparatively easy opera-

Efficient husking.

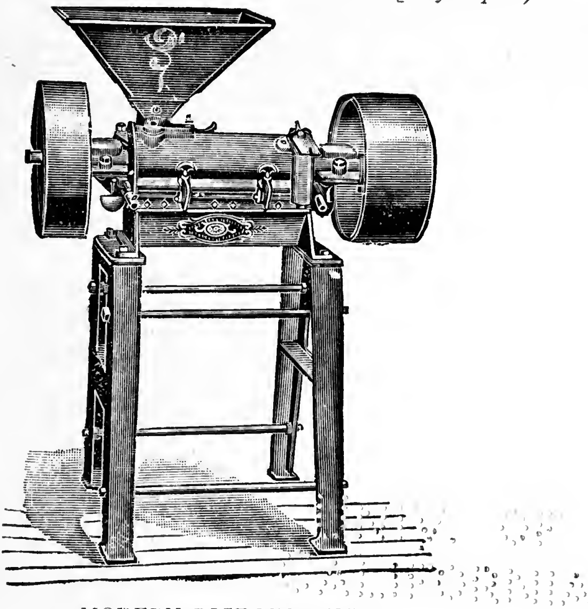
tion. Among country-made machines may be named those constructed by the aforesaid Mr. Rakhal Das Khan and by Mr. Suroputty Ghatak of Chetlah. Of shellers and hullers made in foreign countries, may be mentioned those manufactured by Messrs. Hind and Lund, and by Messrs. William R. Dell and Son, both of London, as well as those made by Herr F. H. Schulze of Hamburg. In the husking of unboiled paddy which is a difficult operation, the most effective hullers must, however, be used. As may be expected, these machines come from the United States of America and Burma, two renowned rice-milling countries. The hullers made by the Engelberg Huller Company of Syracuse N. Y. are the most efficient machines for small millers, as those constructed by Messrs. Chas. R. Cowie & Co., and by Messrs. Bulloch Bros. & Co., of Rangoon, are the most suitable for large mills.

The Engelberg Huller.

The machine best adapted for husking among those constructed by the Engelberg Company is its Huller No. 2 an illustration of which is given in Plate XXX. The paddy is fed into this machine through the hopper at the top and thence it passes over a chilled-iron cylinder where it is husked. It is treated between the longitudinal grooves on the surface of the cylinder and a steel blade running parallel to it. This cylinder also breaks up the husk. The hulled grain and powdered husk then pass into a screen where they separate. The grain emerges from a spout in front of the

Plate **XXX**.

[*To face p. 196.*



MODERN RICE-MILLING.

Rice-Huller No. 2 made by the Engelberg Huller Company.

huller and the husk falls below the machine whence it is carried away by a shoot. The huller works at a very high speed, the revolutions of the driving pulley which turns the cylinder being about 450 per minute. About sixty maunds of medium quality Bengal paddy is husked in this machine in a day of eight working hours.

An illustration showing the husking-section of a rice mill in Chetlah is given in Plate XXXI. In this mill a Cowie's Huller is used. This machine consists of two cast-iron discs with serrated faces on which is applied a composition of emery and cement. When thus prepared, they are referred to as stones in a rice-mill. Only one stone revolves, being fixed to a spindle which is connected to a driving pulley, while the other remains stationary. The two are mounted on a wooden platform and covered over with a sheet-iron casing. Above the machine is a hopper which receives the paddy. The huller being situated in the top-floor of the building, the paddy is conveyed to its hopper from a silo in the ground-floor by means of an elevator. The paddy is then directed between the two stones where it is husked. The grain and husk emerge from a spout beside the lower stone. This combined product is then run by means of a shoot into a 'double-fan,' where the husk is separated from the grain. From the fan the grain goes into a 'direct-acting sift,' as it is called in the Rangoon Mills, which is precisely the same as the 'shaking-screen' already described. This

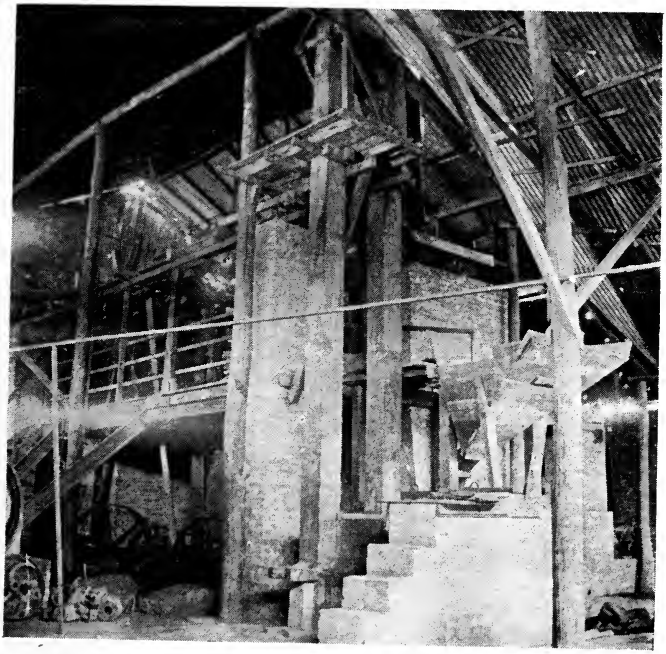
Cowie's Huller.

sift separates the husked from the unhusked grain. Here it may be observed that, after one treatment in the huller every grain does not get husked ; the paddy therefore reverts to the silo to be sent again to the huller and the brown rice goes to be cleaned. In certain mills, after the first treatment in a huller, the husked and unhusked grain are not separated but sent on together to another huller for a second treatment. This practice, besides increasing the husking operation unnecessarily, subjects the husked grain to undue pressure and thereby induces breakage. In the husking process, the rice and husk obtained from the huller are in the average proportion of two-thirds to one-third. For coarse qualities of paddy the rice increases, and for fine qualities it diminishes ; thus, in the former the average proportion would be 27 seers to 13 seers, and in the latter $25\frac{1}{2}$ seers to $14\frac{1}{2}$ seers in the maund of paddy. Breakage in rice depends not only on the quality and condition of the grain, but also on the system employed in husking. A medium quality of Bengal paddy under normal conditions should not render more than 3 to 4 per cent in broken tips in a Rangoon huller. The out-turn of this huller, which is made in different sizes, ranges from 100 to 200 maunds of brown rice daily.

When paddy is husked, a brown coating appears which has to be removed. This is done in the cleaning operation in which by the action of the cleaning machine and its consequent friction on the grains, the inner cuticle is

Plate XXXI.

[To face p. 198.



MODERN RICE-MILLING.

The husking section of a rice-mill in Bengal.

From a photo taken by the author.]

worn out. Cleaning is done by small millers in the Engelberg Huller No. 1 an illustration of which is given in Plate XXXII. The brown rice is fed into a hopper at the top of the machine whence it goes into the groove of the huller cylinder. Here, being treated by the action of a blade which causes friction on the grains, the rice is cleaned. The white rice and the meal thus obtained pass into a screen, called the huller-screen, where they separate. The rice is then received by the polisher cylinder which is covered over with sheep-skin. Here it gets thoroughly cleaned and somewhat polished. The rice and meal now obtained pass through another screen, called the polisher-screen, where also they separate. The cleaned rice is finally delivered by a spout and the meal falls under the machine.

The process of cleaning.

If a large quantity of brown rice has to be cleaned, the most economic and effective machine is the White Rice Cone made by Messrs. Chas. R. Cowie & Co. This machine consists of a cast-iron conical stone pierced by a vertical spindle to which it is fixed. The sides of the stone are covered with a composition of emery and cement. Half-way down the spindle is fitted a pulley by which the machine is driven. The stone is placed inside a casing consisting of a top-cover made of two semi-circular plates and a wire net all round its sides. Over the net are rivetted four curved pieces of grating. Below the stone is a grain recep-

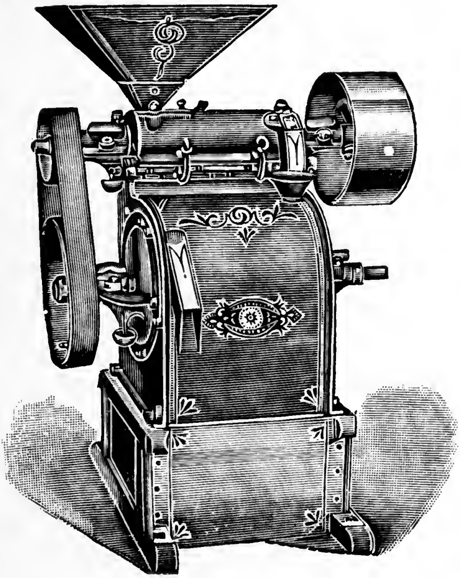
The White Rice Cone.

tacle and two outlet spouts. The brown rice is fed into a hopper above the machine and goes between the stone and its casing where it is scoured against the net by the revolution of the stone, and thereby cleaned. The meal going through the meshes of the wire falls all round the stone. The cleaned rice goes into the receptacle and emerges from the two outlet spouts. The machine is located on a wooden floor and is left open all round, so that its net may be brushed every now and again to prevent the meshes from being clogged. The room in which this machine is situated is usually so full of meal and dust that a 'cyclone-collector,' such as is used in flour-mills, may with advantage be utilised here. The collector consists of a conical sheet-iron chamber into which the meal-laden air is driven by a fan. A whirling motion is set up within the machine, where owing to centrifugal force, the laden air entering the chamber tangentially strikes its casing at a high velocity, thereby causing a separation of the meal from the air. The meal runs down the apex of the cone and the air rises through the tube at the top. In the cleaning process, nearly 2 seers of rice are lost in every maund, that is, 40 seers of brown rice would yield a little over 38 seers of cleaned rice and nearly 2 seers of meal.

After the cleaning operation, the ordinary qualities of rice are ready for the market, but the finer qualities are polished. This is done by small millers in the Engelberg Huller No. 1 by putting the rice through the machine a

Plate **XXXII**.

[*To face p.* 200.



MODERN RICE-MILLING.

Rice-Huller No. 1 made by the Engelberg Huller Company.

second time, but the proper machine for this purpose is the 'Engelberg Rice Polisher.' In the centre of this machine is a cylinder covered with sheep-skin. All round the cylinder so dressed is a wire-cloth. The rice is fed into a hopper above the machine and runs in between the revolving cylinder and the cloth where it is polished. It is delivered by an outlet at the foot of the machine. The driving pulley is fixed to the lower end of the cylinder. The sheep-skin has to be replaced whenever it wears out.

The polishing process.

The installation of a rice-mill, as in a flour-mill, is continuous as much as possible, so as to save the labour of conveyance which in the case of a heavy product is considerable. The machines are consequently connected to each other by elevators and shoots which convey the product from the first to the last machine. In large mills, in addition to these conveyors, worms or screws are also used, thus rendering the mill completely automatic.

The varieties of Indian rice like paddy are numerous. The chief ones obtainable in Bengal are those produced from and named after the principal varieties of paddy already mentioned. Among them, *kamini*, *bansmoti* and *benaphuli* are three well-known qualities of naturally flavoured rice. There are, besides, certain blends prepared for the market by mixing together different varieties, a process known in Bengal as 'piling.' The principal blends thus formed are called *rari* and *kazla*,

Varieties of rice.

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each of which is divided into three qualities and is numbered accordingly. *Rari* rice is prepared from medium qualities of paddy, such as *sitashal* and *ramshal*, *panathi*, *khulna* and *balasore*. *Kazla* rice is obtained by blending coarse qualities of paddy, such as *mushakani*, *ghoonshi*, *gaytee*, *orashal* and *chandbally*. There is a very extensive consumption of par-boiled rice in India, unboiled rice being generally used by the poorest people who find it more sustaining. In Burma both these qualities are prepared, perhaps more of the latter as her exports are of this rice. In the United States of America, however, unboiled rice is generally produced. This variation in quality is principally due to the various purposes for which the products of these countries are required. Indian rice is used exclusively for food, Burma rice for food, distillation and starch, and American rice for food and confectionery.

During the latter half of the last century, the modern system of rice-milling has been adopted by a few small mills set up for this purpose in North-Western India, in the Madras Presidency, and in Bengal. These mills are so few in number and their methods of work so undeveloped, that rice-milling in India may yet be regarded in a state of infancy.

The modern industry in India.

The seat of this industry is to be found in the suburbs of Calcutta, known as Ramkristopur and Chetlah, where nearly a score of mills are located. In these mills, however, the cleaning and polishing processes only are carried on. Rice meant to be exported is thus treated before shipment. A few of these mills occasionally husk paddy, but this section of the industry is not regularly conducted by them. As these mills are unable to meet the demand of foreign countries, dhaki rice is also exported. This rough rice is brushed by shippers in a hand-brushing apparatus, some of its qualities blended, and the product then shipped.

Export trade in rice.

Unlike the heavy export of rice from Burma, a very small percentage of the rice-crop of India goes out of the country. The undernoted figures show the export of rice from Burma and India to foreign countries during the last five years.*

Year.		Tons.			Value.
1904-05	...	2,474,000	...	Rs.	19,61,90,000
1905-06	...	2,152,000	...	,,	18,63,69,000
1906-07	...	1,935,000	...	,,	18,52,51,000
1907-08	...	1,913,000	...	,,	20,33,63,000
1908-09	...	1,512,000	...	,,	15,88,75,000

Of the above quantities, the share of Burma was as follows† :—

Year.			Percentage.
1904-05 ...	...	...	76·2
1905-06 ...	...	...	73·3
1906-07 ...	...	...	73·4
1907-08 ...	...	...	76·4
1908-09 ...	...	...	72·4

* *Vide* "Review of the Trade of India in 1908-09," by F. Noel-Paton, p. 4.
† *Vide* Idem. p. 47.

From these figures, it will appear that the quantity of rice shipped from India as compared to her average annual production of 29 million tons is almost negligable. There is a noticeable export trade to internal ports, the largest portion of which is represented by the shipments of Bengal rice to Southern India; but on the other hand, Burma rice has in recent years been imported into Calcutta. The principal foreign countries that bought rice from Burma and India, chiefly from the former, together with the amount and value of their purchases during 1908-09, are given below,* (Statistics for India are not separately obtainable.)

Ceylon ...	255,181	tons	valued at	Rs.	3·21	crores.
Germany ...	187,486	,,	,,	,, ,,	188·93	lakhs.
The United Kingdom	127,715	,,	,,	,, ,,	119·66	,,
Austria-Hungary ...	103,568	,,	,,	,, ,,	93·49	,,

Japan, China, the Arabian and South African ports took very small quantities during this period. The greater portion of the rice shipped to Egypt ultimately found its way into European ports, and is included in the above figures. The direct export of rice from Burma and Bengal to the West Indian ports is small, but there is a re-shipment thereto from the United Kingdom and Germany.

The average cost of preparing rice by the indigenous method may be calculated at 6½ as. per maund, considering the low value of agricultural labour in the country. This cost increases to about 7 as. for par-boiled (*ushna*)

* "Review of the Trade of India in 1908-09" by F, Noel-Paton, p. 48.

rice and decreases to about 6 as. for unboiled (*attab*) rice. The time that would be required by a single worker to prepare a maund of boiled rice by this method may be calculated at 21 hours. This would be made up as follows :—1½ hours for cleaning and soaking paddy in water, the course of soaking which occupies about 24 hours requiring no attention; 2 hours for boiling; and 1½ hours for drying, the paddy being in the sun altogether for about 5 hours. This would make up a total of 5 hours for the conditioning processes, a single person working all the time. The husking of paddy and cleaning of brown rice in the *dhaki* are always done by two persons who take about 8 hours, working together at these operations. For the purpose of calculation, this would be equivalent to 16 hours for one person, making up a total of 21 working hours for the entire preparation. Similarly, a maund of unboiled rice would take a person about 1 hour for cleaning, 1 hour for drying, and 16 hours for husking and cleaning, making up a total of 18 working hours. Calculating the value of this labour at 3 as. per day of 9 working hours, the cost of 21 hours' labour would be 7 as. and of 18 hours' 6 as., being respectively the cost of preparing boiled and unboiled rice. This average cost of 6½ as. coincides with the rate paid to hired workers for rice preparation in certain parts of Bengal which is generally 6 as. per maund of rice, the worker retaining the half-maund of husk which may be

Cost in the indigenous and in the modern system.

valued at half-an-anna. By the modern system, the cost of rice manufacture per maund would be approximately 2 as. 6 p. for unboiled and 3 as. for boiled, unpolished rice, such as would be needed for home consumption. Rangoon millers reckon an average of 3 as. as the cost of preparing polished rice. If a system of artificial drying were introduced, the cost of boiled rice would probably be reduced by half-an-anna, that is, to 2 as. 6 p. By the introduction of the improved system, there is consequently a prospect of reducing the price of the greatest staple food of the country.

METHODS OF INDUSTRIAL REFORM.

The characteristic of economic history in India.—Desertion of crafts in the competitive age.—A grave economic danger.—The importance of manufacture.—Some industrial conditions at the present day.—'Domestic industry.'—'Institution of guilds.'—'Workshop organisation.'—'Factory system.'—Indian economic institutions not organised as in Europe.—The main roads to industrial progress.—Scientific development.—Economic organisation.—Social reconstruction.

The characteristic of economic history in India.

THE distinctive feature of economic history in India, as we have already seen, has been an early diversion from the growth of useful industries to the culture of industrial arts, a change which best accorded with the spiritual and æsthetic moods of the people. The bountiful gift of nature, as displayed by the ample yield of the soil, rendered the perfection of agriculture or manufacture an unessential toil. But this deviation gradually and imperceptibly brought about a great evil. In the long pursuit of artistic occupations which fostered the meditative and even the literary faculties of the workers, material skill and mechanical ingenuity that so early characterised the life of the people passed through disuse into dissolution. Thus in the subsequent history of the country, if an awakening to material life were ever feasible, either by a period of tranquillity or by the advent of luxury—as seemed imminent after the Mogul succession—the genius of industrialism having become extinct, an industrial revival could not occur. The Emperor Akbar, apparently perceiving the possibility of a restoration of industries, sought to stimulate the decadent faculties of the people. But his efforts were in vain. The materialistic spirit instilled into their minds by the stress of circumstances in primeval days had entirely passed away, and the motive forces of industrialism could not be infused by a perfection of the industrial arts which the emperor encouraged.) It is therefore evident that the economic development of India has always been retarded by the pursuit of paths which ran counter to the road of material progress.

Desertion of crafts in the competitive age.

But apart from the causes which have apparently prevented the growth of manufacture in the past ages, it seems evident that yet another influence deterrent to their development has operated in modern times. The fact that the people could fall back on agriculture if their crafts failed to afford them a livelihood has always been present, possibly with a restraining effect on the growth of these crafts, but it has in the end positively borne bitter fruit. As each indigenous industry began to languish in the competitive age, the workers commenced to desert them and sought in their millions a refuge in the soil, a departure which was soon to receive a dreadful corrective in the starvation which it involved.) The census returns of 1901 show that there were no less than 30 millions of agricultural labourers in the country and that their number had doubled since the census of 1891.*

* *Vide* "Imperial Gazetteer of India" (New Edition, 1907), Vol. III. pp. 1 and 2.

These landless millions have been very largely recruited from the artisan and craftsman class and have come into existence within the last century, but the soil affords them no relief. In periods of famine, it has been observed that these are the greatest sufferers.

A grave economic danger.

While it may be urged with no little cogency that agriculture ordinarily is as great a source of wealth-production as manufacture, it is equally logical that in a country where the land is well nigh exhausted by centuries of cultivation and the yield of crops is exceptionally low—returning an annual income of less than £2 per head—a further pressure on the soil is irrational. It thus happens that whenever the strain becomes too great, nature removes her unbearable burden by famine and disease. Yet it must not be supposed that an extension or development of agriculture is not possible in India. But the difficulties relating thereto are perhaps even greater than those connected with the development of manufacture. Besides some measure of reform in the system of land-tenure and the introduction of scientific methods of cultivation among a people of the lowest stratum of intelligence in the country, an enormous application of capital seems to be needed. Under these circumstances, a continued influx of hordes to the soil would constitute a grave economic danger. It is further obvious from another standpoint that almost every individual in a state cannot be best fitted for cultivation.

By the advancement of manufacturing industries a great source may, however, be created for the increased production of wealth; and, considering the broader economy of national life, an organism of manufacture has become essential and imperative in India. While the work in this connection is beset with difficulty from various points of view, there are certain natural facilities for the attainment of the end which are clearly visible.

The importance of manufacture.

The circumstances encompassing Indian industries may here be briefly reviewed. From the last census it would appear that about 40 millions of people, who principally live in villages are engaged in the pursuit of arts and crafts.* Each village supplies nearly all the wants of its inhabitants and may be regarded as self-contained. This condition has come about owing to the defective means of transport and communication in the past. Owing also to their ignorance and isolated lives, these workers are insular in mind and conservative in method as such people must necessarily be.

Some industrial conditions at the present day.

As a result of this environment, certain types of economic institution peculiar to primitive and mediæval societies are easily discernable. Of these the two most generally met with are the 'domestic industry' and the 'institution of guilds' which

'Domestic industry.'

* *Vide* "Imperial Gazetteer of India" (New Edition, 1907), Vol. I, p. 486.

it may be safely assumed, originated in the country during the early ages. In the former the workers are confined to small groups. Each group produces and consumes for itself. There is consequently no exchange of commodity and no proper market. Moreover there is little division of labour in this system, but the craftsmen and their dependents working for themselves cause a fusion of labour and capital which may be regarded as the truest form of co-operative production—not the self-seeking form that such production has assumed in modern communities.

'Institution of guilds.'

In the latter system, all the workers of an art or craft are associated by a guild in which they are pledged to support and protect each other. Here they turn out goods as required by themselves and their neighbours or what they can readily sell in the local market. As in the trade-union among Western people, these guilds regulate the hours of labour and the work performed by the members; but unlike the former which utilises its funds mainly for the purpose of supporting its members when out of employment, the funds of these guilds, obtained from fines levied for infringement of their rules, are employed generally for charitable purposes. This dissimilarity arises out of the difference between industrial conditions in Europe and in India, in which also the distinctive moral conception of either race is perceptible. In the Indian institution, owing to the nature of its organism, the workers cannot be thrown out of employment, but in periods of difficulty they are helped by the members who are all within the caste.

While these two are the principal types of economic institution in India, they are not the only ones now existing in the country. In small towns and cities may occasionally be found the 'workshop organisation.' Here the head of a guild or a mahajan has assumed the role of an industrial organiser. He has collected together craftsmen from their scattered homes and located them in a workshop, where he furnishes them with raw materials and very often with working implements. A division of labour has thus been attained, time and trouble saved, and the cost of production thereby reduced. The division of labour consists in the artisans specialising in particular kinds of work. These workmen have been converted into mere wage-earners, the organiser who furnishes the capital and raw material having become their employer. It is possible that this institution, which is found principally among the industrial art workers of Agra, Delhi, and Lucknow, was first organised during the Mogul dynasty when it is known that such workmen were employed by Akbar in the Imperial Court itself.

'Workshop organisation.'

Yet another type of industry, though to a limited extent, has been established in the country. At the beginning of the 17th century, the 'factory system' was introduced by Europeans who were either the factors or the proteges of the East India

'Factory system.'

Company, but owing to economic difficulties and the unsettled nature of the country, it did not become an established institution until the middle of the last century, when several cotton mills appeared in Bombay. (This system is found only in centres of labour and has developed with the opening up of a national market by the introduction of means for transport and communication. Division of labour has been extended in this system to its utmost limit. Power-driven machines are used for the various processes of manufacture, workmen direct these machines, a manager administrates the factory, the employer provides the capital as also the raw material, and the merchant attends to the details of distribution. Productive power has been increased herein to an extraordinary degree.

Hence it is obvious that among indigenous workers, industry is not so disorganised as would appear on the surface. To the superficial observer whose vision is blurred by the stupendous and quasi-military organisation of labour and capital in Europe, these isolated groups of indigenous workers would seem a disorganised mass, though they are in reality pursuing their crafts under established economic institutions for centuries. But their isolation consists rather in the difference of locality than in a difference of method or system, and these workers are more united by the bonds of caste and co-operation than the operatives of an industrial centre

Indian economic institutions not organised as in Europe.

in Europe. If an organisation connotes an organism of concordant units capable of self-direction, these institutions are organised; but if it denotes a human machine able to produce wealth in the most economic and efficient manner, then they are disorganised. Now, if there be an organisation in indigenous industries as above stated, it would naturally be asked—wherein lie their defects and shortcomings which prevent them from competing against modern industrial conditions? To this it may be said that they lie principally in their workers continuing crude methods of manufacture, owing to ignorance of mechanical improvements made in the outside world and to the want of means to afford experiments should they ever happen to be acquainted with any development. In some instances the adoption of an improvement may be prevented by want of technical knowledge or by insularity and conservatism, but it is not often that human intelligence is so dense as to allow a source of livelihood to become extinct through any of these causes.

Industrial conditions being so manifold, human nature so complex, the temperament of the Indian so rigid in some cases by long adaptation to environment, and so varying in others by contact with western influences, if the lines upon which industrial reform should proceed were searched, what roads would be revealed? The progress of science has changed the feature of manufacturing methods in countries that India has now to

The main roads to industrial progress.

reckon with, the competition which has ensued has rendered it imperative on all advancing nations to adopt economic systems of work, by reason of which their social institutions even have undergone considerable modification. Such being the circumstances of industrial life at the present day, it is obvious that industrial regeneration in India can only be attained by following the three main paths of scientific development, economic organisation, and social reconstruction.

Scientific development.

By scientific development is implied the application of mechanical and chemical improvements to Indian processes of manufacture, so that they may be rendered as efficient and labour-saving as possible. The most effective way of acquainting indigenous workers with these improvements is by the establishment of experimental factories in their midst, where they could be invited to see and learn the improved processes. But a wider introduction of scientific methods to manufactures in this country can only be attained by the spread of technical education and the training of labour. It is believed that the technical skill of workmen in England, Germany, and the United States of America play no inconsiderable part in maintaining the industrial efficiency of these countries. In India such education and training must keep pace with the growth of manufacture.

While it is evident that indigenous industries are pursued under established economic institutions peculiar to primitive and mediæval societies, it is equally obvious that they have generally failed to comply with the needs of the day. Yet, it would argue a disregard of social phenomena if anybody were to suggest that these organisms should be reconstructed. Such work would be almost beyond the possibility of human endeavour and is best left to the designing hand of time. With the growth of the factory system and the workshop organisation, with the increase of means for transport, and by the spread of education, it is possible that the old structures will crumble away almost entirely and new institutions take their place, thus effecting an economic reconstruction. Only those portions of the old organisms that have virtue and vigour may survive. (But what has now become an imperative necessity in India is the organisation of capital, a work which has been initiated by the formation of joint-stock companies and co-operative credit societies. This should develop the factory and the workshop systems and reinvigorate the indigenous industries that are still possessed of vitality. With the growth of the factory and workshop systems may also be expected a proper division of labour, provided the organisers are conscious of their interests and have a limited division in certain industries and an extended one in others. In industries which produce goods having a limited demand, such as carpet-weaving and sericulture, a limited division is proper and indeed economic; but in those producing commodities having an extensive demand, such as the rice industry and the

Economic organisation.

cotton manufacture, the most extended division is the most economic.

Since the course of industrial reform will be determined to no small extent by the nature and temperament of society, it would not be out of place here to indicate the principal social causes that have prevented economic progress in India. There can be no doubt that a spiritual ideal being directly opposed to a materialistic one, if the extravagant spiritual fervour which produces an apathy towards worldly welfare has not become quiescent in the Indian people, economic development will proceed most sluggishly. In the social institution itself, the system of joint-family is detrimental to self-help and individuality. The principle of co-operation economically is a great force, but socially it destroys the main-springs of personal effort. A social reconstruction must therefore be awaited to complete our industrial progress. No measure of human reform can bring about by a direct scheme a change in the social life of the people, for society will continue to adapt itself to environment which alone can mould its shape and form its temper.

Social reconstruction.

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