

# Nepal\*

## Notes on a Visit to a Country Inaccessible to Europeans

By Henry John Elwes, F.R.S.

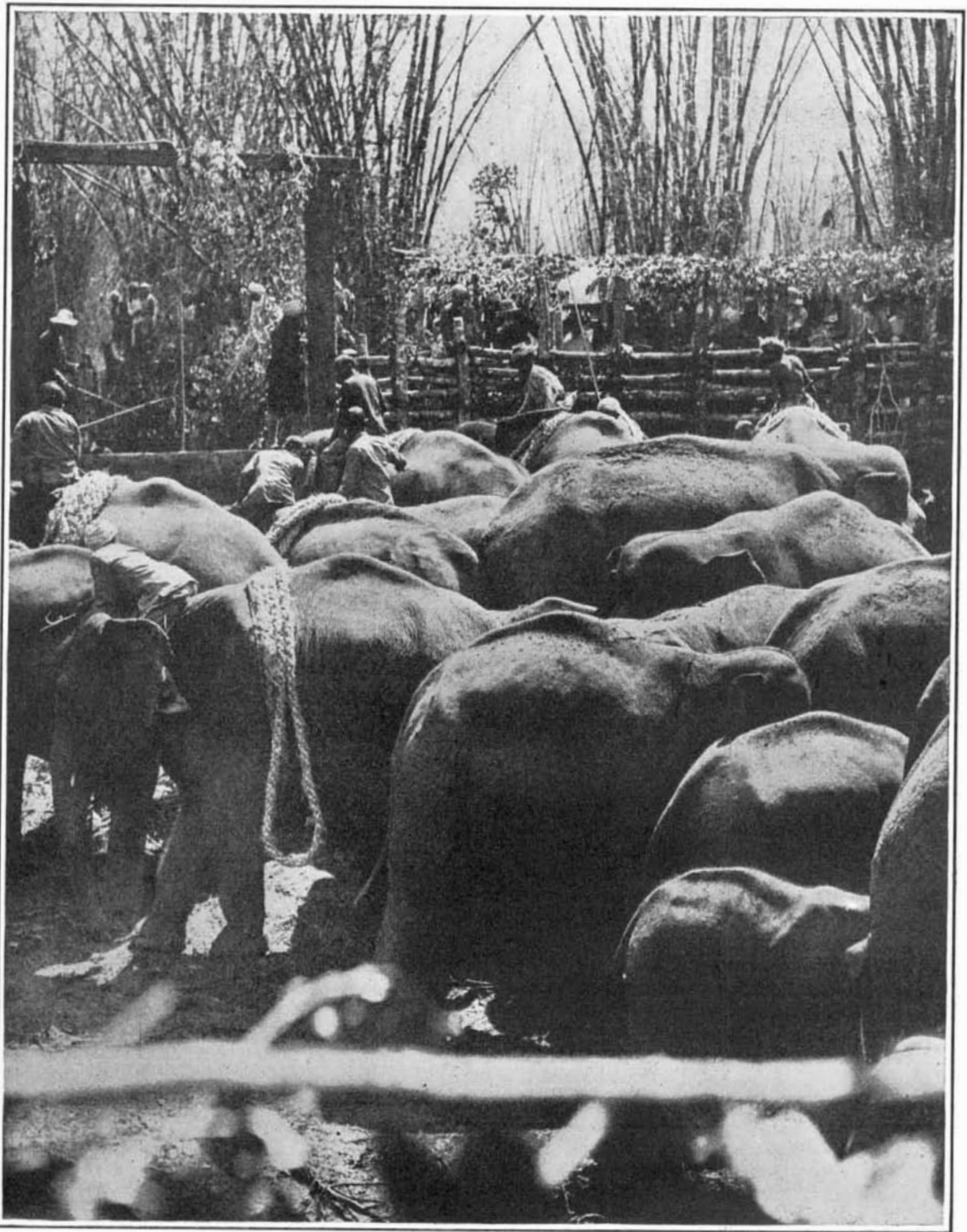
NEPAL is unique in this respect, that it remains a solitary instance in the world, of a friendly country which, from political reasons alone, is inaccessible to Europeans. For, though during nearly a century our relations with its rulers have been perfectly peaceful, and latterly even cordial, and though the present ruler of Nepal is a man of European culture, speaking perfect English, and understanding English customs, politics and civilization in a way that few Oriental rulers do, he has rigidly adhered to the policy instituted sixty years ago by the all-powerful minister, Jung Bahadur, and has maintained a system of government which may be best described as a paternal despotism founded on the religion and customs of his people. It is, therefore, impossible for Europeans even to enter Nepal unless specially invited, as we were, by the British Resident at Katmandu, Colonel Manners-Smith, V.C., or by the Maharaja Sir Chandra Shamsher Jung, G.C.B., G.C.S.I., G.C.V.O., to both of whom our most cordial thanks are due for their hospitality and kindness during our too short stay there.

Though our relations with the Nepalese government were not at first so uniformly friendly as they have been ever since the Indian mutiny, when Jung Bahadur came to our assistance with his army, yet we have learned that it is possible to do what has never been done by any other European government—to live as neighbors on a frontier of over five hundred miles without any friction with an Oriental nation distinguished for the bravery and patriotism of its people. And after comparing the conditions which exist in the kingdom of to-day with the state of some parts of Bengal in recent times, I think that we can learn much from the Nepalese in the art of governing primitive mountain races. I will refer to those who wish to know more of the country to Sir W. W. Hunter's "Life of Brian Hodgson" (1896), who resided in Nepal as British Resident for many years, and who was the first to make known to science a great number of its animals and birds; or to the "Imperial Gazetteer of India," Vol. XIX. (1908), where an excellent account of the country will be found.

We arrived at Gorakhpur, in the United Provinces, on February 6th, and met Colonel Manners-Smith, who had kindly invited us to join him in camp at Bikna Thori, on the Nepal frontier, to see a kheddah which had been arranged to take place near the locality where King George had such grand tiger shooting when he was in India for his coronation. We arrived at the frontier by rail, and rode up to a camp in the low outer range of hills which inclose a flat, and in some places marshy valley, a little higher than the Terai. The usual system of catching elephants in Nepal differs from that adopted in other parts of India which I am about to describe, and is much more dangerous both to the pursuers and the pursued. It consists of driving the wild elephants into a valley where they can be surrounded, and then, after separating those which it is intended to catch from the herd, overpowering them by special fighting elephants and tying them up separately. In these fights many of the elephants are injured, and fatal accidents to the men employed are not uncommon. But on this occasion the Nepalese government had determined to try the system of kheddahs usually adopted in Assam and Southern India by the Indian government, and had obtained the services of Mr. Armstrong of the Bengal police, and of some of the skilled elephant catchers formerly employed by the government kheddah department at Dacca, which has now been disbanded. This valley and the hills surrounding it are of much the same character as the Dehra Dun, and are covered on the dryer land with forest, mainly composed of sal and other trees often of much larger dimensions than those in the Dehra Dun or in the Sikkim Terai, and in the open and more marshy parts by a heavy grass jungle, which forms a sanctuary for wild elephants, tigers, rhinoceroses, and other game which are preserved for use and sport. At this season the country is dry, cool and healthy, but in the rainy season very hot and malarious. The next day we rode on to the large camp which had been formed for the men employed in the elephant-catching operations on the banks of a river, and found that a considerable number of wild elephants had already been surrounded in a piece of forest about four miles in circumference, bounded on the south by the outer range of hills, on the west by a river whose bed was now partly dry and open, and partly covered by grass

and reeds high enough to conceal elephants. The force employed to effect this surrounding consisted of two regiments of Nepalese soldiers directed by the general-in-chief of the Nepalese army. After the wild elephants, about thirty in number, had been surrounded, a line of guards was immediately stationed at posts fifteen to twenty yards apart all round the forest. At each of these posts three soldiers were on guard, who built themselves grass huts, and kept fires burning all night

falling gate on one side, suspended by ropes which were cut to let it drop. From the entrance a narrow lane of strong posts extended for two hundred yards, gradually widening into two wings, which opened out like a funnel, and were extended by a line of cloths hung on poles, to form a lead into the mouth of the alley. The walls of the stockade and the lane leading to it were covered by grass and branches so that the elephants might not suspect danger too soon. During



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A herd of wild elephants penned in a stockade.

to keep the wild elephants from breaking out. Our camp was on the low banks of a river overlooking the scene of operations and close behind the guardline. The first thing to do was to select a position for and build a stockade into which the elephants could be driven, and in this matter the old Jemadar from Dacca, a veteran of seventy years who had spent his life in this work, was the best adviser. He insisted in going alone on foot into the ring where tigers and rhinoceroses were known to be at large with the wild herd, in order to choose the most suitable place. For long experience has shown that wild elephants cannot be driven like cattle, and it became evident, from the frequent attempts which they made at night to break out in a particular direction, where was the best place to build the stockade. This took three days of hard work, as a large number of strong posts fifteen feet long by eight to ten inches in diameter had to be fixed in the ground and supported by struts and cross-bars strong enough to resist the pressure of the herd when driven in. The stockade was a circular space fifty feet across, with a

the four nights that we were in camp waiting for the stockade to be built, there were constant alarms at various points on the line, as the wild herd, after drinking in the river—where we could often see their backs and hear their trumpeting and screams from our tents—made efforts to find a weak spot in the guard line. On the second night a wild tusker, supposed to be a rogue, broke into the surrounded area from the outside, and made the inclosed herd very uneasy. This tusker was very bold, and one night, just after dinner, he came down and stood within twenty yards of the fires where a crowd of excited men were yelling and firing blank charges in his face, and we quite expected that he would attack and break out. But though we saw him quite close in the moonlight, he eventually retired and the camp became quiet again. On February 12th, after several alarms in the course of the night, which must have been a trying and anxious one for the guards, who had now been for four consecutive days on duty, Mr. Armstrong announced that all was ready, and that about eleven o'clock, when the elephants

\* *Journal of the Royal Society of Arts.*

were generally quietest, the drive would take place. Two platforms had been erected above the stockade into which we climbed, and the driving-party, under the command of Armstrong and the old Jemadar, were mustered. The Nepalese were selected from the most experienced jungle men, and between every two of them one of the Dacca men accustomed to this work was placed. Absolute silence was ordered at the stockade when the party marched off in two lines, which spread out from the stockade and swept the whole of the forest within the guard-line, and when the leaders met on the far side, perhaps a mile away from the stockade, gradually closed in toward it. After waiting an hour or so we heard a great noise accompanied by many shots from the guard-line, which told us that the elephants were on the move, and the noise came nearer and nearer till we thought that the herd must be within the wings of the stockade; but after a time the noise died down, and for an hour nothing more was heard. The same thing happened again, and at last Armstrong came back to the stockade, very hot from his exertions, and told us that the Nepalese drivers were so excited and keen that he could not keep them in order, and that on the first occasion the elephants were on the point of entering the wings but were so frightened by the noise that they broke back. After a consultation it was decided, on the advice of the Jemadar, to remove the cloth screens to another position where the grass was thicker and wait a bit before trying another drive. This was done, and about 5 P. M. a final and successful effort was made. The elephants came on within the screens, and then Armstrong and his men lit grass fires behind them, and by dint of firing and yelling got them on the move toward the alley, into which an old cow first came rushing down. The others followed her, and as soon as they were all within the wider part of the alley the crowd of men yelling and firing rushed them forward in a long line. We could only see their backs as they came down the alley one after another and entered the stockade with a rush. The rope which held up the gate was cut a little too soon, shutting out one or two of the hindmost elephants, but these were determined to follow their companions and forced their way through the gate, which was so hung as to push inward. The whole herd was then inside, and until it was dark they continued to go around and round in a dense crowd, while the men who surrounded the stockade prodded their trunks with spears or fired blank cartridges in their faces when any of the larger ones tried to force their way through. It was very curious to see the way in which the youngest elephants, of which there were three only a few months old, managed to save themselves from being trodden down, by keeping between their mothers' forelegs, and the care which their dams took to protect them. As it was then too late to begin to tie up the animals, we left the stockade at dark to the care of the guards who had now left their posts and come to the stockade. Next morning we returned to see the process of roping and leading out the elephants; but though several of the finest and strongest tuskers were brought into the inclosure the mahouts seemed unused to the work they now had to do in such a dense crowd of elephants. There was not room enough for the noosers to go in on foot, and the constant movement of the crowd surging round and round made it very difficult to get nooses on their feet from the outside. This work requires experience which the Nepalese had not previously had, and from the pictures, which were taken at a kheddah in Southern India where they have more experience in noosing in a stockade, it seems that they are there more adept in what seems a most dangerous work. But though the mahouts had spears with which they prick the trunks of any wild ones which might attempt to touch them, I never saw one offer to do so. Many of the captured elephants now seemed to act very tired and thirsty—as well they might be after such days and nights as they had endured—and we never thought the young ones would have survived; but though it took three days before the whole thirty-three elephants were finally tied up and pulled out of the inclosure, not one was seriously hurt, though several of the oldest were released as not being worth the trouble of training. I will not occupy your time any longer with an account of this process, which has been well described by Sanderson and others. But though native mahouts, who have spent their lives among elephants and have inherited from their fathers a knowledge of their management in health and in sickness which few, if any, Europeans have ever acquired, I believe that a lover of animals who would pay the same attention to elephants that many Englishmen do to horses would learn a great deal which would be valuable in managing the elephants which are still indispensable in the forests of India, and might be even more useful in some parts of Africa.

Ten days later we arrived at Raxaul, a frontier station a little to the east of Bikna Thori, where the Resident has a bungalow, and where he had made arrange-

ments for our journey to Katmandu. The first stage of thirty miles through the level plain of the Terai we made in doolies carried by bearers, and at daylight we found ourselves in the Sal forest near Churia, where the outer range of hills begins. Here we breakfasted and went on horseback over a low rocky sandstone range in which *Pinus longifolia* is a noticeable but not important tree; and passing through a narrow gorge, where in many places the dry river-bed is the only road, sometimes impassable in the rainy season, we crossed an open valley where the cotton trees, *Bombax malabaricum*, were of great size. One of which was 120 feet high by 30 feet in girth at 5 feet from the ground, and about 60 feet round the buttresses at ground level.

We then followed the banks of a river along a road practicable for bullock carts and wooded with tropical trees, but not nearly so luxuriant or so varied in its vegetation as a valley in Sikkim of similar elevation would have been. The large white blooms of a shrubby climber called *Beaumontia* were at this season the only striking flowers I saw, and along the road there were but few birds to be seen, as numbers of bullock carts were constantly passing. In the evening we reached Bhimphedi, a large village at the foot of a steep range of mountains over which the path is quite impracticable except for coolies; and here we were met by a party of men with doolies and torches, who surpassed all the bearers I have ever seen in their power. For to carry a man of my weight in the dark up a winding path on a gradient of thirty to forty-five degrees and covered with rolling stones was a work I should hardly have thought possible till I experienced it; and they only stopped for a few moments to relieve each other on an ascent of over 2,000 feet. Near the top of this mountain, the Resident has another bungalow at Sisagarhi, between five and six thousand feet above the sea, where we found dinner and beds ready. Next morning we had a fine view over the outer hills, and found rhododendrons in flower and evergreen oaks all around us on the dry grassy hillsides, reminding me far more of Chakrata in the Northwest Himalaya than of anything in Sikkim. Next morning we went on with the same doolies, and after crossing the ridge at about 7,000 feet descended on foot by a very steep rocky path through a fairly thick forest on the north side, where, though some orchids appeared on the trees and climbing plants and ferns were numerous, the whole aspect of the vegetation was utterly unlike the much damper forest at similar elevations in Sikkim. At the foot of this mountain we found ponies kindly sent by the Maharaja, and turned northwest up an open dry valley, cultivated in places with wheat and mustard as winter crops in small terraced and irrigated fields, and passed over bare grassy downs on which a plantation of *Pinus excelsa* had been made. The villagers' houses were built of brick and roofed with tiles, mostly two-storied, the upper floor being inhabited by the people, and the lower used for cattle and stores. A small primrose, *Primula Munroei*, a Polygonum like *P. vacciniifolium*, and a small stemless *Tragopogon* were the first signs of spring. Crowds of Hindu pilgrims on their way from the plains of India to a religious festival at Katmandu were on the road, nearly all walking, but a few riding or carried on coolies' backs. Among them were large numbers of women, who caused my companion, new to India, to remark that this was the only country he had ever seen where it was possible to pass thousands of women without a smile on the face of one of them. The contrast between their resigned and melancholy expression and the smiling faces of the Nepalese women, who crowd the bazaar and as porters welcome the stranger on his arrival at Darjeeling, is very striking. In the afternoon we ascended another steep ridge through forest mainly of evergreen oak, and at the top had our first view of the great open valley of Katmandu with the snowy mountains in the background. The great open valley terraced and cultivated wherever possible, with the city of Katmandu in the middle of it, and bare mountains covered with brown grass and scrub on the south exposure, formed a scene which, though beautiful in itself, was so unlike and so very inferior in grandeur to the scenery of Sikkim that I could hardly believe I was only two hundred miles to the west of that enchanting country.

Pilgrims, and coolies carrying immense burdens of ironware and European goods on the way to the valley, crowded the path; while those returning were mostly laden with coarse dirty wool from the interior. The last descent was so steep and difficult that a horse-dealer bringing horses from Kabul had some trouble in getting them down. At the bottom we found a good road and a well-appointed pair-horse carriage waiting to take us to the Residency, where we were hospitably received by Colonel Manners-Smith.

It is difficult, if not impossible, for anyone who does not speak fluently the language of a country he visits, and who has no opportunity of conversing freely with the people in their own language, to form a correct opin-

ion of the economic or social condition of its inhabitants, especially when restricted to a very small area surrounding the capital. But after many years of travel in Asiatic countries, including Asia Minor, Siberia, Japan, Formosa, China, Java, the Malay Peninsula, and with an intimate knowledge of Sikkim and other parts of India dating back to 1870, I formed the opinion that the government of Nepal is a form of government well suited to the ideas of Oriental peoples. Though the rulers of Nepal have rigidly kept their country free from European education and commerce, and have strictly adhered to the tenets of their own religion and customs, yet the facts that the people appear healthy, happy, and not over-taxed, that the standing army is one of which any Oriental state may be proud, and that law and order prevail to an extent which has kept the relations of their people and ours peaceable and friendly for a very long period, prove that such a form of government has advantages which modern reformers cannot overlook. And when the internal condition of Nepal is compared with what it was in Brian Hodgson's time, when bloody quarrels among the ruling chiefs and members of the Royal Family were common, one must admit that for a country where the land suitable for cultivation is insufficient for the maintenance of an increasing population, and where the natural products offer few openings for trade or manufactures, Nepal is in many respects fortunate. I cannot help remarking the difference which exists in the friendly relations between British officers, soldiers and tea planters, and their Nepalese soldiers, comrades, and laborers, with the attitude and comparative want of sympathy between Europeans and most other natives of India. One cannot work long with Nepalese without acquiring a respect and liking for their pluck, endurance and cheery goodwill under conditions of danger and hardship; or ignore the devotion they show to Englishmen who treat them properly and understand their ways. As pioneers on the northeast frontier of India they have no rivals, and though there is much difference between the various castes and tribes, yet, on the average, I prefer them to any other natives of India with whom I have had to do. The fact that we are able to recruit and maintain no less than twenty battalions of the best native infantry in India entirely drawn from Nepal, and that the laborers employed in the large and important tea industry of British Sikkim have been almost entirely supplied by Nepalese immigration, proves the importance to British India of our friendly relations with Nepal.

The Maharaja has done much to improve the native breeds of cattle, and has imported from India and Europe bulls of various breeds with this object. He is also trying to improve the sheep with rams from my own flock. The native sheep are a large coarse woolled breed, similar to those kept by the Nepalese on the frontier of Sikkim and commonly brought to Darjeeling for mutton, and are able to endure the cold and wet climate of the higher ranges better than the improved breeds in England would probably do; but below, about 6,000 or 7,000 feet, it is not a country generally suited to sheep, though goats are numerous.

Buffaloes are kept in large numbers in the Terai, and are valued for their milk and meat, but do not seem to be used for agriculture as much as in Formosa, where on steep hillsides, lying with a slope of twenty to forty degrees, narrow irrigated terraces are ploughed by buffaloes, which are much more active and better climbers than their normal habitat would lead one to suppose.

In Nepal, as in Sikkim, most of the cultivation is done by hand labor, and irrigation is general wherever water can be brought. In the dry weather it was impossible to judge of the crops, but the rice and maize stubble did not indicate such good soil as in Sikkim; and I believe that the area of land available for cultivation at healthy elevations is in most parts of the country too small to allow much increase in the population, who emigrate in increasing numbers to Sikkim and the frontier districts of Assam.

Both sexes from their childhood acquire the habit of carrying very heavy loads on their backs, especially the tribes of the higher levels, who carry on nearly all the trade between Nepal and Tibet in loads of from 80 to 200 pounds over paths that would be impassable to beasts of burden.

The forests of Nepal do not seem to have received from the government anything like the attention they deserve, as the growing scarcity of timber in Bengal and the United Provinces must make them valuable in future if they were properly protected. Neither tea nor camphor, both of which would no doubt grow as well as they do in Sikkim, are grown, though I believe that camphor might become a valuable and profitable product.

Whether the necessity for increased revenue to pay for the many kinds of European goods which the government and upper classes are requiring in larger quan-

tities, will eventually induce the government to pay more attention to trade and industry than they have done at present is a problem that time alone can solve; but up till now no permission has been given to any foreigners to embark on such enterprise—Nepal for the Nepalese being the fixed policy of the past and present rulers.

Of the natural history of Nepal I can say little from personal observation, because we were not able to visit the mountains of the interior, where are found a great variety of birds and animals which have been described many years ago by Hodgson, who, during his long residence, employed native collectors to procure, and native artists to draw, all that he could get. In this way most of the rarer animals which inhabit the central Himalaya were first made known to science, but of their distribution little is known. There are a number of genera represented in the northwest Himalaya by species different from those which are found in Sikkim and Bhutan, and it would be very interesting to know where these species meet, and whether they overlap and interbreed. But the mountains nearest to the valley, where alone the Resident and his friends are allowed to go, are too low, and so little virgin forest remains, that their fauna and flora are much poorer than those of Kumaon, Garwhal and Sikkim. In the Maharaja's grounds at Katmandu we saw three living deer which had been caught on the frontier of Tibet and of which little is known to Europeans. One I believe to be a female of the species known as *Cervus Wallichii*, of which a fine male, now in the Zoological Gardens, was presented by the Maharaja to King George when in India four years ago. Another is a male of *Cervus affinis*, which inhabits the high forest country in the northwest of Bhutan, and whose antlers are sometimes brought by natives to Darjeeling, where it is known as the Shou. The third is *Cervus Thoroldi* = *C. albirostris*, discovered by Dr. Thorold in the country northeast of Lhasa and not known to be a native of Nepal.

In the Maharaja's palace, which is a large modern building in European style, I specially admired the very delicate carving which is done by native carvers in a wood known as Dar, *Böhmeria regulosa*, Wall.; this is a very close-grained red wood, easy to work, and found along the lower hills, but not usually attaining a large size. The immense quantity of fine woodcarving, with which the older houses of Katmandu are adorned, shows the talent of the Newars in this branch of art, which, however, seems to be a dying if not a dead industry, as there are now no professional carvers except those employed by the Maharaja, and no shops where such beautiful work can be procured. The same seems to be true of the workers in copper, brass and silver, who now work only to order, and I cannot help thinking that these arts might be encouraged by making an outlet for their work in British India, where there is now a good demand among tourists and residents for the fine metal work brought from Lhasa, much of which is similar in character to that of Nepal.

To most travelers the buildings, temples and ancient monuments of the towns of Katmandu and Bhatgaon are probably the greatest attraction in Nepal, as their architecture is unique.

We must remember that although at the present day Buddhism and Brahmanism both obtain in Nepal, where the two are indeed inextricably confused, it was not always so. When the Buddha made his first converts in the Himalayas, five hundred years or so before the Christian Era, he found Brahmanism the established religion of Nepal. Therefore, just as birds, under the memory of the species for a once warm home, go northward with the spring into Arctic lands, so these poor Hindus move northward to a home of the infancy of their faith.

I have seen many pilgrimages—pilgrims from the farthest confines of the Roman Church drawn to Lourdes for healing; pilgrims on their way to Mecca; Russians from Siberian wastes come down to the Jordan for the dipping of the shrouds that will enwrap them when they die; Hindus from far Ceylon bathing in the sacred river at Benares—but this pilgrimage in Nepal was certainly in some way the most remarkable. Of those thousands of struggling men and women many were infirm and aged, some so worn by the hardships of the weary way that they would probably not live to see their homes again; a few who had money to spare for this advantage were huddled up in baskets on porters' backs.

The Gurkha, as far as Nepal goes, only dates from the eighteenth century. We are here concerned with the Newar, the original inheritant of the country. The Newar is Tibetan, as the Gurkha is supposed to be Rajput, in origin. His are the arts, the industries, the agriculture. All, then, that we see here in these pictures—architecture, woodcarving, metal work, stone—is Newar in conception and workmanship. And although the pagoda in principle is Chinese, its detail is so entirely different from that which we are accustomed to see in works on China, its decoration is so vigorous, so unconventional, and so true to life, that Nepal may be said to have a distinct art of its own, and that art expressed by great artists.

The Newar is primarily an artist in wood, and his control over that medium is astonishing. The decorative forms of windows, doors or plinths are not confined to shrines or to houses of the well-to-do; it is a principle throughout the land, some of the poorest country cottages having most beautiful workmanship. The picture of a wayside cottage shows the same form of horseshoe-headed window, with its lattice, that we later find elaborated in the wonderful buildings of the town. For although geometrical design forms the basis of this work, it is not "left at that," as in the lattice screens of India and Burma, but, where the money was sufficient, is overlaid by a complicated tracery of foliage, flowers or animal subjects. These are not only in their main lines true to Nature, and therefore quite recognizable (notice the mango over the doorway), but are arranged in a well-defined scheme of composition in the most artistic way. The ability to portray well-known animals is common even to primitive people; the reindeer of the Cave-men are real reindeer, the antelopes of the Bushmen are unmistakably Oryx or Sable, as the case may be. But these people, each in their day, were the children of the world, and their drawings, like all drawings done by children, insisted on detail as the child's eye sees it.

The Newar artist had advanced a long step farther;

he was no nursery artist—he had "arrived." He knew exactly how to generalize, how to insist on the big features that gave his plant or his animal its recognizable character and individuality, and how to drop all those details that did not tell. And this was equally true whether he worked in wood or in metal; less so, perhaps, in stone. For all that, when form demanded it, he could be as strictly conventional as a Greek. As examples of this, notice the conventional lotus on the well-head and on the capitals of the monumental columns.

Two types of temple are noticeable in these pictures—the Chaitya type and the Pagoda type. The first is the Buddhist form, the other is Nepalese Hindu. These latter are not found, I believe, in India, if we except one that stands out unmistakably among the temples of Benares—the pious gift of a Maharaja of Nepal. It will be noticed that each story of these pagoda temples is supported by long wooden struts. Recourse to such a device to support an overhanging plinth or other structure is elsewhere common enough; a familiar instance is that of the Ponte Vecchio. But the Newar has gone one better than the Tuscan, for he has carved each strut elaborately from end to end.

The shrines would take a paper to themselves. They are of wood, metal, and stone. In noticing their extraordinary wealth of decoration, it is necessary to realize that nothing is introduced without a meaning; that each detail, decorative as is its effect, has a distinct and definite significance in the religious sequence of a people's worship.

The doorway of the Durbar Hall in Bhatgaon is, of course, well known as one of the greatest achievements in metal in the world. It is of copper overlaid with gold. It is, indeed, a thing of fascination; the folds of its serpent seem to writhe, the lizard on its lintel might be darting in the heat.

But of all the remarkable and beautiful features of the streets of these Nepalese cities, nothing holds the attention so strongly as the monumental statues. I do not know whether these are absolutely peculiar to Nepal, or whether they are also met with in Tibet; the writer, at least, had never seen anything like them. They are sculptured portraits of various rulers who built the temple in front of which they stand. First there is a simple base, then a square stone pillar, perhaps 30 to 50 feet high, then a beautiful capital of lotus pattern. On this is placed sometimes a throne of copper gilt, based on animals—elephants or others. On the throne the Newar king is seated, with the cobra or a gilt umbrella as a canopy above him. In some examples his family are about him; in others he sits upon no throne, but kneels in an attitude of adoration before the temple of his gods. No description could adequately convey an idea of the extreme and beautiful dignity of these monuments. What they owe to their surroundings it is impossible to say; they belong to Nepal and not to Trafalgar Square. There are, at any rate on the Maidan of Katmandu, some very fair equestrian figures of Maharajas that are of western making; and to come upon these after the others was to change the sublime for the commonplace. Seen where they were, these columns of the rulers seemed structurally, decoratively, spiritually, and in their beautiful repose, a final word in art.

### The Combustion of Coal in Boiler Furnaces

In a preliminary report on a series of experiments conducted by J. K. Clement, J. C. W. Frazer, and C. E. Augustine on the factors governing the combustion of coal in boiler furnaces at the Bureau of Mines, the following practical points are noted. These suggestions, together with a detailed account of the first of a series of experiments on the above subject, will be found in Technical Paper No. 63, issued by the Bureau.

The efficient use of coal is dependent on proper furnace design as well as on proper firing and control of the furnace. Many furnaces are built without regard to the special characteristics of the fuel to be used, with the result that for years fuel has been burned in an inefficient and wasteful manner, and so as to aggravate the smoke nuisance.

In the design of boiler furnaces the requirements of efficient combustion have been made secondary to many less important factors, largely because of a lack of definite information about the processes of combustion.

The combustion of coal may be considered as taking place in two stages: (1) Distillation of volatile matter and partial combustion on the grate, and (2) combustion in the combustion chamber of the gases rising from the grate. In order that the second stage of the process may be complete, it is essential that the combustible products given off from the fuel bed remain long enough in the combustion chamber to be entirely burned before they become chilled by contact with the relatively cold boiler surface. If the combustion space is too small the gases will pass out of it only partly burned, and a loss in heat and a lowering of efficiency will result.

Combustion is influenced by many factors, the most important of which are the following: The volume and shape of the combustion chamber; the kind of fuel used, especially the amount and character of the volatile matter and rate of firing; the rate of heating the fuel; the air supply; the rate at which air is mixed with the combustion gases in the furnace; and the temperature of the combustion chamber.

The composition, as well as the amount, of volatile matter given up by a given coal varies greatly with the temperature to which the coal is heated and the rate of heating. The influence of temperature on the amount and composition of the volatile matter distilled from various coals has been studied by Porter and Ovitiz of the Bureau of Mines.<sup>1</sup> They found, for example, the following values for the volume of combustible gas given off in ten minutes from 10 grammes of air-dried Pocahontas coal:

RELATION OF TEMPERATURE OF FURNACE TO VOLUME OF COMBUSTIBLE GAS.				
Temperature of furnace, deg. Cent.	600	700	800	900
Volume of combustible gas, cubic centimeters	50	670	1,570	2,300

The amount of tar produced increases with increase of temperature in about the same proportion as does the volume of combustible gases.

The heavier constituents of the volatile matter, especially the tar, do not burn readily and require more time for combustion. The higher the temperature at which distillation takes place, therefore, the greater is the amount of volatile matter drawn off and the more

<sup>1</sup>Porter, H. C., and Ovitiz, F. K. The volatile matter of coal: Bull. 1, Bureau of Mines, 1910, 56 pp., 1 pl., 9 figs.

difficult is the combustion of its constituents. A rapid rate of heating of the fuel produces a rapid evolution of slow-burning volatile matter. A slow rate of heating results in a gradual and uniform liberation of volatile gases, which are more readily combustible. One advantage in the use of the automatic stoker over hand firing is that in the automatic stoker the coal is heated gradually through the temperatures at which distillation takes place, whereas in hand firing the green fuel is thrown on the incandescent fuel bed and thus heated from room temperature to the furnace temperature.

In the tests described in this report the supply of coal was regulated automatically and the rate of heating was constant for each rate of firing. In a future investigation it is planned to vary the rate of heating the coal and to study the relation between the rate of heating and the volume of combustion space required.

With the type of stoker used in the tests the coal is fed continually to the grate, and with proper regulation of the speed of the stoker engine the thickness of fuel bed may be kept fairly constant. In the tests with Pocahontas coal the thickness of bed carried was about six inches. No attempt has been made to study the relation between different thicknesses of fuel bed and the space required for combustion. There is ample evidence at hand to show that excessive thickness of bed favors the formation of CO by the reaction:  $\text{CO}_2 + \text{C} = 2\text{CO}$ , the reaction that takes place in the gas producer. Increasing the thickness of the fuel bed, therefore, not only reduces the combustion space above the bed, but produces greater quantities of CO, and thus increases the volume of combustion-chamber space required.