CARTOGRAPHIC CONQUESTS: MEN, MACHINES, METHODS 1830 -1870

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CERTIFICATE

This is Certified that the dissertation titled "*CARTOGRAPHIC CONQUESTS: MEN MACHINES METHODS 1830-1870*" submitted is the original work by **Oyndrila Sarkar** in partial fulfilment for the award of the degree of the Master of Philosophy. This dissertation has not been submitted for any other degree to this university or to any other university to the best of our knowledge. We recommend that this dissertation be placed before the examiner for evaluation.

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Dedicated to

the two people at home who taught me to

love geography

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In his account of the measure of one of the meridians of the Trigonometrical Survey of India Colonel George Everest laments the difficulty of his project saying:

"It was unquestionably the most harassing duty I ever had to perform, and I had to bear nearly the whole burden of the arduous task myself, for there was at that time a no person at my disposal to whom I could depute any portion of the work except under my own immediate supervision and control."

(George Everest, Accounts of the GTSI Volume XXIII)

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CONTENTS

CHAPTER ONE:

Chapter 1: Introduction

INDIA TRAVERSES: MAPPING A NATION'S IDENTITY

Why would I want to carry out research on something which has already been worked upon by a number of eminent scholars? The stalwarts like, Matthew Edney[1], Ian J. Barrow[2] and Deepak Kumar[3] have already addressed the process of development of science and technology leading to map making and surveying in India, but there are an immense number of questions which still remain. The Survey of India which evolved over the decades was a hive of people constituting of a sharply defined hierarchical framework. It comprised of the administrative section, surveyor section, engineering, drafting and computing section, the Indian staff, instrument repairers and even the *khalashis*.

My dissertation will focus on three major themes. Firstly, studying the career of the people employed in the Great Trigonometrical Survey of India, secondly, the social history of the objects and instruments used in the surveys themselves, exploring the methods and means of the surveying (with regard to theodolites, camps, baselines, travelling observatories, and complex computations) and thirdly, the phenomenal process winding up under Andrew Waugh, causes leading to an amalgamation of the three departments of survey in 1865 and its administrative and political after-effects occurring in the latter half of the 19th century. This chapter assesses the books which have engaged with the history of the trigonometrical surveys carried out by the East India Company in India. For thematic clarity I have grouped them under four basic

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1 Matthew H Edney, *Mapping An Empire: The Geographical Construction Of British India, 1765-1843*, University of Chicago Press, 1997

2 Ian J. Barrow, *Making History, Drawing Territory- British mapping in India*, c.1756–1905, OUP, 2003

3 Deepak Kumar, *Science And The Raj 1857-1905*, OUP, 1995

heads, firstly the literature on a surveyor's career in the GTSI. Secondly, the social history of the objects, technology, surveying concepts and survey instruments. Thirdly methods of surveying, mapping and territorial imaginings and concluding with a literature on native Indian participation in the colonial surveys.

Science was integral to the consolidation of British rule in India. India was seen as a rich technical resource for western domination. Deepak Kumar in his *Science and the Raj* begins by arguing that western needs were both military and economic in nature. Amidst the chapters of the survey and early phase of colonial science, he emphasizes on the organization under governmental institutions, scientific educational growth and research. Indians were eager to learn about Science. The East India Company had realized the importance of survey works for the military and revenue considerations. He fleetingly mentions Radhanath Sikhdar as part of the native response to the western scientific surveys. Mohsin Hussain of Arcot with his theodolite impressed George Everest. Of Radhanath Sikhdar, George Everest (Surveyor General 1835-1865) had said – *'In his mathematical attainments there are few in India – Europe who can at all compete with him.'* Radhanath was the first to compute in 1852 that a peak designated XV, observed from five different stations was the highest peak on earth. The Raj rested on prestige; native workers were different with their dressing habits, eating habits, working habits which were often criticized by the survey officials. Regarding another aspect of the native reception of the new science, Deepak Kumar engages with an idea of the new *bhadrolok* who had become so enamoured by the Oxbridge tradition to rudimentary scientific course. He argues that the natives always never met with reprobation. Saiyid Mohsin's theodolite was accurate even after 30 years of man-handling in the surveys. Smyth and Thulliier said that the Parts III, IV, V of the *Manual of Surveying* were written by Radhanath Sickdar. However his name had been omitted. Acknowledgement of valuable scientific work done by a native was probably indeed inconsistent with the British prestige. As a critique one could simply say that Kumar has not really engaged with the discussion of any single specific aspect of the Great Arc or the Great Trigonometrical surveys, though in general he has touched upon all the scientific Surveys and the spirit in which they were all carried out.

Thongchai Winichakul gives us an unusual and intriguing study of nationhood exploring the 19th century confrontation of ideas that transformed the kingdom of

Siam into the modern conception of a nation. His innovative research "*Siam Mapped, A History of the Geo Body of A Nation*" [4] deals with wars and boundaries of the territory of Siam. He brings out an imaginary approach to the boundary formation of a nation-state and argues that no boundary had a similar character: they shifted ,evolved, matured, cemented, or at times remained permeable. Overlapping territory were common in the area, Winichakul argues, saying areas where no country claimed its sovereignty existed, creating a buffer corridor. As Europeans moved into the core (Siam), from the peripheral areas in the 19th century bringing in new geography and technology of mapping, the confrontation between modern and indigenous conceptions of boundary and sovereignty caused misunderstandings in diplomacy, confusion in surveying, boundary demarcations. Europeans and later Siamese rulers desired a country defined by new technologies of surveying and mapping. Ultimately the mapped geo-body replaced the indigenous territory and Siam as a nation emerged.

Matthew Edney used this similar argument with regard to British image as a ruling power. Edney in his book, *Mapping an Empire: The Geographical Construction Of British India, 1765-1843,* [5] takes us to a much more nuanced understanding of the production of knowledge on the periphery of empire. Edney focuses on shifts of ideology corresponding to the shifts of surveying styles from Rennell to Lambton. The GTSI was an empiricist delusion. Edney here can be said to be making an imagined gap between cultural idealism and Native - European technical competence.. There was a definite gap between the geographical narratives of triangulation and Trigonometrical survey and the supposed GTSI workability. Imagining India as a nation state in which national identity was related to India as a topographic reality was retarded as well as the places of geographical survey within the same milieu of the broader context of British science. The main argument he makes is that the British were flawed in their belief that they could reduce Indians to a rigidly coherent, geometrically accurate, uniformly precise imperial space within which a systematic archive of knowledge about Indian landscape and its native people could be imagined and thereby constructed.

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[4] Thongchai Winichakul, *A History Of The Geo-Body Of A Nation*, University Of Hawaii Press 1997

[5] Matthew H Edney, *Mapping An Empire The Geographical Construction Of British India, 1765-1843*, University of Chicago Press, 1997

Ian J Barrow, in his book, *Making History, Drawing Territory. British mapping in India, c.1756–1905* [6] brings in the concept of territory and representation of land. Drawing upon Winichakul's thesis, Barrow asserts that the East India Company's efforts in mapping terrain through their national scientific efforts represented land as "territory", nothing imagined, all was a representation of the colonial possession. He speaks of a demarcation of territory, leading to the creation of a nation's identity. Whereas he dwells with much emphasis on the scientific surveys becoming a political tool to provide legitimacy to the East India Company's rule, he brings out shifts in ideologies and simultaneous shifts from route mapping to Trigonometrical surveying. What he doesn't dwell upon and which precisely corresponds to my research theme is on the institution of surveying, the survey department, the operations of the phenomenal Trigonometrical surveys, methods employed and the men employed in these methods. It is of great interest that he brings in the imaginative aspect of remembering a memory with a particular historical event and helping it to become an iconic point in the mental terrain in certain places in certain time periods. (eg., Holwell's monument in Calcutta, recreated by Curzon to bring back a nostalgia in the minds of the tourists about the Black Hole tragedy). Keeping this emotive argument in mind Barrow remains surprisingly silent on the essence of the people conducting the surveys, his thesis thereby giving importance to the ideologies of mapping territory, than studying the social interplay between the agencies and forces behind the actual surveying.

James Akerman's edited volume opens with Edney's essay. Essentially this collections' name suggests that the essays deal with cartography and the Empire trying to manage itself. His *The Irony of Imperial Mapping* challenges the notion of a map as "imperial".[7] Again the notion of a 'core-periphery' of a territory comes up, either for administration or for mapping. He argues that fluid boundaries exist between core-peripheries of a territory, either for administration or for mapping. He

[6] Ian J. Barrow, *Making History, Drawing Territory British mapping in India*, c.1756–1905, OUP, 2003

[7] Ackerman James R. *The Imperial Cartography And The Mastery Of Empire,* (University Of Chicago Press 2009)

argues that there are distinct differences between a colony and a centrally imagined nation-state. He gives an example of the topographical survey of France before the French Revolution of 1789, which set the surveys in motion for extended mapping agendas in later occupied territories. The critical difference is possibly in the use of surveying towards this state centric demarcation of territory. What is significant in the process is – *who is mapping, who is being mapped, and what purposes are served by the cartographic projects*. So essentially the scholars dealt in depth on the questions of marking boundaries and the permeability of such demarcations and the imagined nation-state, and the ideologies of the imperial or not so imperial cartographic projects. However the effort to study the actual people and Surveyors involved in the groundwork gets totally lost in the process.

Among the most interesting edited essay collections, one which speaks volumes is "*Images and Contexts*"[8], edited by Druv Raina and Irfan Habib. The way in which their collection offers a textured study of the role of how Science begins to shape Indian intellect in the latter half of the 19th century is of much interest to me. He gives an overview of the historiography of Modern Science in India. Though belonging to a much later period, he speaks about Mahendralal Sircar[9] and Prafulla Chandra Ray[10] and how these scientists of Bengal created awareness in the intellectual circles. In one essay, he examines the life of P. C. Ray, one of the founders of Indian chemistry in the early 20th century. Ray was not only active in instituting chemical research in India; he was also involved in nationalist politics, while simultaneously researching the history of Indian science. These seemingly disparate studies came together in his mind. Science held the keys to emancipation from British domination, while historical research could explain the concrete, social reasons why Indian science had "declined" in the centuries before the advent of British rule. In tying together these strands of Ray's life, Raina succeeds in showing the ways in which a social history of science might influence positive outcomes in scientific research. In exploring this and other episodes in the historiography of Indian science, Raina emphasizes the complexity of the interactions and encounters between the intellectual space of the Indians and

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[8] Druv Raina, *Images And Contexts-The Historiography Of Science In Modern India*, OUP, 2003

[9] ibid page 122

[10] Ibid page 48

Westerners. Though these figures are located at a much later period, my work will take up Radhanath Sikhdar as a pioneer scientist as well as an entrepreneur in his own way who belonged in a similar passionate intellectual space, though a decade earlier where opportunities were more scarce, and professional categories were sharply delineated.

The dynamics of the interaction between western (global) knowledge and Indian (local) knowledge comes up as Kapil Raj's argument in his book *Relocating Modern Science Circulation and the Construction Of Knowledge In South Asia And Europe, 1650-1900*. He argues that Modernity didn't mean westernization which means it is in relative. Modernity in knowledge was an awareness brought about by interaction between these two forces. Kapil Raj argues that, the history of science should be an account of how knowledge was set in motion, through interactions, not by any sudden transplantation - but by material, economic and symbolic transactions. He brings into the picture the unique concept of "diffusionism" [11] but remains silent on the aspect of Indians blindly accepting western science and playing no role in acceptance or rejection of western science regarding mapping. Kapil Raj argues that early European cartographic enterprise in South Asia preceded by means of a negotiated adaptation of embodied skills and instruments connected with terrestrial surveying before the EIC and the GTSI stepped in. It was a solid case of the social history of these people embracing western scientific ideal,, but it was kept narrowed down to the points of contact between the two disparate cultures and planes – global and local.

The main theme of Robin Butlin's book *Geographies Of Empire; European Empires And Colonies 1880-1960*[12], is that exploration became part of Britain's culture. Other colonial powers showed confidence in scientific knowledge but also showed changing national identities that were closely linked with imperialism and colonial settlement. At the head of British exploration was the Royal Geographical Society set up in 1830, where there was an advancement of geographical science and promotion of earth sciences by means of grants. It becomes certain that he advocates Geography being overtly and covertly linked up with imperial power through Survey and Mapping. The

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[11] Kapil Raj, *Relocating Modern Science Circulation And The Construction Of Knowledge In South Asia And Europe*, 1650-1900, Palgrave Macmillan , 2007

[12] Robin A Butlin, *European Empires And Colonies*, C. 1880-1960, Camb. Uni. Press, 2009

second important point he makes is the mapping of empires and colonies. The power of the map was seen in surveying and dissemination of geographical information for peaceful and military purposes were the basic features of imperialism. Trigonometrical surveying was firstly a labourious process, ranging from rough hand ready traverse surveys of the explorers, to fantasy maps or cartograms. The character of the British Empire depended on the four way competition between – need for geographic information; the availability for labour to undertake surveys; availability of money to pay for the surveys, adherence to cultural expectations for making accurate maps. The GTS defined India. The colonized space was a space of negotiation between the colonizer and the colonized. Furthermore for power and control over territories, mapping and surveying was required, which was influenced by the technology used.

For any layman, and it is a derogatory to club anybody as a layman, John Keay's approach to dealing with the Great Arc and The Great Trignometrical Survey is the best read! In his book, *The Great Arc: The Dramatic Tale Of How India Was Mapped And How Everest Was Named*, he shows how the EIC tried to determine the length of the arc along a longitude or meridian. The basic idea was to determine how regular the "oblateness"[13] was and from this measurement to gain more accuracy about the earth's shape. The Great Arc would become like a skeletal framework, a "spine of a tree", which could embrace the country and be used as benchmarks for regional surveys. Under the increasing consolidation of the EIC, the Great Arc would help the mapping of India mirroring the progress of the Empire as it were. This Great Arc gave rise to the Great Trigonometrical Survey. The surveyors, Keay says had fuelled British superiority as well as Indian grievance, and he goes on to explain how the various tools and instruments of triangulation, like bars, chains, rules, became objects of political strangulation! The Survey had encouraged the mindset of autocratic imperialism. He definitely goes no further to explain triangulation or methods of surveying more than the basic idea, and there is a silence about the surveying methods or the surveyors in general, except when he deals with Everest. But his passionate narrative gripped me to get into the mood for an adventure down to the age of

[13] Earth being called an oblate spheroid, due to its shape like an orange, and not totally spheroid like a ball

runaway elephants, remarkably clever computers, monsoonal rains, and mutinous villagers.

With *Geography Militant* [14], Felix Driver has quite successfully spoken more than what most geographers would normally speak. Rather than concentrate solely on the adventures of explorers (in this case, Britons who trekked in Africa), he takes the reader into the realm of the cultures of exploration. He is concerned with how exploration narratives were "produced and consumed," who aided (and hindered) explorers, who benefited from their accomplishments, how their exploits were publicized, and, most vitally, what role the public played in the theatre of geographical adventure. The title of this volume is drawn from an article that Joseph Conrad published in National Geographic in 1924. Conrad wrote about *Geography Fabulous, Geography Militant, and Geography Triumphant.* He claimed that these were the three epochs in the history of geographical knowledge, and that Geography Militant clearly was the most important. In the romantic period of Geography Militant (especially in the 19th century), empirical knowledge of the Earth's geography was diligently sought, and the "foot soldiers" in this quest were heroic land and sea explorers. Driver presents in his last chapter considerable evidence that Geography Militant still thrives today, having been regenerated in the literature of advertising and tourism, in adventure stories, in the sale of exploration relics in auction houses, and even in fashion magazines. David Livingstone, the subject of a certain chapter, is considered by Driver to be the best example of the "cultures of exploration." Even though Geography Militant focuses on nineteenth- century Africa and Victorian Britain, it deserves the attention of all who have an interest in geographical exploration and discovery, no matter what their specialties might be.

One of the most important work to be done on any such Trigonometrical surveying expedition has been that of Sekhar Pathak, *Asia Ki Pith Par - Pundit Nain Singh Rawat: Jeevan Anweshan Tatha Lekhan.*[15] The topography of Tibet was unique, because no elevation on earth can be compared to its tablelands and mountain chains.

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[14] Felix Driver, *Geography Militant: Cultures Of Exploration And Empire*, Wiley Blackwell 2001

15 Sekhar Pathak, Uma Bhatt , *Asia Ki Pith Par – Pundit Nain Singh Rawat : Jeevan , Anweshan Tatha Lekhan,* Pahara Publication, New Delhi 2008

It was forbidden territory for all moghul, hindustani, *firangi* men. Sekhar Pathak recounts the tale of Nain Singh, a school teacher who entered Tibet in the guise of a monk with only a prayer wheel and a rosary in hand and armed with a magnetic compass, sextant, chronometer and a bottle of mercury secretly hidden. Nain Singh made his journey by foot from Nepal to Lhasa, through the upper valley of Brahmaputra to its source in Tibet. Sekhar Pathak is the first of his kind to give us a stupendously detailed historical narrative on this Trans-Himalayan exploratory survey conducted under Capt. T.G.Montogmerie in 1868-1874. His book is almost a biography. He has used the worn out illegible diaries of Nain Singh which can be seen in the National Archives of India even today.

Jogesh Bahal gives us a glimpse of Radhanath's mathematical achievements in his article, "Radhanath Sikhdar – The Great Mathematician and Discoverer Of Everest".[16] Radhanath Sikhdar wrote in his autobiography[17] that he had been appointed as surveyor and that he left Calcutta on October 15, 1832 to work on the baseline of Dehradun, the Serang baseline. Radhanath Sikhdar continued his studies in higher mathematics and Everest was kind as to train him. Everest was impressed with Sikhdar's departmental work. He proved himself indispensable for his service in a very short time. It was a case of long continued exertion, an arduous profession of unremitting self cultivation and professional merit. Eventually Radhanath formed the ground work leading to the system of computations in the Great Trigonometrical Surveys. Appreciative references of Radhanath's services were also made in the report submitted by the Great Trigonometrical Survey to the British Parliament on April 15, 1851: "*a more loyal, zealous and energetic body of men than the sub assistants forming the civil establishment of the survey department is nowhere to be found ... Babu Radhanath Sikhdar a native of India of brahmanical extraction whose mathematical attainments are of the highest order.*" [18]

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[16] The Hindoo Patriot gave a summary of it in its issue of april 18, 1861.

[17] Radhanath Sickdar – the great mathematician and discoverer of Everest by, Jogesh Bahal, Modern review April 1933

[18] Modern Review, April 1933

Research questions:

1. What was the social and institutional history of the Indian agencies under the Great Trigonometrical Survey department?
2. What was the hierarchical division of work force ranging from the surveyors and draftsmen to the computers and the field workers, what were the ongoing frustrations on the job?
3. What were the skills and training of the surveyors in the department?
4. What were the efforts made in skilling the personnel in the technology and methods of survey?
5. What were the different survey instruments used? What was the social history of its evolution in the survey department?

Relevance of the study

Most of the scholars, specifically focused on the Indian aspect, have dealt in depth with the ideology behind the surveying of the subcontinent. They have dealt in depth on the attainments of the Raj and the Indian people, mapping the country, mapping their land to map their control, mapping the terrain to further consolidate. Nobody has raised any innovative questions as regards the lives of the people concerned (those employed in the Trigonometrical survey department), nobody has raised questions as regards the people who worked in the field at the survey department, people who sat at the computing tables, people who drew at drafting tables. Nobody even wondered as to the methods and instruments which enabled them to carry out the surveys. The much delicate and in turn cumbersome instruments and survey equipments had to be handled carefully, because of the dearth of readily available replacements, and some of these instruments now kept at the Dehradun, the Headquarters of Survey of India office bears a witness to those adventurous days they had seen. My aim ideally would be thus to study the Great Trigonometrical Survey as a separate phenomena which helped shape colonial India by mapping the terrain and people and also the nexus of relationships between each and every crevice of the survey department under the headship of the Surveyor General which might bring forth a nuanced understanding of *the social history of the people who actually mapped India by surveying it,* but remain invisible even today.

Chapterization

Chapter one: making of a surveyor

In the 1st chapter I will be discussing the institutional life of the Survey of India the policies with regard to the training and development of the skills required for the surveyors to carry out their tasks. The beginnings of the departmentalization which started under Lambton and continued under Everest to Waugh and the development of the upper levels of the skilled Indian agencies, the draftsmen, computers, engineers, as well as the administrative reins being in the hands of the British trainers and officials. The background to the training of the Indians their frustrations of the job with regard to their importance and dearth of status in the sure department will also be dealt with. I will also be looking into the reconstruction of the mathematical and astronomical knowledge and skills in handling all field and survey instruments in this chapter. A case of an Indian individual who has been held in high esteem as the most significant contributor to the phenomenal process of the survey calculations, Radhanath Sikhdar will be taken up as an ideal case of Indian excellence. Whether or not this reconstruction of making him a tragic figure or under achiever or under acknowledged will be dealt critically countered with the sources.

Chapter two: the tools of a surveyor

The 2nd chapter will be smoothly flowing into the same processes of training and technology only now with a different perspective with regard to the tools and instruments of survey required for triangulation and field work. I will deal with the technical history of the various instruments like baseline chains, eight different kinds of Theodolites, cranes chronometers micrometers, zenith instruments, astrolabes and other astronomical instruments. From there on I will be discussing the programmes and efforts and training given by the British officials and scientists to the staff and personnel in the areas of measurement, drafting and computation and fieldwork. It will be an approach to study the social history of the objects and instruments of the Trigonometrical survey.

Chapter three: An Indian Pioneer and the Great Trigonometrical Survey

The instruments of the GTS produced masses of geographical data. But, the data was useless without the extensive analysis that occurred after a field season. The mathematics necessary for the GTS were extremely complex and at the time were at the very forefront of European mathematical practice. Geodetic measurements especially were especially complicated but all parts of the survey required intense mathematical work. In order to ensure that the surveys were as error free as possible the mathematical determinations of the triangles were compared against the measurements taken with compensation bars on the ground. This two-fold process was the central part of the GTS and the reason that the surveyors could claim to possess such accurate measurements. Constant checking and rechecking greatly increased the persuasiveness of the presentation of the knowledge of the GTS. Everest did not do all of the mathematics. Radhanath was a Bengali who became extremely significant in this field and deserves a special mention along with another important figure of a native artist from Arcot, Mohsin Hussain who created and maintained Everest's instruments.

CHAPTER TWO:

Chapter 2: Making of a Surveyor

Purpose

The purpose of this chapter is to show how a Surveyor is made out of an individual. I will discuss the institutional life of the Surveyor in the survey department and the development of his skills and specialization to carry out his task. The survey department comprised of various departments, like that of drafting, computing, clerks, correspondence and engineering. This division of skills started under the surveyor general of India William Lambton[19] in 1806 and was revised under George Everest[20] in 1830s. What we see as maps or manuscript records so easily in the cartographic section in the archives today was not so easy a process back then. There were very many complexities and phases of activities to construct an institution whose documents we readily use as primary material today for research. The Great Trigonometrical survey of India[21] was a major project by which the British Empire wanted to measure the entire Indian subcontinent. They did this to make a general reconnaissance of the British occupied territory in India as well as the entire territory lying for their potential expansion. So it was basically a geographical survey of the subcontinent from Madras to the opposite coast, and from the Deccan to the Himalayas. The process of surveying is something I will go into detail later. But this chapter proposes to essentially show how the different working elements (both

[19] George Everest was the author of "*Account of the measurement of an arc of the meridian, account of the measurement of the two sections of the arc in India*" and "A *series of letters addressed to his royal highness the duke of Sussex*". He was appointed Superintendent of the Trigonometrical survey of India on Lambton's death.

[20] William Lambton was the Superintendent of the Trigonometrical Survey of India, which he began in 1802. In 1796 he was promoted to Lieutenant and posted with his regiment to India, under the leadership of Colonel Arthur Wesley. After the capture of Mysore, Lambton had proposed that the territory be surveyed, using the new techniques of geodesy employed by William Roy in Great Britain, and this was approved. Lambton then recommenced the survey northwards until his death. He was succeeded by Valentine Blacker for a very short period till George Everest took over.

[21] See Markham Clements, A memoir on the Indian Surveys, 1878, page 67.

European and Indian) of this survey department evolve into a skilled group of surveyors. No layman was allowed into the department. There was an acute need for skilled officers, engineers who would not only be able to carry out specialized work, but also be able to train the other groups engaged in the survey according to their specializations. So this is a people-centric chapter which will look into few important questions:

Questions

- How did the GTSI department evolve?
- What are the concepts of specialization and standardization?
- What are the concepts of skilling and training?
- What was the nature of the inter-flow of men and money to and from the revenue department and the Trigonometrical survey department?
- What were the problems seen in this process of the making of a surveyor?

Evolution of the GTSI Department

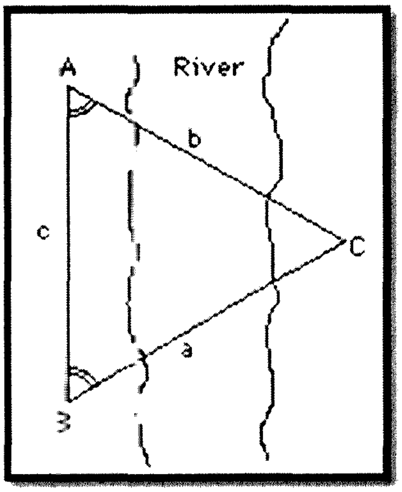
To delve into the evolution of the survey department, one should possibly look into the origin of the department in itself and the origin of the word "GTSI". The great Trigonometrical survey of India was the largest surveying project taken on by the British government in Indian soil. It was an attempt to accurately determine the dimension of the country and the location of important geographical features in terms of latitude and longitude.

Not to divert, but to add an insight to the origin of the effort, 1799 saw Col. William Lambton propose a plan of a Mathematical and Geographical Surveyright across the peninsula. In his proposal, Lambton noted: 'In a former communication I took the liberty of stating...My idea of a survey to be extended from the Coromandal to the Malabar coast, with a view to determine the exact position of all the great objects that appeared best calculated to become permanent geographical marks…facilitating a general survey of the peninsula and particularly the territories conquered… when these points are laid down in the exact situations in which they are upon the globe, all the other objects will also have their situations true in Latitude and Longitude'

(Phillimore 1950:234).[22] The origin of the Trigonometrical survey can thus be put in very simple words even for any lay man, the measurement of the dimensions of India. Lambton's proposal of measuring the meridional arc along 78 degree east from Cape Comorin to determine the size of the earth was given Government approval in February 1800.

Now to give a very vivid picture of what my readers are getting themselves into, I will shed a bit of light on what trigonometry and triangulation is all about; and be as less technical as I can. It is a survey of a portion of country by measuring a single base, and connecting it with various points in the tract surveyed by a series of triangles, the angles of which are carefully measured, the relative positions and distances of all parts being computed from these data. The basic problem of trigonometry[23] runs somewhat like this:

You stand next to a wide river and need to know the distance across it--say to a tree on the other shore, marked on the drawing here by the letter C (for simplicity, let's ignore the 3rd dimension). How can this be done without actually crossing the river? The answer would be to stick two poles in the ground at points A and B, and with a tape measure the distance c between them ("the baseline").



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[22] Kalpagam, U. ' Cartography in Colonial India', EPW vol. XXX no. 30 pp. 87-98

[23] Captain Frome, *Royal Engineers - Outline of the method of conducting a Trigonometrical survey for the formation of geographical and topographical maps and plans; military reconnaissance, leveling, etc.; with the most useful problems in geodesy and practical astronomy and formulae and tables for facilitating their calculation*, London 185[illegible], 2nd edition, pp 1 - 13

Figure 1 – Basic trigonometry, measuring a baseline[24]

Now in the Great Trigonometrical Survey, the surveyors simply removed the pole at A and replaced it with a surveyor's telescope like the one shown here (theodolite), having a plate divided into 360 degrees, marking the direction (azimuth) in which the telescope is pointing. Sighting the telescope, first at the tree and then at pole B, they measured the angle A of the triangle ABC, equaled to the difference between the numbers read from the azimuth plate. The same process would be repeated from the point B. The length *c* of the baseline and the two angles A and B, contain all there is to know about the triangle ABC--enough to construct a triangle of the same size and shape on some convenient open field. Trigonometry (*trigon* meaning triangle) was originally the art of deriving the missing information by pure calculation. Given enough information to define a triangle, trigonometry lets you calculate its remaining dimensions and angles by pure mathematics.

In mapping India, the surveyors divided it into triangles and marked each corner by a "benchmark". After measuring a baseline (such as AB in the example of the river) the surveyor measured the angles it formed with lines to some point C, and use trigonometry to calculate the distances AC abd BC. These can serve as baselines for 2 more triangles, each of which provides baselines for two more and so on, more and more triangles until the entire country is covered by a grid involving only known distances. Now for the real study.

When George Everest succeeded William Lambton as the surveyor general of India, he was met with a wide variety of events and arrangements to deal with.[25] 1830 was the precise conjuncture when Lambton passed away leaving behind a huge budding institution and technologies which required immediate attention.[26] Everest was faced with the issue of training the officers and employers of the survey department. Methods of survey were becoming outdated, and there were newer technologies and instruments of survey which he had seen being implemented in the Great Ordnance Survey of Britain and he knew he could try to implement them in the Indian conditions. There was a proliferation of survey parties all over the subcontinent. Right

[24] Ibid, page 11

[25] See Phillimore (vol 4, pages 25-68)

[26] Ddn vol 265, 8-10-35

from Madras, Bombay, Bengal, and the north east, there were semi-autonomous field offices carrying out seemingly independent survey of the regions.[27] The local governments were experimenting with their own system of revenue surveying. The deputy Surveyor Generals of these states came directly under the Surveyor General, making him responsible for work in both the Bombay and Bengal presidencies. The surveyor general was also faced with the question of whether to continue on the project of the Great Arc or re-measuring the work done earlier with the newer techniques and technologies.

The Trigonometrical survey of India was independent of the work of the revenue department. But there was a constant flow of tension to and from the revenue survey department and the Trigonometrical survey department. One of the major reasons was that the revenue department had the entire calculations of the finances and taxes while the Trigonometrical survey department was always short of funds, short of money, short of men and they had to do the maximum quantity of work allotted to them by the Court of Directors with as less sources as they could. The people comprising of the survey department required to be more expert in their work, to be more specific, specialized in the kind of work which Everest had in mind. Multifarious levels of work were on the plan and needed dedicated workers both European as well as Indian.[28] It will be a eulogy of Everest if anybody says that he was a perfect man bringing in new technology and changing the entire perspective and nature of the survey department and revolutionizing the Great Trigonometrical Survey Of India and that is precisely what I am trying to avoid. Everest never stepped back from finding faults in his men and instruments when faced with the immediate problem of making a working plan for the Trigonometrical survey and the recruitment, organization and training of a kind of a staff to carry out that plan.

Specialization and Standardization

The men in the survey department were not any random officials from the British government offices. And all men involved directly and indirectly were not British at

[27] Ddn vol 286, pages 223-226, 31-10-35

[28] See, C.E.D Black, *A Memoir On The Indian Surveys*, see Phillimore also, (vol 3,4 chapters 1 – 3)

all. There were scores of Indians who were employed by the survey department. The Trigonometrical survey department could be divided onto the following divisions:

The office of the surveyor general: Renell as surveyor of Bengal, had his office in Dacca with harcarras, sickligars, peons. munshis, draughtsmen, and native interpreters and writers at his aid. Mackenzie had his headquarters in the Nilgiri hills in the south. Colebrook and Lambton and Everest had their offices in Chowringhee in Calcutta with their train of lascars, darwans, peons and interpreters. Along with the regular domestic help, every English officer was "required" to have 6 native helpers.

The clerical department: The clerical department under the Surveyor General's office was split into three groups. The first accompanied deputy Surveyor General to Allahabad with Alexander Botelle as accountant and Peter Dias as the writer. The next accompanied the registrar Charles Morrison to Mussourie with Joseph Dias as writer. The third party accompanied Joshua de Penning and stayed on at Calcutta. Finances show that the pay was meagre – Rs.45/month. The registrar drew Rs.400, while the head writer drew Rs.150 and the rest were drawing Rs. 45 a month![29] There were cases of dismissal by Everest. He basically was a task master and we see that when pressed with correspondence he called Dias to Mussourie, and Dias started demanding that his family should be brought and that he should be paid more, Everest immediately asked for his discharge of the 16 years of faithful service. He complained that Dias was wealthy enough receiving work pay, travel allowance plus an additional charge from the government.[30] He was taking advantage of the goodness of the department, so he recommended his immediate dismissal and instead engaged two other willing workers at the same amount being wasted in this manner! Also Dias was reported absent from work often by the registrar[31] and the directors instantly sanctioned Everest's plea. Everest was indeed a strict old man.

The drafting office: This being a very important division, I will be a bit more detailed. The drawing office was under the charge of John Graham who had been the head draughtsman for a long time. Among the names of the European and east Indian

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[29] Dehradun Volume Number 286, 16-2-34

[30] Dehradun Volume Number 286, 14-5-34

[31] Dehradun Volume Number 286 – 114-5 (reports make amusing reading – Dias complains of Morrison's threat "to kick you by the arse!")

draughtsmen whose names appear on the many beautiful maps of that era are – C.K,Hudsun, Breton, Mcreddie, Rodrigues, William Wilson[32], and Winston. Among the Indians who have been mentioned were Abdul Khaddar, Khadam Ali, Maniruddin, Mian Jan, Rahim Bucksh.[33] Starting salary was Rs.16 for the Indians and Rs.20 for the Englishmen. But they were expected to be able to engrave, be good lithographers write in splendid handwriting on the atlas which were continuously being produced print beautifully, draw well and be extremely docile and tractable. De Penning was left in charge in the Calcutta office.[34] Mr. Graham was preferred to others to the head draughtsman because he was both intelligent and trustworthy.[35] Everest writes however to move with caution. He asks Penning to be kind to his people. Not to lax, be strict in matters of duty and be indulgent with propriety. Men would never work half as well as when their hearts go with their heads.[36] Specialized Madras draughtsmen were brought in 1835, Wiliam McVicars and Charles Joseph. They both had knowledge of the plane table and chain surveying and Everest had no trouble in training them. They employed a moochie, whose identity is uncertain as documents submitted to the department were of an important and delicate matter and required a special charge and responsibility as they had to be maintained and repaired.[37]

The jobs in hand of these draughtsmen under Everest were the compilation of Captain Webb's routes in Oudh, Benares division, examining the Nagpur section, compilation of Everest's route, Chunar to Hyderabadh, copying Captain Wilcox's reduced map of the Brahmaputra copying the catalogue of the maps of the Court of Directors of the correspondence branch. The men were leaving for more lucrative work, resigning from the drafting office. This was mainly because of less remuneration for their exquisitely skilled work. Draftsmen could be divided into two branches, the compilers

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32 William A. Wilson – The assistant revenue surveyor in 1834. At the end of 1834, he transferred to the revenue survey dept., and was posted to Monghyr. And later moved to the Hooghly district in Bengal. His last posting was in Oudh till 1861 under Waugh.

33 Dehradun Volume Number 263, 318-20, 23-9-31

34 Dehradun Volume Number 283, 217-24, 24-11-32

35 Dehradun Volume Number 283, 228-31, 8-12-32

36 Dehradun Volume Number 283, 19-10-32

37 Dehradun Volume Number 286, 14-10-33

and the copyists. The compilers had complex duties and required intelligence and discrimination and knowledge of the pentagraph, how to protract routes and make maps from field books. They would not only make copies of them. Those of the latter group were simply to make copies from the maps compiled. The salaries of the copyists should be regulated according to the neatness and style of their work and of the compilers is their proportion to their usefulness.

During the years 1828-30 when the offices of the Surveyor General and the revenue surveyor was united the lowest pay of an ordinary draftsman was Rs.50, an apprentice was Rs.60, and of the compilers Rs. 50 to Rs.250 every month. De Penning recommended increases. Everest's repeated appeals to the government brought no redress and after two years Everest wrote that it was melancholy to witness the rapid decadence of the drawing department.[38] All the valuable draftsmen had left due to less remuneration, and those who stayed back were working only due to the fact that they had to because they had no better employment or wait until at the expense of the pens, ink, paper, and other drawing instruments of the State, they shall have perfected their skills and style so as to enable them to follow a like course.[39] The government replied that they were averse to any revival of your office establishment while a considerable portion of it was absent from the presidency. In the meanwhile they were at a liberty to fill the vacancies by resignations, either promoting individuals or by entertaining an equal number of others. Everest however struggled to hire capable men but reported that he could not get competent draftsmen at least in Calcutta. Even untrained apprentices could not be recruited from the upper orphan school for less than 60-70 Rs.. In spite of the difficulties, the outrun of the drawing office was very large and mostly of the first quality due to mainly to the supervision of Bedford,[40] De Penning and Graham. Everest wrote on his departure that it would have been utterly impossible to conduct the duties of the drawing department but for the valuable aid of Graham. The geographical materials have for the last 11 years been sent to the India house in a complete set as much accurately as possible.[41]

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38 Dehradun Volume Number 311, 13-2-36

39 Dehradun Volume Number 286, 10-5-36

40 Dehradun Volume Number 341, 6-6-36

41 Dehradun Volume Number 453, 13-12-43

The computing department: One of the main problems Everest had to face on his return back to India was the organization of an efficient body of computers not only for current work but to also bring up the arrears of the work by Lambton's observation and those of Ollivers' and himself in between 1822-1830. Even though Lambton had never kept any separate body of computers for himself, his computations were always carried out by himself and his assistant surveyors in the middle of the field surveys.[42] Very often his travelling department would remain at the headquarters for well over 12 months. For his own work, Everest had found time for his computations only when he was in a really bad shape and his health was failing or possibly when the work had stopped due to the rains. A computing establishment distinct from the field staff was now of the greatest importance though each party would be expected to take out their angles and set up their triangles. In order therefore to have all the arrears of the previous year's calculations brought up to date and any further accumulation be prevented in such a manner.[43]

Everest requested the appointment of a head computer and a deputy each on respectable salaries, an authority to engage and train a certain number of young native computers at salaries varying from Rs. 30 – 100. The men engaged would be required to possess a thorough knowledge of arithmetic and logarithms and of English. The number should be fixed at 8, because he believed that too many cooks would surely spoil the broth.[44] In respect to the head computer there wasn't any person eligible in sight then. Joshua De Penning was head of the Trigonometrical survey department under Lambton. He was then employed under Captain Montgomery and he would not agree to reside in Calcutta and undertake a responsibility with a salary less than 400 Rs. plus a pension granted in advance. The government agreed but wanted detailed estimates and ordered that these 8 computers be selected from that presidency itself. De Penning would act as the trainer of these people for 6 months and instruct them to avoid any blunder. When a party returned from a survey they couldn't engage themselves with active computation of data and also when a party was getting ready to prepare for the field, there was a lot of preparation and computations would simply interrupt their activities. If the party in field confined themselves to the computations

[42] Dehradun Volume Number 265, 4-2-31

[43] Dehradun Volume Number 265, 18-8-31

[44] Dehradun Volume Number 267, 17-12-31

and send their materials and field books to the office two computers under an active person like Penning would bring in all the work indoors and prevent any accumulation of errors. The computing office was sanctioned and established in no 35 Park Street, Calcutta. Joshua de Penning reached Calcutta about 20th November and in accepting the appointment he emphasized Everest's promise – he would never go into field without anybody's consent on his own, or to go further from Calcutta than the place where the office was established. He would labour hard to give his best – and in return wanted Everest to be responsibility of his security and safety. For reasons entirely unknown the offers of employment were sent out to the Bengali students, the terms being Rs. 30 a month whilst on probation. There would be a principal computer of Rs. 100, 1 deputy of Rs. 60, and 6 computers at Rs. 40. De Penning was chief computer and Peyton was his deputy among the probationers. Radhanath Sikhdar[45] accepted the appointment in December in 1831, and Everest soon appointed him as the sub assistant declaring that that he was the ablest student that the Hindoo College had ever produced and his mathematical acquirements are of a superior quality. Everest still doubted whether or not he would turn out to be efficient and hardworking, but he had no option than to keep him. The 8 young Bengali computers were – Sivshundar Deva, Rajnarain Bysack, Madhubchunder Mullick, Jadub Chunder Set, Kallycoomer Bose, Radhanth Bose, Nilcomul Ghose, Gooroochurn Dass.[46] They rapidly progressed in computing data and filled up the forms for latitude azimuths etc completing almost 5 – 6 daily.

The correspondence office: After the two posts of the Surveyor General and Superintendent of the Great Trigonometrical Survey of India were used into one, there was quite a lot of work for the Surveyor General in the general direction and control of his department.[47] In neither capacity had Everest any staff officer to take charge of the burden. He was overwhelmed with work as we all are at times. The scariest part was that the correspondence on Everest's desk was voluminous and frightful to contemplate. All copies of the originals would have to be preserved as well as the originals received. Much time and money was being lost, the office was overflowing with official correspondences, the Chief of the correspondence department was

45 Dehradun Volume Number 264, 19-12-31

46 Dehradun Volume Number 266, 16-7-32

47 Dehradun Volume Number 265, 12-10-31

heavily dependent on his registrar/ supervising clerk, or else the entire system got crippled. [48] There were set rules for sending correspondence from the field survey parties to the Surveyor General's office and there were rules laid down for replying from the Surveyor General's office to the survey parties on field. As he became more and more involved with the great arc, Everest became more and more, less able to handle correspondence even to the smallest quantity possible. He made clear with a disheartened soul that one could only write to him if they could not in the gravest of circumstances advance without his guidance and aid.[49] Also the *dak system* in India was so slow that it made the posting and delivering of letters and reports very inconvenient.

All these different specialized departments were directly responsible and answerable to the Surveyor General.

Concepts of Skilling and Training

The skilling and training processes also didn't restrict themselves to simply British surveyors and officials either. The natives were also trained to skill themselves. Getting into the above specialized departments, one needed to be exquisitely skilled in those arts and sciences. "The earliest and most distinguished civil engineers in England were men of little or no education."[50] The greater education was however acquired in workshops than in colleges. [51] In India where the engineer would have to do the work of half a dozen different men at once or exchange one work for another, the education required was different. And for the wants of the government it would be best supplied by any civil engineering college. The Thomason Civil Engineering College, Roorkee was the oldest engineering college founded in 1847, originally designed to supply the wants of the European Oversees and Native Subordinates on the Ganges Canal Works. The senior department there consisted of officers of the army, the first were young civilians, who studied to qualify for public works and the

[48] Dehradun Volume Number 378, 10-2-32

[49] Dehradun Volume Number 328, 166-167

[50] Professional papers on Indian engineering: The Thomason Civil Engineering College, by Major J.G.Medley, 1865

[51] Ibid, page 18

survey departments. The second department consisted of English soldiers who went out as overseers in the PWD, while the third department was entirely for natives. Instruction was in English as well as in vernacular and the pass outs went out as sub-overseers and sub-surveyors in the survey department and PWD. They all were given training in Mathematics; civil engineering, surveying, and drawing, higher instruction was in chemistry, mineralogy and photography.

Regarding my interest in the context I found out that surveying training included the use and adjustment of theodolites, chains, compasses, sextants, level and theodolites, execution of surveys with chains and plane tables, trigonometrical surveying, levelling, contouring and mastering the basics of practical astronomy.[52] Drawing included the construction of scales, making plans and sections from the actual measurements, mapping and architectural designing, mechanical and perspective drawing. Other than this prestigious institution at Roorkee, the Calcutta Civil Engineering College was founded in 1856. Officers and soldiers did not study here. There was no instruction in vernacular. The majority of the students were *Bengalis* whose instruction was basically in English They usually passed out for sedentary pursuits than the survey practical engineering employments. The Madras Civil Engineering College was also established in 1859 with just 20 military and 26 civilian students. There was also a Civil Engineering College in Poona in the Bombay Presidency which trained native and European subordinates, though the Bombay Engineers were skeptical of the training of the young recruits from this institution.

It was here that I will mention an Indian Radhanath Sikhdar, the most ablest computer from Everest's computing office. Along with the eight other Bengali graduates from the Hindoo College, (Calcutta) Radhanath as Everest says was in favor with everyone in the department. He was an energetic man ready to undergo any fatigue and acquire a practical knowledge of all parts of his profession. There wasn't a single instrument that he couldn't handle nor a single computation which he cannot master.[53] Eventually Everest had faith that he would prove that the aptitude of the countrymen for the practical as well as the theoretical is in no way inferior to that of the Europeans. However after a considerable period of time, due to reasons I will dwell upon in detail

[52] Ibid, page 18-21

[53] Dehradun Volume Number 289, 2-4-35

later, most of these young men left to accept newly established posts as deputy collectors in the revenue survey department giving the Surveyor General no prior notice.[54] The only one who stayed on was Madhub Chunder Mallik. Everest very heartbroken and disillusioned reported that the good fortune with which he had attended them would have caused him gratification if they would have paid more attention to the common curtsies of life at the time of their exit. Not one of them, even after being treated with kindness and support other than Gurucharan had the civility to thank him at their departure. This was a sorry mode of quitting his patriarchal influence and showed that they had no learning how to respect their "official superiors"![55] Madhub stayed on and was promoted to the salary of Nilcomul because he probably deserved it for his hard work as well as the general good conduct and zeal which he showed at work for the work as well as for the office. In his way Joshua de' Penning got a lot of unwanted work in his hands. He had to now train a batch of totally untrained new recruits for the posts of computers.[56] He was at the same time distracted by the responsibility of the workshop. Naturally to no real fault of Penning the computations suffered again much to Everest's distress.[57] He vehemently wrote to Penning – the computing office was organized and you were placed at the head for facilitating the computations of the GTS and the Great Arc. No duty was to be executed which is calculated to retard those computations. He wouldn't receive orders or comply with requisitions emanating from any other quarters than the office of the Surveyor General or the military department. And also Everest ordered him to desist from answering any letters unless they came from his office in the field or directly from the government through prescribed channels, which would have to be forwarded to him in turn. In this way Everest left Penning under a whole lot of pressure.

Following the desertion of the 7 computers from office, Everest was in a lot of distress when Radhanath Sikhdar asked leave to accept a profitable post as teacher to a public institution.[58] He begged the government to grant him a substantial increment in Radhanath's pay immediately to induce him to stay! 'Of the qualifications of

[54] Ibid, deputy collectors of Balasore and Bakhargunj

[55] SG to de Penning, Dehradun Volume Number 348, 15-3-33

[56] Dehradun Volume Number 475, 25-7-38

[57] Dehradun Volume Number 342, 25-4-38

[58] Dehradun Volume Number 342, 18-2-38

Radhanath, I cannot speak too highly. In his mathematical attainments, there are few in India whether European or native who can at all compete with him and even in Europe those attainments would rank very high.'[59] As a computer he was quite indefatigable and there was nobody else in Everest's department so thoroughly skilful in the application of the various formulae. [60] These qualifications so valuable to his department would be thrown away upon that to which he now looked a transfer to another job, and Everest needed him, needed his clear headed shrewd intelligence very much indeed at that moment! Computers comparable to Radhanath couldn't be hired in England at a less price then one guinea per diem and persons so qualified wouldn't be able to undertake the business on any terms that could be offered. Already there was a dearth of men and money on the horizon, and this sudden fear that Radhanath might leave aggravated Everest's situation. Habituated to Radhanath and his style of work of applying formulae but to investigate them and trained under Everest's own eyes he would be the cheapest instrument that the government would ever employ in a task of this kind. If that young man quit Everest's office Rees[61] would be required to go back to Everest's help with the cheapest salary and passage, and camp equipment furnished at the public expense, and moreover Rees would waste 4 months simply just to get to Everest's office, simply withdrawing without being of a dot of use to the entire computing office devastating the entire balance of his so hard kept system. And all this entire trouble could be avoided if only Radhanath's salary could be a bit increased to avoid him from leaving! [62]We can actually feel the frustration of Everest's state reading his account of the entire scenario. The government was sympathetic to the flustered Everest and agreed to immediately sanction the amount.

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[59] Dehradun Volume Number 475, 25-4-38

[60] Dehradun Volume Number 303, 2-9-33

[61] Vincent Louis Rees was the sub assistant computer in Calcutta office. He arrived in India in 1821. He refused the offer of going up country and in the hill stations of the north, and continued work in the computing office at Calcutta helping the Bengal computers , training them and taking full responsibility and management of daily time signals. Later because he became physically disabled to carry out further work after Everest's tenure, he took up work as a professor of maths at the Hindu College under the education department at 300 rs per month.

[62] Dehradun Volume Number 342, 139-44, 25-4-38

Secondly Radhanath was reviewed strictly and found that his talents, services to the British government was valuable, his salary increment was thus justified and seen with much respect and relief, and they hoped that his services would now be sealed and retained in the department. The new batch of computers soon settled down though there were frequent bouts of complaints and absenteeism. De Penning was often forced to bark out his discontentment to people like Baboo Gopaul Kissen Dutt who was extremely irregular in his work. During the rains of 1840, the computing office was honored with a visit from Lord Auckland and the computers took an opportunity of present him with a petition regarding their pay and prospects sending a copy to the Surveyor General very smartly. Everest replied that he would waive all objections to the irregularity of the channel. Though he took interest in native improvement and view with eagerness the progress made within the 20 years. Though he never had personal touch with these later computers they as well as all other members of the department were fully conscious of his patriarchal regard and in December there was a pleasant exchange of greetings between the retiring Surveyor General (George Everest) and the 8 computers then serving – Sreenath Sikhdar, Radhanath Sen, Gopee Nath Sen, Nil Comul Ghosaul, Mote Chunder Chatterjee, Bholanath Mazumder, Jagat Chunder Dev, And Shama Charan Bose. [63]

Everest brought in many new methods and instruments of survey in India. "Skilling" also refers to the adaptation of these newer methods to survey.

The Honourable Court of Directors supplied Everest with geodetical instruments and apparatus of every description which Messrs. Troughton and Simms made for him. The equipments consisted of a complete base line apparatus, the invention of colonel Colby precisely similar to that employed on the ordnance survey a great thodolilte 36 inches in diameter, even till date stands unparallel by any other instrument of the kind in the world. The efficient signals and recently invented heliotropes, reverbatory lamps and Drummond's lights. [64] These modern inventions together with the extreme precision of Troughton's graduation as well as the optical power employed and the rigorous system of changing zero, introduced by Everest had brought the territorial

[63] Dehradun Volume Number 404, 165-6, August 1840 from SGO office to the Head Computer

[64] Lights used as the substitution of luminous signals for opaque ones. They have contributed vastly to the improvement of the observations, cited in "Professional papers on Indian engineering: The Thomason Civil Engineering College, by Major J G.Medley, 1865" page 236

operations to a refinement of accuracy which may almost be pronounced unsurpassable. During his absence Everest had made himself familiar with the English Ordance System and with the modern improvement in geodetical matters that had taken place in Europe.

The apparatus supplied by the order of his Honourable masters was superior to any in the world and the London artist Mr. Henry Barrow was sent to India to maintain the apparatus in order. Thus splendidly equipped colonel Everest returned to India. In addition to the duties of superintendent he had now to perform those of surveyor general of India to which office he had recently been appointed by the Honourable Court of Directors. This union of offices though it served to facilitate arrangements nevertheless vastly increased his labours. In 1833 moreover the offices of deputy surveyor general at Madras and Bombay were abolished which further increased the duties of the surveyor general of India so Everest had to perform the work which had hitherto taken the undivided attention of 4 officers. In sequel these reductions have found to operate conveniently. The work was continued till 1841 when the whole Indian arc from Cape Comorin to the Himalayas mountains forming the main axis of Indian geography was finally completed.

The new technology which Everest brought in from Great Britain after 1835, were unique and never used before in the early years of the survey. The government was asked to sanction the erection of high masonary towers[65] across the Delhi plain towards the Siwaliks. Nov 1833 he reconnoitred this country between the den and Saharanpur and selected a stretch of ground west of Dehra as suitable for a base line. Everest had devised portable masts by which blue lights could be shown at a height up to 90 feet above the ground while he would himself be perched 30 feet above on a scaffold. He planned to maneuver this by trial and error to get well shaped triangles at inter-visible rays with sides of 25 miles. Blue lights were most brilliant to work at such distances but they burnt only for a few minutes at a time. As work proceeded he devised an even more rapid and reliable procedure. This was the ray-tracing method. It proved to be of great value in the running of the great arc and also in the running of other surveying series. Everest had planned for special astronomical observations to be made simultaneously at Kalianpur near Sironj and at Kaliana. In April 1837 he set

[65] Cited by R.J.Phillimore, Historical Records Of The Survey Of India, Volume 4, Page 297, 303

up two astronomical circles that had been constructed by a certain Troughton and Simmua to his order, but to his horror found both instruments to be top-heavy and rickety. New brass pillars were ordered from Fatehgarh and iron base plates and astronomical circles from Calcutta came in. (Mohsin Hussian whose technique had greatly improved was now entrusted with the very difficult task of dividing the circles. He carried this out successfully at Mussourie under Everest's supervision; both instruments were ready for service by October 1839 which they took to work in the field at Kalianpur and Kaliana.)

The **theodolite** had an azimuth circle of 34 inches in diameter and by means of 5 microscopic micrometers the divisions could be read to one tenth of a second. Great importance was attached to the construction of stations. Throughout the doab it was necessary to erect artificial structures of sufficient height to overtop the trees and of sufficient solidity to afford a firm support to the theodolite. These were of a very substantial kind, square solid masonry towers, 50 ft high. A stone slab supported on 2 transverse stone beams formed the floor on which entirely disconnected to avoid vibration while the observations were going on. The centre of the station was carefully defined on a metal plate let into stone and sunk in the ground for further security and the theodolite and signals were in all cases accurately adjusted over the centre. The sites of stations were also carefully selected with a view to well-conditioned triangles. A rule adhered to was that no angle of nay triangle should be less than 30 degree. Sides of the triangles should range to 35 miles.

The **heliotrope** was used for day observations. It had to be adjusted by signals from the observer, used only for short distances. Reverbatory lamps with burners and enclosed sir tight cases were used by night time and when these became too feeble recourse was had to blue lights burning at regular intervals. Means were provided to prevent any rays from the luminous object reaching the observer at the telescope excepting those which passes over the centre of the station. With the heliotrope and the blue lights it was found to be scarcely possible to arrange for the observation of more than one signal at a time, and hence the usual mode of proceeding was to take the angles between a mark of reference at some convenient distance from the station where the instrument was placed and the signals displayed from each of the surrounding stations successively and independently. For computing the sides of the triangles, *the theorem of legendre* was used.[66]

The relative heights of the stations were determined by means of their observations of their vertical angles as seen from each other made with 18 inch altitude and azimuth circles. The observations were reciprocal – one observer was placed at each of the two stations whose difference of altitude was to be found with a heliotrope by the side of his instrument and each observed theangle between the zenith and the signal of the other at the same instant according to pre - concerted signal giving. This method is perhaps the only one which can be depended on in any country. In India the effects of terrestrial refraction were greatly irregular.

There was a slight clash according to sources in 1829, a Triigonometrical survey in the Bombay presidency was commenced by Lt. Shortrede on an independent base and point of departure. These desultory principles were objected to General Hodgson at that time Surveyor General Of India who recommended that the work should emanate from the Great Arc and proceed to Bombay precisely according to Colonel Lambton's original design. This injunction remained unheeded and General Hodgson's authority the survey proceeded in an unsystematic manner till Everest put his foot down in 1831. Finding that no use could be made of this confused net of triangulation the colonel directed that the longitudinal series should be taken up where he left off in 1823 when Lambton died. Shortrede resigned, or fact could be that he was left with no choice but to resign and was succeeded by Lt.Jacob Black of the Bombay engineers by whom the Bombay longitudinal series was brought to a conclusion in 1841 successfully, without any more diversions.

Immediately after the measurement of the Calcutta base, Everest fitted out a party under lieut. James western of the engineers to triangulate along the meridian of the Parasnath Hill for the Calcutta longitudinal series. However he fell sick, and while

[66] Of the sufficiency of the methods, and the great precision of the whole geodetic operations the most satisfactory proof is found in the agreement absolute in the lengths of the 2 bases at the extremities of the arc as found by actual measurement and by computation through the series of triangles from one near the middle, "Professional papers on Indian engineering: The Thomason Civil Engineering College, by Major J.G.Medley, 1865", page 285

returning to England, died on the voyage. But the work went on under A.H.E.Boileau till 1838 resulting the work to be of really secondary grade. Instruments employed for the Ranghir series and the Amua series under Colonel Andrew Waugh were of an inferior order and the resultant triangulations were therefore of inferior quality too.

Interplay between the Revenue Department and the Trigonometrical Survey Department

It will be foolish to assume that each of these departments under the survey of India were homogeneous. Most of them had overlapping duties, and sometimes if not overlapping, they were heavily dependent on one other for some reason or the other. In this case, the interplay between the Revenue Survey Department and the Trigonometrical Survey Department is very important.

The Lawrence Memorial Roya Military School at Lovedale, Nilgiri, was a surveying school where the boys were trained in the field of practical surveying for the present government service as well as for future service.[67] The young boys were fully furnished with instruments, books, clothing. They were trained for the drawing branch. Maps and architectural designs made by them were submitted to the revenue board and the revenue board made arrangements with the School Governors that the boys must be passed on to the Revenue survey department once they pass out fully trained.

In the 18th century revenue surveys had been conducted in the presidencies of Bengal, Bombay and Madras by their respective surveying departments under the general oversight of a government body called the board of revenue. In 1814, the offices of the surveyor general in the 3 presidencies were combined and a new office of the surveyor general of India was created with its headquarters in Calcutta. Colin Mackenzie the surveyor general in Madras was appointed the first surveyor general of India. Despite the formal unity of a surveyor general there was little coordination on

[67] The Thomason Civil Engineering College, by Major J.G.Medley, 1865", page 1-5, also see Phillimore(vol 4, page i-x)

the ground between the revenue surveys in the individual presidencies which to all intents and purposes continued to be driven by the regional interests of local authorities.

In the Bengal presidency for instance the board of revenue was responsible for the surveys of lower provinces from its headquarters in Calcutta and for those of the northwest provinces greater coordination ensued. In north India the revenue surveys were a composite of 2 operations professional and native. The survey were under the charge of an European surveyor (military and civilian) who worked closely with local European and Indian officials, landholders and other local notables as well as the native staff whom he recruited information. The survey was essential was essentially topographical with administrative and village boundaries measured with precision by professional surveyors. Other information concerning the layout of individual property holding was sketched in by the eye and details about registers usually by the district officials and their Indian staff.

The professional part of the revenue survey commenced with district officials marking the boundary of the village to be surveyed. The European surveyor then demarcated this boundary scientifically using a Theodolite and chain. The objective of such a survey was to demarcate the external boundaries of taxpaying villages (mauzas) and to identify revenue paying estates (mahals) resumed tenures rent free tenures (lakhiraj) and lands concealed from taxation. In addition to the map, a file was prepared which gave a full description of the boundary and the names of adjoining villages. In the second phase of the revenue survey, a general survey of the village under assessment showing the cultivated lands within it followed. This so called "native survey" comprised of a map which wasn't drawn to the scale, and a corresponding field book.

An accountant registered each field number in the khasra along with the name of the proprietor, its area, soil type and the crops grown. After 1833, a change was brought into this process. A professional surveyor was placed in charge of the khasra surveys. In 1837, Lieutenant Henry Thullier insisted on the addition of a compass and scale to the maps. He devised a simple and basic surveying process that allowed him to employ native assistants instead of Europeans and Eurasians thereby reducing the cost of the survey. The native surveyor made his measurements by using a compass mounted on a graduated circle with a chain. Since all native measurements were based on the surveyor's circuit. This allowed the reconstruction of the territorial profile of a village in a neat progressive fashion. The survey field books called khasrah chittas continued to contain information about field size, proprietors, location and number of fields and estates in the collector's roll.

Every attempt was made to relate the revenue surveys to the ongoing work of the great trignometrical surveys of India which had commenced operations in 1799 and was still in progress. It was hoped that the revenue survey would be able to fill in the triangulated spaces fixed by the GTS and put "sinews and flesh on the colossal skeleton which the survey constructs".[68] The idea was that triangulation would provide a mathematically rigid framework on which all future surveys (topographical and cadastral) would be based. This aim worked though imperfectly and on many occasions the revenue surveys were carried out before the GTS had begun in the region. The revenue surveyors were able to anchor their surveys to the GTS generated points as in the case of the revenue surveys of the district of purnea 1840-1847. The faulty sequencing of the two map making projects characterized British surveying efforts throughout Asia and the GTS emerged as the structure of the imperial geographic archive only around the time of the retirement of George Everest (the surveyor general) in 1843. Meanwhile the revenue surveyors tried to narrow the discrepancies between their data and that of the GTS. For example the first surveying group to work in an area was supposed to leave a prominent marker at each triple boundary point, (where three pargana boundaries met) and to erect a small masonry platform for the benefit of any surveying parties that might follow.

How this actually worked out between the people on the field is unclear but surveyors reporting a decade or more less seemed not to have experienced any particular difficulty in aligning the two surveying systems. Later to judge from the reports sent to the surveyor general the confidence expressed by Mackenzie in the usefulness accuracy effectiveness and superiority of the revenue surveys only grew throughout the rest of the century.

The revenue surveys were conducted with varying degrees of success in the three presidencies. Even within a single presidency there were variations. The surveys

[68] Ibid page 3

conducted in the north western frontier province in early 19th century were considered inaccurate and of limited administrative value. There was considerable debate among governmental official surveyors and the general population concerning their scientific value, accuracy and use of native surveyors and their intrusive character.

It is now widely accepted that colonial cartography played an imp role in the established of British rule in south Asia. The revenue surveys produced valuable info on the structure of property rights and the productive potential of land in south Asia; they also represented the first attempt to map systematically the ancient pargana divisions thus revealing their disconnected and fragmented nature.

The territorial reorganizations that followed greatly facilitated the creation of a new geographical template for representing the modern state as a well-defined territorial entity with a hierarchy of non-overlapping internal divisions capable of representations on maps. The establishments of new police revenue and judicial divisions through the reconstitution of the older pargana divisions was one of the great silent projects of territorial adjustment conducted by the colonial state in south Asia.

Problems

There were problems at all stages of surveying, mapping, drafting, dispatching and delivering. The state of the survey office establishment was quite a dismal picture after all.[69] One could consider the hindrances of the monsoons and the jungle fever to be of deterrent to the surveyors but one cannot leave out the lack of staff, lack of money and lack of time to complete the colossal project which once Lambton dreamed of. While the revenue department was nearly flooded with funds, all that the trigonometrical survey department wanted was to maintain its accurate not even high standard of work. Even for that Everest had to beg the Court of Directors to allow some more funds to flow in! He pointed to the error in Olliver's longitudinal series that had been revealed by the closing on the Calcutta base for costs getting out of hand, but the Directors ordered that the spacing of future meridional series and for

[69] Ddn vol 402, 11-9-40, also see, The Thomason Civil Engineering College, by Major J.G.Medley, 1865", pages 268-269

reasons of economy be spaced at 2 degrees apart instead of one. Everest said he would obey orders if they were insisted on but pointed out that though such errors might be permissible to maintain the highest attainable standard of accuracy on the great trignometrical survey.

As work on the great arc and earlier subordinate series drew to a close, Everest had some difficulty in holding in holding the government to the original programme. Owing to the difficulty of working the triangles across the plains the whole survey was costing more than expected There was a lot of compromise on the cost factors which the surveyor general had to perform. The trignometrical survey department were lacking funds where as the revenue department on the other hand had aplenty. High cost had forbidden the construction of substantial masonry towers expect on the great arc and work elsewhere was carried on from low towers and mounds of sun dried and mud bricks with sides of triangles shortened to less than 15 miles. To atleast keep the quality of the survey high, Everest tried his best.

The mass evacuation of computers and other petty clerks and registrars from his survey office in Calcutta, led Everest to appeal to the Court of Directors. The government at this stage took two important steps. The employment of individuals already in a department under the GTSI was forbidden to any other department to avoid such mass evacuation of any department.[70]

One of the biggest drawbacks in combining the two posts of the Surveyor General and Superintendent of the Great Trignometrical Survey of India was that no adequate provision was allowed for the close control of the subordinate units. There was quite a lot of work for the Surveyor General in the general direction and control of his department. But it was asking too much for the same man to organize and administer the operations of the trignometrical survey which was no longer just confined to a single chain of triangles.[71] As Superintendent he not only had to build up and equip and equip new establishments of all grades but in Everest's case he has also to execute personally the operations of the master series of the Great Arc, devise new innovative methods to meet new problems and take a major part in reconnaissance and observations.

[70] Dehradun Volume Number 307, 338-9, 1-4-40

[71] Dehradun Volume Number 265, 12-10-31

In the correspondence department, another problem arose that the *dak system* in India was so slow that it made the posting and delivering of letters and reports very inconvenient. But developments worsened from the other side too. If Everest could lose it with his fellow workers the opposite could happen as well, as can be found. Bedford [72], and Penning was equally irked by Everest's failure to respond to the letters sent from the survey parties. Colonel Everest was so deeply engaged with his astronomical calculations at the Sironj base line that he was never prompt enough to reply to letters when in field and his sickness was always a bad quickner.[73] To the government he explained that business had fallen into arrears precisely what Everest had earlier tried to avoid, now taking on a monstrous shape. Countless documents were piled up, waiting in rough draft and wanting a copy and indexing. He earnestly had requested for as many writers and copiers as possible hired for not more than 50 Rs. per person. Such was the infrastructure and manpower he was equipped with while managing such a colossal project!

The very thing which turns a surveyor from a simple man to a master of is work are the survey instruments and the different measuring apparatus. For a proper understanding of the work of any surveyor it is essential to know what instruments he used. This will be the start of my second chapter having dealt with the concepts of 'specialization, skilling and standardization' which 'makes' a surveyor a surveyor. My attempt here is to describe not only the instruments used but also their pattern, and the manner in which they differed from the modern instruments but also their evolution and the employment of surveyor general's newer instruments. There were first the instruments for measuring distance, chains and perambulators. Next were the instruments for measuring angles, quadrants and sextants, compasses, circumferentors and Theodolites. And thirdly there were telescopes of special make for astronomical work and chronometers and watches for the transfer of time and longitude. (Protractors, brass scales, levels)

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[72] James Bedford, from the Bengal infantry, was the revenue surveyor of sahaswan in 1822, was also on the Burmese war front in Assam. He declined an appointment in the GTS because he honestly said that he possessed no knowledge of triangulation and trigonometry. Later he was glad to be deputed to Calcutta in 1837to advise on the revenue surveys of lower province of Bengal. However he had some disputes during this period with Joshua de penning and George Everest, Phillimore (vol 4, page 383)

[73] Dehradun Volume Number 344, 279-82, 20-11-39

Illustrations

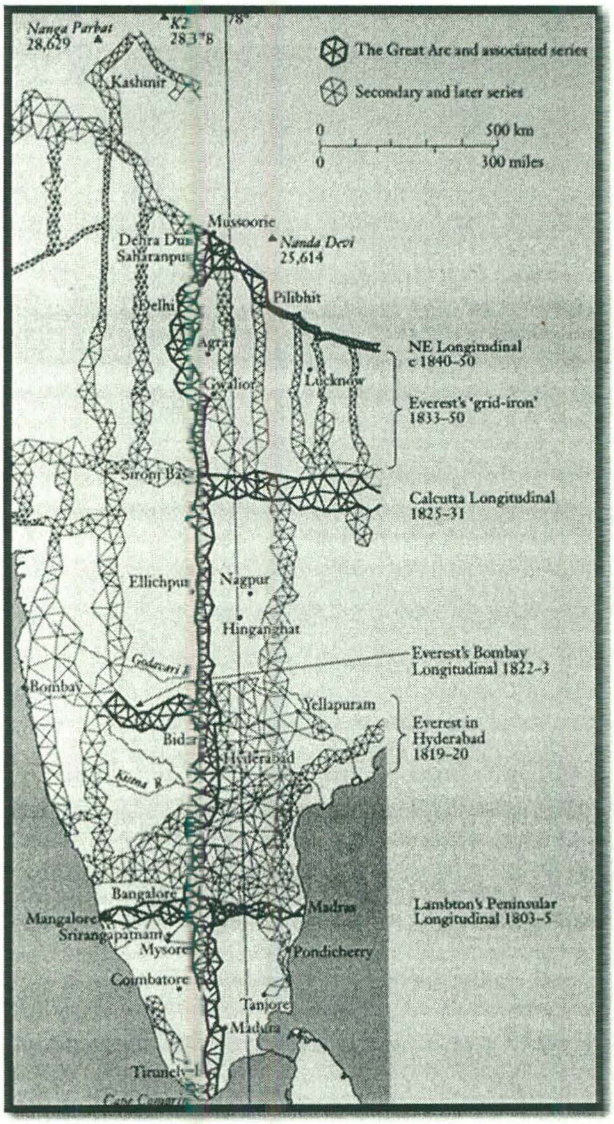

Figure 1: The Great Arc and Its Associated Series[74]

[74] Map taken from John Keay, "*The Great Arc; The Dramatic Tale Of How India Was Mapped And How Everest Was Named*", Harper Collins, London, 2000

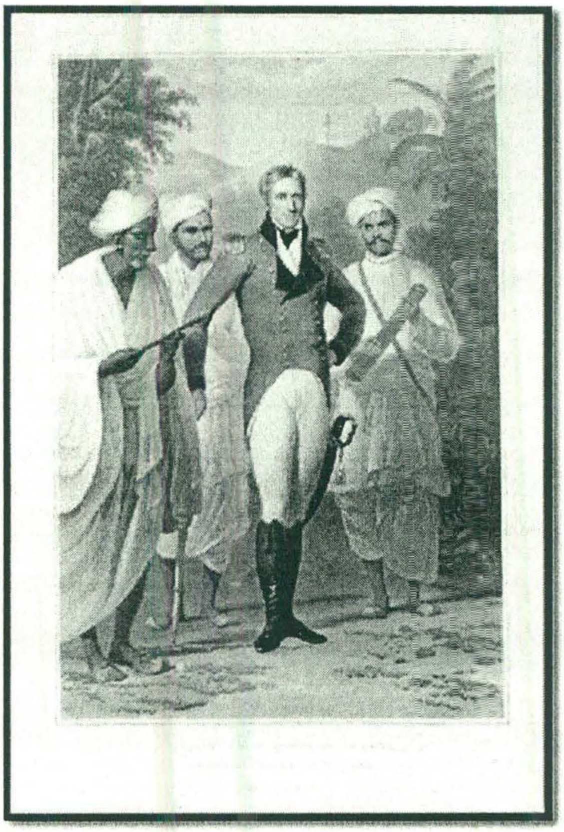

Figure 2: William Lambton

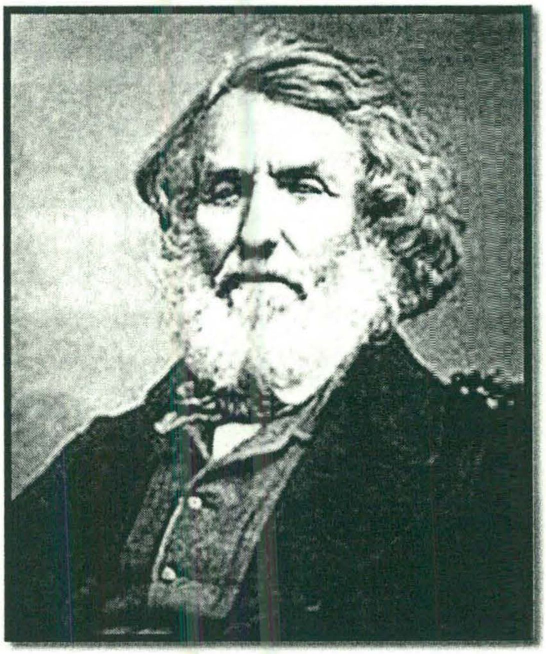

Figure 3: George Everest

CHAPTER THREE:

Chapter 3: Tools of a Surveyor

In the wider methodology of the history of technology and instruments, Robert Fox in his book, "*Technology in Society*", has spoken about the methodology of the history of technology.[75] In 1960s the history of science was beginning to make more intimate links with other disciplines, in particular with that of the social sciences. Thirty years later the history of technology was engaged in similar process of bridge building mainly with the social sciences. Scientific knowledge was in some ways "socially constructed".

This chapter will deal with the tools that a surveyor requires to carry out his survey. The themes of enquiry being the shifts in the purchase policy of the tools and instruments, the introduction of inspection practices of the various tools, the different adaptations of the instruments carried out by the artisans in the workshops under the strict orders and requirements of the Surveyor general. There will also be a short section on the workshop and the artisans and their training practices.

In "*Evolution of Technology*", George Bassala challenged the popular notion that technology advances by the efforts of a few heroic individuals who produced a series of revolutionary inventions and owe little or nothing to the technological past. He touches upon a somewhat chronological account of the development of technology by giving historical examples – including many of the major achievements of western technology the waterwheel, the printing press, the steam engine, automobiles and trucks and transistors to support his theoretical framework.

It was of major interest to me because if one enquired about the scientific tools used during the surveying operations under survey of India, one required to know how and why technology changes. The figure of George Everest as the surveyor general in India becomes important, not because he needs to be discussed in a more complex way, as to why the changes were required and what the factors behind the need for such changes were.

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[75] Robert Fox, "Technological Change", Amsterdam, Harwood Publishers, 1996

Daniel Headrik argued that Imperialism did not work by ideology alone. European technologies like quinine and rapid fire rifles made it easier to establish colonial holdings on Africa throughout the 19th century.[76] Imperialism was intricately linked up with its cartographic purposes. Surveyors in Ireland found that they could not always apply English conventions to a hostile populace and a landscape encompassing a dramatically different civil and economic infrastructure. Irish cartography developed in synchrony with the cycles of rebellion and conquest that constitute the broader canvas of Irish history. Cartographic progress was closely intersected with the imperial history.[77] Maps were one of the many means by which cultures and societies redefine and represent themselves. The british in India neither misrepresented themselves, nor did they represent themselves. They simply tried to create a geographical conception which would serve them well within their imperial boundaries. They required utilizing the resources and it was better to do so with an arranged system.[78]

But as regards India and the Great Trigonometrical Survey, Matthew Edney argues that the surveys and the maps had transformed the exotic land of India into a well defined geographical entity. The horizontal spaces of India which enclosed divided, and gave different political meanings to other homogenous spaces, merged smoothly with the vertical boundaries of the empire's social hierarchies. The empire, Edney says could have defined the map's extents, but the map in itself defined the empire in its actuality.[79]

From many instrument manuals and manuals regarding the nature and description and methods to maintain these instruments, we find few very basic instruments which the surveyors required for their surveying operations. The only study however which deals with instruments is by Sreeramulla and it wholly pertains to the archaic and

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[76] Daniel Headrick, "Tools of the Empire: Technology and European Imperialism in the 19th Century", London, Oxford University Press, 198 , also see Daniel Headrick, "Tentacles of the Progress: Technology Transfer in the Age of Imperialism 1850-1940", London OUP, 1988

[77] Thomas A. Boogaart , Annals of the Association of American Geographers, Vol. 89, No. 1 (Mar., 1999), pp.162-164 , review of 'Shapes of Ireland: Maps and the Makers, 1564-1839. J. H. Andrews. Dublin: Templeogue, 1997'

[78] Ibid, page 164

[79] Matthew H Edney, *Mapping An Empire: The Geographical Construction Of British India, 1765-1843*, University of Chicago Press, 1997, page 243

exotic astronomical instruments in ancient India.[80] The historiography of astronomical instruments in India is underdeveloped. Ancient texts in which we have read about astronomical instruments are Brahmagupta's *Brahmasphutasiddhanta*, and Bhaskaracharya's commentary on Aryabhatta. Sreeramulla Sharma argues that the history of astronomical instrumentation in India has been dominated by two mutually contradictory yet complementary currents. On one side, there is the shadow of certain inescapably archaic instruments that held their sway even after they had become obsolete while on the other side, Indian astronomers have been very receptive to exotic instruments from other cultures.

Deepak Kumar in "*Technology and the Raj*", amply demonstrated that technological innovations and Western scientific paradigms played a much greater role in shaping the political and socioeconomic transformations associated with Western domination than much of literature on colonialism would lead one to believe.[81] As imperial consolidations involved huge construction works, civil engineering received a patronage. Industry-oriented branches like mechanical electrical and metallurgical engineering came only after 1930s. Deepak Kumar argues that technical men like engineers were less interested in 'local knowledge and practices. The instruments employed in the surveys used to be brought from England in the early phases under James Rennell, but later this changed because the tools had to be applied suiting the Indian conditions, climate, temperature and terrain. Indian fields, and hills became the experimenting laboratory for the British surveyors.

S. Ambirajan and Arun Kumar call attention to yet another cluster of critical consequences of technological and scientific transfers under colonialism: the fundamental shifts in organization, technique, and epistemologies that resulted from the introduction of Western education and such ambitious Colonial projects as the Geological Survey of India and Canal, Road, and Railway construction.[82]

In many instances science and technology converge reflecting a pattern that was common in colonial situations. In part, this convergence reflected a more general

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[80] Sreeramulla Rajeswara Sharma, "The Exotic and the Archaic", New Delhi, Manohar Publications, 2008

[81] Roy MacLeod and Deepak Kumar, "Technology and the Raj: Western Technology and Technical Transfers to India 1700-1947, New Delhi , London , Sage Publications, 1995

[82] Macleod and Kumar

global trend that has been seen as one of the defining features of the second industrial revolution of the late 19th century, particularly in Germany and the United States. But, as Kumar argue, this fusion can also be traced to the fact that science in the colonial context usually meant applied (rather than theoretical) science, which could be readily linked to what colonial officials viewed as projects with practical utility and rapid economic returns.

The organization, and shifts in the technology of surveying have not been made dealt in detail in any essay, which necessarily doesn't mean that there was no change or shift in the colonial organization of the surveying technologies.

The very real racial barriers that even the most brilliant of Indian scientists and inventors faced, was the fact that even the best of them were denied pay equal to that of often less gifted Europeans or posts commensurate with their talents and level of education. As Kumar shows, most strikingly in the case of the naming of Mt. Everest, Indian scientists were also denied the international recognition that their findings ought to have earned them. A British administrator named the peak after his mentor and patron, George Everest, despite the fact that Radhanath Sikdar had been the first to recognize that it was the highest point on earth; as Kumar tersely observes, "nowhere did [the administrator] mention the contribution of Sikdar"[83] (pp.59-60). In this regard it is worth noting that scientific research and, one might add, technological innovation in the colonies was at best a difficult and often a demoralizing pursuit in many ways. Radhanath sikhdar was the only individual out of his entire batch of Derozians who took up science as his profession remaining true to the ideal of discovery and enquiry. The rest of the firebrand derozians were mostly into social reform movements in Bengal.

Technology can be seen from the perspectives of social history, economic history and cultural history. It may not drive history but has an undeniable presence in its consequence. Techniques form the basis of what Braudel calls material civilization. Any account of the ***homo faber*** would be a history of technology.[84] And a social history of technology would be a relationship between society and technology, assuming that changes in one can bring about possible changes in the other. In many

[83] Ibid, p 59-60
[84] Ruth Cowan, "A Social History of American Technology", OUP, New York, 1997, p3

ways technology is central to human society shaping its political and cultural and social changes.

Technology brought by the British colonialists acted as a watershed to previous traditional surveying tools and methods. Since for a proper understanding of the work of any surveyor it is essential to know what instruments the surveyor used, an attempt is made to describe not only the names of the instruments used during the 18th century, but their pattern, and the manner in which they differed from modern instruments. Since the objective of this chapter is to shed light on the history of instruments and the tools with which the surveyor carried out his survey it could be said at the onset that Trigonometrical survey operations saw the most significant innovations in instruments on field and in the workshops off the field.

However much we try to restrain our admiration for the surveyor generals under whom the radical changes were carried out, it still comes out clearly that George everest and Andrew Waugh were the two primary figures who brought about a massive change in the GTSI. The superiority of modern instruments rested mainly on the perfection to which the manufacture of the instruments had attained. Markham in his "*Memoirs of the Indian Surveys*" points to the process of slinging native men down in order to get astronomical observations in 1777 to the changes taking place after 1830 when Colonel George Everest returned from England after his sick leave.[85] This period can be called a watershed because of the changes in the surveying techniques and instruments he alone had brought about.

Supply of instruments:

Under the old system from Rennell to Mackenzie every surveyor on full allowances provided his own instruments, whatever pattern he fancied while the Surveyor General and the Commissary of Ordnance maintained small stocks of the commoner pattern for issue to assistants and to the officers for military surveys. These instruments were not suited to The Great Trigonometrical Survey and had to be approved by the surveyor general since many of them were his personal design.

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[85] Clement Markham, "A Memoir on the Indian Surveys", page 51

Under Everest's administration, instruments used to be stocked by the Surveyor General and issued on government service. While approving this arrangement for The Great Trigonometrical Survey, the government insisted on keeping the old rules for a field or river surveyor whose allowance covered the provision of instruments. Bearing in mind the trouble that had occurred after Colonel Lambton's death and that experienced by Colonel Hodgeson in getting a clearance certificate on account of departmental stock and issues, Everest ordered that all instruments in either division of the department are to be public property.[86] The surveyor general had the sole authority to issue instruments applicable to the occasion to only those officers employed under his orders who were able to give receipts for them and be responsible for keeping them in good condition. That is to say that no officer would be allowed to use his own private instruments without the sanction of the Surveyor General, or even keep such instruments in his possession without notifying him. There were never enough instruments to go round and Joshua De Penning at the Calcutta instrument office was given authority to purchase on the Calcutta market any delicate and expensive instrument of the character of a chronometer which could be required for public surveying service.

The normal channels of the supply of instruments were from England through the military board which ordered that the custody of all instruments should be vested in the hands of only the surveyor general. In the case when the surveyor general was not in his office at Calcutta, De Penning had to face difficulty to issue, because it would "harm the efficiency" of Everest's department.

It is interesting to record the first introduction of the instruments. In 1831 the Court Of Directors called to attention to a new description of measuring tape, chronometers, and cheap plane tables. With great satisfaction, on his return to India in 1830, Everest asked for the appointment of a separate committee to report on the highly complicated compensation bars and other instruments which he had selected with so much care in England, Theodolites of various patterns and lamps, and heliotropes.

[86] Phillimore, Historical records of the survey of india, volume 4, page 124

In 1825 Everest was ordered by the Court of Directors to superintend the construction of certain instruments. The Court of Directors also announced that they would be employing Troughton and Simms (celebrated artists in England) to supply for the East India Company. With Sir Thomas Anbury as the President of the Court of Directors, the committee expressed satisfaction at the quality of instruments that were tested and constructed under Everest's regime. [87]

Custody of Instruments

During Everest's absence in England all the more important instruments of The Great Trigonometrical Survey such as Lambton's Great Theodolite, Zenith Sector and Steel Chains that were not required by Olliver's party were packed away safely in the military magazines of Agra and Sagaur.[88] On Everest's return he ordered them to Calcutta. To make room for them at the Surveyor General's office and also for the new instruments from England, he asked permission to transfer to the arsenal all "common surveying instruments" in excess of the departmental requirements. The *Mathematical Instrument Maker* was not in charge for stock and issue which was normally the business of the registrar but which early in 1832 was temporarily passed to one of the new assistants , George Logan who was given charge of the barometers, thermometers, and other meteorological instruments. He was required to send daily reports and in case of any instrument breaking down or malfunctioning, it would have to be sent to the mathematical instrument maker in Calcutta.

For instruments in the regular departmental use one of the senior assistants were made responsible and in 1836 Rossenrode was directed to receive charge from Mr. Morrison of the instruments.[89] After Barrow left Calcutta, Joshua de Penning was given full responsibility of all the instruments in the workshop as well as those in store. He was in turn responsible to the Deputy Surveyor General who took charge till 1839 and asked that those instruments not required by The Great Trigonometrical Survey or for current office use should be immediately sent to the Fort William,

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[87] Phillimore, volume 4, page 125

[88] Olliver was the surveyor who completed the Calcutaa Longitudinal Series under Everest.

[89] Rossenrode was

where there were men to look after them and clean them when required. The Surveyor General was equally insistent on the fact that he be relieved of the duty of the instruments beyond the requirement of the department. Even though new rules were laid down everyday Everest writes that,

> "my term is so soon to close that I hardly think it desirable to make any new arrangements to meet my case, for my successor I presume will be of a different temperament." [90]

After Everest retired, the authority was eventually transferred to the Commissary General's arsenals of all the instruments except those required for the surveyor general's and the revenue survey department.

Introduction of Inspection Practices:

All important instruments which required accuracy in their construction were still being made in Europe and moreover they would have to have the benefit of scientific supervision of the highest order if they were to prove efficient in such a service as the Indian Survey. The supervision of instruments was a constant requirement. In 1862, the supply of a completely new set of instruments had been sanctioned for The Great Trigonometrical Survey.[91] And in the following year the importance of having all the instruments for India had been subjected to special scientific examination. It had been be impossible to find half a dozen men in England who combined the experience of India, knowledge of highest branches of mechanical science, fertility of resource, and inventive genius which were required in the officer to whom the superintendence of the manufactory of instruments for the Indian Survey could be properly entrusted.

Colonel Lambton during the Bombay triangulation, was in constant difficulties with his instruments though he was eventually provided with the best that the period could offer him, he had no means of getting repairs done, and no proper person in England

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[90] Phillimore, HRSI, Vol 4, page 148

[91] refer to The Accounts of the operations of the GTSI, Volume 2, Page 312

to refer to until his assistant Captain Kater went home.[92] He used to repair his damaged instruments himself.

Difficulties arose regarding the measuring chains in the latter half of his general ship, and Lambton felt the need for a proper system for the supply and testing of instruments. In those days it was the custom of the service until the first Burmese war for officers to supply their own instruments. Colonel Hodgeson when he was surveying had instruments and books of his own to the value of Rs. 13,000 and nothing belonging to the government.[93] As surveyor general he considered this to have been a better system than the supply by contract and declared that the instruments sent out by contract were not such a good observer would consent to use. [94]

Everest saw these evils and provided a remedy. He personally superintended every detail in the construction of his instruments while he was in England watching them at every stage. When he returned to India with them in 1830 he took an accomplished maker, Mr. Barrow out with him and established a Mathematical Instrument Manufactory at Calcutta.[95]

Most fortunately the services of Colonel Strange were secured, an officer who possessed all these qualifications. He was a member of The Great Trigonometrical Survey from 1847 to 1860. It will be remembered that he had conducted the Western Longitudinal Series, superintended the measurement of the Karachi Baseline and for a short while, had been in charge of the Coast Series. He thus had had considerable practical experience in trigonometrical surveying while his mechanical genius and knowledge of mathematical, geodetic and astronomical instruments had not been surpassed by any man in England.

In 1862, the Secretary of State for India entrusted Colonel Strange with the task of designing and superintending the construction of geodetic and astronomical instruments for The Great Trigonometrical Survey and in 1863 he was appointed to

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[92] Captain kater was

[93] Markham, page 59, Served in the GTS in Cawnpore and Dinajpore distrcts in UP and Bengal respectively 1821 - 1932

[94] Ibid, page 51- 65

[95] Markham, page 68

examine and test all the instruments ordered for India.[96] A set of instruments were required for the efficient discharge of his duties and a special observatory for testing was an essential necessity. The provision of those requisites was sanctioned in 1864-65 and the observatory was erected at the warehouse of the store department of the India Office in Belvedere Road where Colonel. Stranger's office was established.

When Strange was first appointed there was no one kind of instrument supplied to India which wasn't faulty either in respect of form, principle or craftsmanship. The improvement effected by Strange has been attained by three measures, the abolition of patterns, the abolition of tenders, and a system of thorough inspection. In December 1867, Mr Thomas Cushing, an accomplished mechanic trained under the eye of Mr. Thomas Cooke of York was appointed as Stranger's assistant. Under the Colonel's instructions he became qualified to inspect, adjust, and observe with every description of scientific instrument and apparatus furnished to the Indian services.

Colonel Strange employed instrument makers and gave them orders to make more than one instrument. Each kind of instrument was made and reproduced into 2-3 specimens of the same model. This plan stimulated effort and afforded the means of checking any augmentation of prices. Makers were called upon to give estimates not tenders for each class of instruments. The instruments were subjected to rigorous inspection and to actual trial, before payment was made. This raised their price but at the same time it greatly increased their accuracy. In 1865 there were 4,148 instruments inspected, which cost Rs.1,06,094. In 1872, the number inspected was 18,000 and the cost was Rs. 2,08,452.[97] The number of different instruments ordered by Colonel Strange was about 150. He took special care to inspect the instruments made. Several of them had to be individually carefully examined and tested and some required to be taken to pieces. He mentions in his reports that the number of instruments which would be supplied if inspection existed would possibly be the same as that supplied without any inspection. Also the effect of efficient superintendence must be and has been to raise the price of instruments.[98] With the death of Colonel Strange on 9th March 1876 he was succeeded in the duty of testing instruments by his assistant Mr. Cushing whom he had himself trained with his own hands.

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[96]Markham, page 69

[97] Phillimore, volume 4, page 176

[98] Historical Records of the Survey of India, Volume 3, page

I argue here that the board of directors granted the employment of specialized trained military officers who were either directly related to the Ordnance Survey of Great Britain to be employed in India under The Great Trigonometrical Survey for the testing and maintenance of the survey instruments. They would in turn train their subordinate officers who wouldn't necessarily be given any formal training but that on the field of the varied uses and the means to keep these instruments in order.

Adaptations made:

Colonel George Everest had completed one of the most stupendous works in the whole history of science. No scientific man had ever had a grander monument to his memory than the Great Meridional Arc of India. The whole conception of the survey as it exists even today was the creation of his brain. He had entirely altered and revolutionized the old system for the network system of William Lambton by substituting the ***gridion*** for the network method. He introduced the compensation bars which had measured every Base line in India down to present day.[99] He invented the plan of observing by heliotrope flashes and the system of ray tracing and designed the plan for the towers. There had been modifications and improvements since his time but nearly everything in the surveys was originated by him. In his letters to the Duke of Sussex he spoke of two of his assistants as having "attained a degree of accuracy and perfection of skill which it would be impossible to surpass".[100] One of them had been Sir Andrew Waugh and the other had been Major Renny Tailyour.

The Instruments

The instruments which were used by the surveyors under the Surveyor Generals from the time of Colonel Mackenzie (1816-1821), William Lambton (1800-1823), George

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100 Everest George "On Instruments and Observations for Longitude for Travellers on Land", Journal of the Royal Geographical Society of London, Vol. 30 (1860), pp. 315-324

Everest (1823-1843), and Andrew Waugh (1843-1865) were Chain, Perambulator, Chronometer, Sextant, Theodolite, and Prismatic Compass.[101]

Chains

Chains were probably used for all large scale surveys but not for military route surveys. There were many references to the Gunter's chain but only one specific reference to a 100ft chain. Lambton used this chain with links of 2 ½ feet each.[102] But chains often gave faulty measurements and the inaccuracy with which the survey had to be re-done, leading to confusion and the wastage of time and expense.

Perambulators

Perambulators were used in preference to the chains, because chains had proved to expand due to heat in the summer time and provide inaccurate measurements. The essential parts of a perambulator were the wheel which used to be driven along the ground and a Cyclometer was geared to the wheel and graduated in miles and various lesser units.[103] Perambulators were used rarely by James Rennell in the early days of the survey. In 1851, Everest described them as "the staple commodity for route surveying is the perambulator. All English perambulators were flimsy, with bigger wheels, and incapable of working except on a smooth road. The one used in the survey here was the Pringle's Perambulator. Often however these would break down between and the exact situations of places couldn't be obtained (Cuttack couldn't be mapped because the perambulator broke down between Cuttack and Balasore).[104] Small wheels would serve the purpose, because large wheels often had the tendency to break down.

Chronometers

Although it was still the policy of the Company that surveyors should provide their own instruments a few of the more common sort were held by the arsenals. The Surveyor General had a small stock of special instruments and in 1802 proposed that a few good chronometers, sextants, theodolites should be sent out as these were too

[101] Catalogue of British Scientific and Technical Books, London, 1876

[102] Comparison of the old and new Chains, William William Lambton, London 1802

[103] Phillimore, vol2, page 219

[104] Dehradun Volume 49, 1805

expensive in this country to deter the gentlemen from purchasing them and learning their uses. These might have been kept in store or deposited in this office to be delivered out occasionally as surveys were ordered. Packages of 'Gunter's scales', 'Gunners's quadrants' and instruments of that nature in wax cloth was very exceptional.[105] They were stored carefully in boxes, cases and rasps.

Compensation Bars

While in England during 1825-1830, Everest used his time constructively in studying the newest improvements and superintended the construction of instruments on the most approved principles. When he returned to India in 1830, he was provided with the best instruments that could then be produced. He had a large theodolite with an azimuth circle of 36 inches in diameter constructed by Troughton and Simms. But the most improvement introduced into the survey by Everest at this time was the measurement of the Bases by compensation bars instead of the old inaccurate method by chains. Inaccurate is not a term I would use but measurements and triangulation under Lambton were faulty and inaccurate and Everest after having finished on his grand project of the "The Great Arc", would have continued re-measuring the entire subcontinent had it not been for the decision of the Court of Directors that he should let that be and concentrate on closing the triangulations in the frontier provinces and the borders instead of "wasting' time and resources in re-measuring. One of the objections to the chain method was the impossibility of determining the temperature of its different parts while in actual use. Colonel Colby of the Irish Survey invented the method of eliminating the errors arising from changes of temperature by compensation of self correction.[106] Colonel Everest arrived in Calcutta in the autumn of 1830 with 6 sets of bars and well supplied with the most improved instruments. He combined the appointments of the Surveyor General and Superintendent of The Great Trigonometrical Survey in his own person. He found that Mr. Olliver had nearly

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[105] See 'Gurley's Manual of Surveying Instruments", London, 1850

[106] Advantage is taken of the unequal expansion of various metals to eliminate the effects of the temperature variation. Two bars one of brass and one of iron about 10 feet long are clamped together in the middle so that no motion can take place near the centre, and any expansion in temperature must be towards the extremities. At 62 degrees the two bars would be of the same length. At the end of both bars an aperture is worked out to admit a conical pivot and both pivots are adjusted to a flat iron tongue. When the temperature rises the brass bar will be lengthened more than the iron one and the tongues will incline inwards and vice versa. Consequently there is a point on the tongues at which theoretically the expansion of the bars is compensated by the inclination of the tongues.

completed the Calcutta Longitudinal Series which originated at Kalianpur and terminated at Fort William. On Everest's arrival he resolved to measure the Base Line of verification for this series with the compensation bars.

In 1832 Everest resumed the work connected with the meridional arc series and he had to encounter difficulties. His staff had to be trained to the work, plus in addition to all the incessant labour in the field he had to transact all the business connected with his office as surveyor genera

Permanent Masonry Towers

When the surveyors entered Delhi they had been faced with a different problem. There were mangroves and lofty trees thickly scattered all over the villages. The dust clouds also obscured the view. So he innovated a method of erecting permanent towers for stations on the Gangetic plain. And in order to select their positions, Everest designed a mast of 30 feet high with a circular table, 40 inches in diameter at the top round which a square scaffolding of large bamboo was built. This was intended to observe from and 13 other masts almost 70 feet high with cross bamboo staves having an ignited blue light at one end and a sway rope at the other end were placed on the surrounding stations. The instrument used at the top of these observing masts was the "Troughton and Simms" 20 inch theodolite.[107] The signals at the pinnacles of the other masts were blue lights burnt by sets of 4 at ten minute intervals. But owing to the distance between the stations the signals were scarcely visible to the naked eye and it was necessary to lay the telescope in the proper direction to be calculated before hand by a series of minor triangles. This system invented by Colonel Everest was the ray tracing method. He also used the heliotrope for day observations at short distances and reverbatory lamps with burners and blue lights for the night.[108]

Heliotrope

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[107] Accounts of the operations of the Survey of India Volume 2, page 45, 48

[108] The lamps constructed by Everest in 1830 consisted of a parabolic reflector 12 inches in diameter applied to an argand burner the whole enclosed in a wooden shed with a glass window which served as a packing case in travelling. The heliotrope is a circular mirror 10-12 inches in diameter fitted for vertical and horizontal motion, Markham page 73

The heliotrope is a silvered glass mirror of 6 to 8 inch diameter. It is suspended horizontally in a semi circular frame which is mounted vertically on a light tribach. It can be turned round in altitude and azimuth so as to reflect the sun rays in any required direction by tangential screws. A hole is bored through the centre of the glass or a portion of the silvering is removed to enable the instrument to be looked through and aligned. An upright diaphragm is set up over the station having cross wires whose intersection is exactly in the normal of the mark below and the heliotrope is set up 2 feet behind the diaphragm on the prolongation f the line between the intersection of the wires and the observation station.

The aperture of the diaphragm is made to vary with the distance to which the rays have to be transmitted in the proportion usually of a tenth of an inch to a mile for a larger apertures the pencil of rays would dazzle the eye of the observer using a telescope of high magnifying power. The method of manipulating the instrument is readily learnt and the natives of India soon became greatly adept in the art and even in the more difficult matter of transmitting the sun's rays in a given direction by double reflection with the aid of a second heliotrope when the sun's rays couldn't be directed reflected. [109]

Argand Lamp

The Argand Lamp with its flame placed in the focus of a parabolic reflector had a depth of 5 inch and an aperture with a diameter of 12 inch. The whole of it was enclosed in a wooden case which was air tight all around but had a removable chimney of sheet iron placed directly above the glass chimney of the burner; thus protected the lamp burns satisfactorily in all weathers without the fear of getting extinguished by the Everest's gale of wind. The box had a glass door which was covered with a small aperture suitable to the distance and considerably larger than the aperture of a heliotrope.[110]

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[109] Ibid, 58, also refer to Account Of The Operations Of The Great Trigonometrical Survey Of India Volume 1.Colonel J.Walker , Dehradun, 1870

[110] Phillimore, volume 4, page 132

It was customary for the signallers to set up the heliotrope during the day time and lamp during the night each being removed in turn to make room for the other. But arrangement was found unsatisfactory in practise causing much delay and being attended with the risk of losing the alignment in hazy weather

The Theodolite

From the very commencement of the operations of this survey under Colonel Lambton the instruments employed in measuring the principal angles have invariably been theodolites; and these have all been of considerable magnitude, the diameters of their azimuthal circles ranging from a minimum of 15 inch to a maximum of 36 inch. In every instance these instruments have been provided with micrometer microscopes for reading the azimuthal and vertical circles. Smaller theodolites provided with verniers had been employed in preliminary operations and the secondary triangulation but never used in the principal triangulation. One of the first theodolites procured by William Lambton was the largest theodolite employed in any operation hither to.[111]

A detailed study of the theodolites employed in the survey is found in the accounts of the operations of The Great Trigonometrical Survey.[112] The names of the principal theodolites were given the name of the original maker or of the person by whim the theodolite was remodelled and also of the dimension of the diameter of its horizontal circle.

Cary's 36 inch theodolite – it was obtained by Colonel William Lambton in 1802 when it had only 2 microscopes for reading the horizontal circle and as many for the vertical circle which had a diameter of 18 inch. The telescope had a focal length of 37 inch and the magnifying powers ranged from 36 to 66. It was seriously injured in 1808 while being raised to the summit of a lofty pagoda in Tanjore, the horizontal circle receiving a violent blow and becoming so distorted that it became completely

111 Accounts of the operations of the GTSI, Vol 2, page 49

112 Ibid, page 50

useless. The symmetry of the circle was restored by native artificiers working under Colonel Lambton's superintendence but the extent to which the graduation had been injured was never ascertained very definitely. In 1833 it was reconstructed at Calcutta by Mr. Barrow by whom the circle was newly graduated and furnished with five "fixed" microscopes at 72 degrees apart and since then it had been known as "The Barrow's 36 inch theodolite and had given excellent results.[113]

Throughton and Simms's 36 inch theodolite – it was constructed under Colonel Everest's instructions in the year 1830 by the celebrated firm whose name it bears. The horizontal circle was hand divided by Mr.Troughton and it was furnished with five equidistant flying microscopes. The telescope had a focal length of 39 inch and magnifying power ranging from 49 to 98. This instrument had possibly been the best of all the instruments appertaining to the survey and it had been most extensively used. [114]

Colonel Waugh's 24 inch theodolite – these instruments were constructed in 1846-47 under Colonel Waugh's directions from the parts of various instruments which in their original form had been found to be unsatisfactory. The horizontal circles were hand divided by Mr. Troughton, with 5 equidistant flying microscopes and telescopes having a high focal length. They have both given excellent results and been used extensively in the surveying.[115]

Troughton and Simms 24 inch theodolite – these instruments were constructed in 1847 and their circles were graduated by the admirable self acting dividing engine which is described in the Volume XV of the Memoirs of the Royal Astronomical Society, the azimuthal circles were originally furnished with 3 fixed microscopes but the usual number of microscopes were substantially increased to 5 which were placed as usual at equal distances apart. These instruments had given admirable results and

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[113] A Catalogue of British Scientific and Technical Books covering every Branch of Science and Technology Carefully Classified, prepared by A Committee of the British Science Guild, London 1921, page 159

[114] Ibid, page 165

[115] Account of the Operations of The Great Trigonometrical Survey of India Volume 1.Colonel J.Walker , Dehradun, 1870, page 52

were little inferior to those obtained with the 36 inch instrument made by the same makers.[116]

Barrow's 24 inch theodolite – these instruments were constructed in England by Mr. Barrow in 1847-48. The circles were believed to have been hand divided, originally furnished with 3 fixed microscopes but the design of each instrument was subsequently modified in this country, the horizontal circles were fixed to the tribachs and were surmounted by 5 flying microscopes. The telescopes all had focal length of 30.6 inches with magnifying power of 25 to 116. They were both good instruments but not equal to the Troughton and Simms 24 inch theodolites.[117]

Troughton and Simms 18 inch theodolite – these instruments were obtained by Colonel Everest in 1830 though apparently similar in most respects, their horizontal circles must have been divided in a different manner. There were errors of graduation. The first of this genre of theodolites had caused great dissatisfaction though the results which had been adopted from the readings of this theodolite in particular have been far more accurate. The second of its make has been considered as a good instrument for its size though decidedly inferior than the 24 inch theodolite. The horizontal circles of both are read by three fixed microscopes placed 120 degrees apart, the focal lengths are of 20 inch and their magnifying powers are between 25 and 50. Both of the instruments had been largely employed in the surveys.[118]

Syed Mohsin Hussain's 11 inch theodolite –this instrument was almost wholly constructed by the intelligent mechanic, a native of Arcot, who was trained in the workshops of the Mathematical Instrument Department at Calcutta to the charge of which he had been initially appointed. On the retirement of Mr. Barrow, it was constructed in the year 1840. The graduation of the theodolite was done by hand, he even fashioned the entire fabric in metal. The only portions which were got from England were the microscope lens and the eye pieces. The horizontal circle was furnished with 3 equidistant flying microscopes, and the telescope had magnifying power of 36-47. It had been a very creditable piece of mechanism employed in the

[116] Ibid, page 52
[117] Ibid, page 53
[118] Ibid, page 53

Gurwani series of triangulation but it had not been used ever since the 24 inch theodolites came into being.[119]

Cary's 18 inch theodolite – of these instruments, little is known. Colonel Lambton had obtained one of them from England in 1802 at the same time as Cary's "great theodolite". Its horizontal and vertical circles were both of 18 inches and the focal length of the telescope was 18 inch and its power was 40. It had been employed only in the Ranghir Series.[120]

Cary's 51 inch theodolite – this instrument had a vertical circle with two microscopes of the same diameter as the horizontal circle, focal length of 19 inch and a magnifying power of 50. It had been employed in the Malancha Series.[121]

Barrow's 15 inch theodolite – this instrument had been originally constructed as an alt-azimuth with a vertical circle of 18 inch. It had been converted into a theodolite with a 15 inch horizontal circle and a 12 inch vertical circle. The telescope had a focal length of 19 inches and a power of 36 to 47. This instrument had been employed on the Gora Series.[122]

Dolland's 15 inch theodolite – this instrument had been designed by the celebrated Captain Kater for Captain Shortrede and had been extensively employed in the triangulation of the Bombay Presidency. The azimuthal circle used to be read by 3 microscopes and the vertical circle 12 inch, the telescopes were 6 inch with a power of 21 – 120[123]

Taking Care of these Theodolites

When dismantled for travelling, the 36 inch and the 24 inch theodolites used to be packed in two different cases, one containing the telescope and the vertical circle and

119 Account of the operations of The Great Trigonometrical Survey of India Volume 2.Colonel J.Walker , Dehradun, 1874
120 Account of The Operations of The Great Trigonometrical Survey of India Volume 1.Colonel J.Walker , Dehradun, 1870
121 Dehradun Volume No. 329 (21-6-38)
122 Dehradun volume No. 431 (1-4-40)
123 Handbook of Professional Instructions for The Topographical Branch, Survey of India, prepared by Col. J.R.Hobday under the direction of Lieut. Col.R.B.Longe, Surveyor General of India, 3rd Edition, Calcutta, Office of The Superintendent, Government Printing, India, 1905, page 230

the other used to hold the body of the instrument, the tribach, the horizontal circle and the microscopes for reading it, and the pillars which carried the telescope. Though these parts used to have been packed in two different cases it would have necessitated a frequent separation of the rotator and fixed portions of the instruments which would have been troublesome and be attended with no little risk to the vertical axis. The stand consisted of a third package. All these 3 packages would used to be carried by men and never on bullock carts because primarily good cart roads crossing the country didn't exist and also the instruments if carried by men could be transferred up to the summits of high hills over difficult terrain with much less risk of damage.

The workshop

Instrument Repair

Everest had long recognized the need for a skilled mechanic to keep his instruments at high working pitch and while he had been in England he had asked the court of directors to send such a man to India so that 'valuable instruments may be repaired without loss, risk and attendant expenses of being sent home.' He had been introduced to Mr. Barrow, by William Richardson of the royal observatory in 1829. After appointing barrow Everest brought him to Calcutta and employed him fully in collecting and training his staff, fitting up the machines and helping with new base line operations. Later when Everest had the time to look into the workshop, he discovered that barrow did not like the interference. Everest however laid down meticulous rules for the conduct of the workshop in Calcutta and its staff and for the submission of regular daily reports to him.[124] To further establish his hold over the workshop, Everest sent a copy of these correspondences to the government. There was however constant friction between Everest and barrow for the years that followed. There was an instance in 1837 when the astronomical circles had to be graduated by hand and the only man on the job was Barrow. But he did not take up the issue and Everest frustrated at having to wait for so long till his instructions were carried out wrote to The Court of Directors, that

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124 Dehradun Vol 286 (43-9), Dehradun Vol 296 (19) dated 17-7-37

"If Mr. Barrow cannot or will not divide instruments he is not required in India. There is nothing however to save this situation in which my sub-assistant Said Mohsin is not his equal and in many points is his superior being in far better practice as a workman."[125]

Calcutta workshop [126]

The Calcutta workshop was basically for the personal accommodation of the 'mathematical instrument maker', Mr.Barrow. It used to be the old property of a Baboo Shiv Prasad Ghose. Everest made sure that this place had ample space for both the workshop activities as well as barrow's family. He was allowed a writer, 4 armourers, a turner, a carpenter, a peon, durwan, and a sweeper. He could even submit a monthly contingent bill for his expenses. Work had started on the circular instrument, Lambton's great theodolite, Cary's repeating circle, the boning instrument and the comparison of the existing chains against the parliament's prescribed chains. Barrow could never find the workmen of the right type and when such consignment instruments came into the workshop he tended to keep them aside and focus on petty repairs which had no significance to the surveyor general's interests. The surveyor general on the other hand was extremely meticulous about the management of the workshop. He required a daily report from barrow each afternoon, an absentee role, and no artificer (they were never called artisans at that time) could be employed on private instruments unless he sanctioned them to , or showed his preference that these would be employed soon for public service. Barrow soon became claustrophobic with Everest's stringent rules. And he also resented Everest's growing appreciation for the artisan mohsin Hussain. As soon as Everest wanted barrow to employ Hussain to the workshop, barrow immediately retaliated. He would neither do the repairing on time, nor would he allow Hussain to become a part of the workshop:

> "i hope the instruments I have undertaken to repair and alter may be left entirely to my own execution and performance. I had declined your position earlier as I now d again accepting such aid as interfering too much with my own business" [127]

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[125] Phillimore, HRSI, Vol 4, page 123

[126] page 122-131

[127] DDn 309 (49) 1-12-32, HRSI vol 4 page 122

Everest was forever in a fix, because barrow kept delaying with the repairing. He personally wrote to de penning to make sure barrow made haste and didn't allow the artificers to get employed in other departments. Barrow kept the surveyor general waiting and even the madras observatory instruments which had been sent quirte a while back were left untouched.. it was holding up the surveys and the weather conditions in India were unpredictable. Theer were constant frisctions between barrow and everest as is evident form phillimore's descriptions of cases where barrow used to go up-country without any workmen or tools and the repairs were heavily needed. An interesting juncture of enquiry is that there was a growing demand on the workshop from the revenue surveys and other departments which the military coard encouraged. The matehmatciacl instrument maker with his establishment was ordained to be placed directly under the surveyor general by whom his accounts should be audited and then forwarded to the military auditor general. Also if the military borad required any instrument or any instrument to be repaired, this would have to be immediately executed. The surveyor general regarded the MIM and his staff as teh servants of teh GTSI and considered rhar if the Calcutta workshop was to be employed by any other departments then they should pay for it. The entire expense of barrow's establishment was paid by the GTSI. [128]

Barrow was succeeded by Mohsin Hussain who possessed great mechanical talent. Colonel Everest liked most men of genius and had a sort of intuitive perception in selecting the right man and at once singled out Mohsin Hussain as an able mechanic. Though he could not speak English he could still have taken a leading place among the top European instrument makers. When he died his place was taken by a mechanic from Mr. Cooke's establishment at York factory.

The government still hedged suggesting that Mohsin Hussain might in time succeed to Barrow's post and that there was now no very delicate or difficult work to be executed for The Great Trigonometrical Survey, appointed Sir Alexander Boileau to take charge of the Calcutta workshop.[129] In the meantime, the skilled services of Mohsin Hussain were in constant demand in the field. Without Mohsin's help, the

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[128] Ddn 343 – 13-6-38

[129] Ddn 431 – 21-4-40

astronomical circles couldn't have been made, and the directors strongly recommended that Mohsin Hussain be made the worthy successor of Barrow. In spite of Everest's' protests the government ordered that he should be stationed at Calcutta with a salary of Rs. 250 per month and designated "head artificer in the Department of Scientific Instruments".

Everest protested so strongly that the Directors then ordered that he should be made termed "mathematical instrument maker" and to the greatest extent possible be made available to the Trigonometrical Surveys as recommended by the Surveyor General. Under Hussain developed a small team which were taken out to the field on every working season. Barrow refused to have to do anything with the astronomical circles. Everest ordered his discharge and brought Mohsin Hussain to Dehradun. Hussain along with the astronomical circles fixed the argand lamps, heliotropes, and the Theodolites which were being constantly used by in the surveying operations. After 2 and half years of anxiety and determination these instruments were completely reconstructed and made fit for observations beyond reproach. This was one of the outstanding triumphs of Everest's professional career in The Great Trigonometrical Survey.

The field

The surveyor general really had a lot on his plate. He was constantly suffering from having his instruments getting damaged on the field. He had earlier applied to the court of directors to employ a "small establishment of artificers', which had not been granted. The artists he picked up on his way after establishing barrow's quarters at Calcutta was Mohsin Hussain who was a carpenter and Ram Dheen who was a blacksmith and he appreciated the fact that such persons existed because otherwise his troubles would have doubled.[130] It was at Mussourie the working place of the surveyor general that he ordered a makeshift workshop to be constructed. The bare minimum which could be build and maintained at a simple cost, though he stressed the need for the establishment to be of masonary because of the risk of fire. Of these

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[130] Phillimore, volume 4, page 122

two helpers, Everest says "the native artist is of great talent as a mechanic and is able to repair all the smaller instruments and to supply the minor parts of the greater instruments." Ram Dheen under Mohsin's expert training also improved with every passing day. And maybe it was because that his superior was Mohsin, an Indian that he could work freely without having to face much trouble. Had he been employed under Barrow, he possibly would have a different story altogether.

The workshop at the field was well supplied with tools which helped both of them to be on their toes all the time. Everest was not allowed a permanent building but sanctioned a number of workmen on the field. Mention may be made of carpenters, turners, file men, firemen, hammer men, amounting to a total artificer helper population of 90. Under mohsin Hussain they were a united team. Barrow came up country without any tools or workmen, and Everest was left aghast at his irresponsibility. The interface with the military comes in again here, because the surveyor general immediately requested to the Cawnpore Magazine to supply assistance to him on his field workshop. The Cawnpore Magazine dispatched two Indian natives – Purotee and Laloo who were a brass man and a file man to serve in the field workshop. The Fatehgarh military establishment also lent help to Everest sending him a craftsman Jerriaow who had been engaged in the Mint. [131]

It was more challenging to repair instruments at the field with so less staff and such less time in hand. Yet, among the instruments made by Mohsin Hussain were several barometer pumps designed by Everest himself. Other instruments like heliotropes, lamps, were in progress. He was proud of his native artificer team and constantly tried to make them content by encouraging them. The surveyor general lamented the fact that the amount of time and money wasted at establishing a separate Mathematical Instrument Maker at Calcutta was performed right in front of his eyes at his field workshop in the matter of simply 18 months. All the instruments made and repaired bore the touch of accuracy and sophistication and nobody even the best of the instrument makers of the world could distinguish them from the production of any celebrated artist of Europe.[132]

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[131] Ddn volume 286 (25-6-33)
[132] Ddn 344 (21-3-49)

The field workshop being a total success in this way, mohsin was made head artificer at the mathematical instrument maker in Calcutta. The surveyor general requested the court of directors to give him th3e charge of a special workshop up country which would be in touch with the surveyor general's field establishment in case of any emergency either at Delhi or Agra. The government however nullified his requests because they saw how useful mohsir had been and prepared to order Hussain to come down to Calcutta where the rest of the repairs required to be taken care of immediately.[133]

So we see how important the figure of mohsin Hussain was from these accounts. He was such an indispensable figure that Everest protested against this vigorously and he said

> "The repairs which need a *mathematical instrument maker* are of diverse kinds and by far the greater portion can be achieved by a delicate and skilful artist. I am quite satisfied of the capability of Seid Mohsin acting under my directions but it will be a very different affair when he comes to be at a distance from me under the control of a person independent of my authority and nominated without my acquiescence. Hitherto every instrument has undergone an annual process of examination and cleaning as also of repairing when needed by Seid Mohsin under my own eye and this is a precaution much too valuable to be rejected."[134]

The court of directors agreed and allowed Mir Sahib to remain at the headquarters till Everest retired.

The operations of this period form a group among themselves and had little in common with the subsequent operations having been executed at a time when the science of geodesy was in its infancy, the several instruments employed in executing the linear and angular measurements were very inferior to those by which they were superseded shortly afterwards and the methods of reduction and analysis were still rude and imperfect. It was further shown that the year 1830 marked a highly important epoch of transition in the history of The Great Trigonometrical Survey because it was

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[133] Phillimore, volume 4, page 132

[134] Ddn 402 (15-8-42)

in this year that several new instruments – the great theodolites, astronomical circles, the Colby Base Line, Compensation Bars and Microscopes began to be received from England where they had been constructed under the care and supervision of Colonel Everest for the operations of the survey with much skill that they are still scarcely surpassed by the best instruments.

With the new instrumental equipment, new systems of observation and newer methods of reduction were introduced which were better calculated than the previous processes to elicit the full capabilities of the instruments and to lead to results of corresponding accuracy and precision.

Illustrations

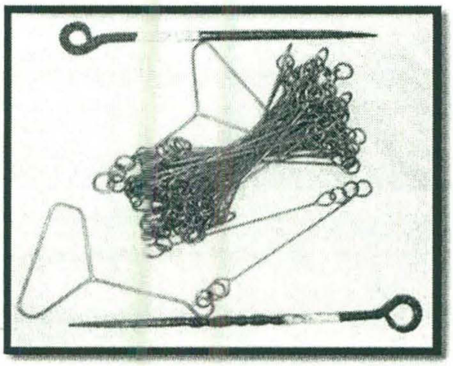

Figure 1: Chains (Google images)

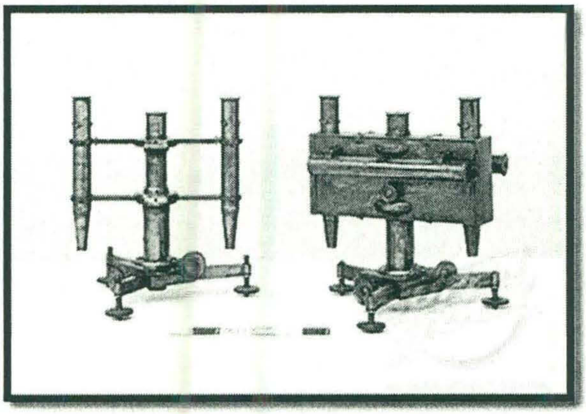

Figure2: Compensation Bars

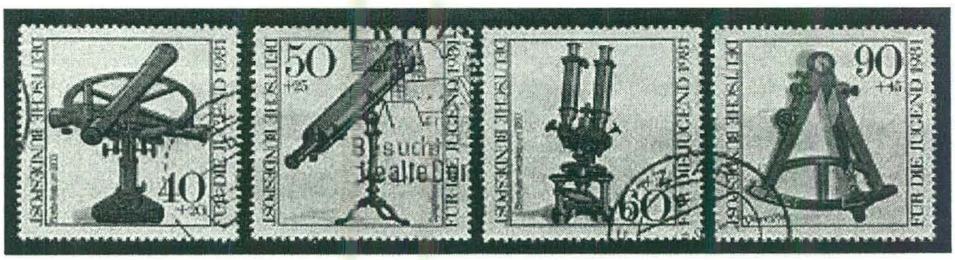

Figure 3: Instruments Portrayed In The Deutch Stamps

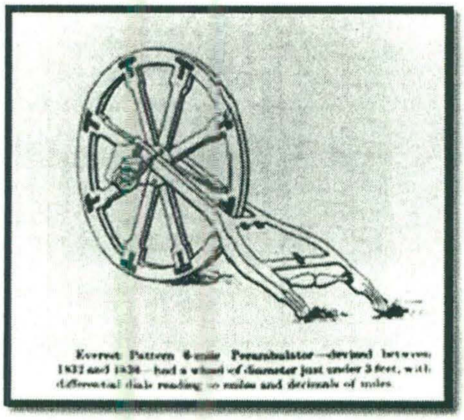

Figure 4: Perambulator Designed By George Everest (Phillimore volume 4)

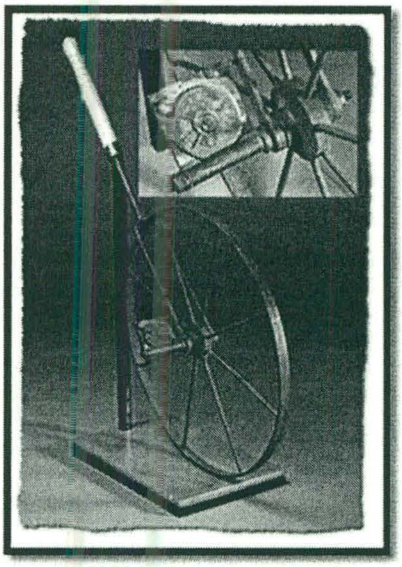

Figure 5: Standard Perambulator Used In the Surveys (Google images)

Figure 6: Brought Out by Edinburgh Showing the Details of a Chronometer (Google images)

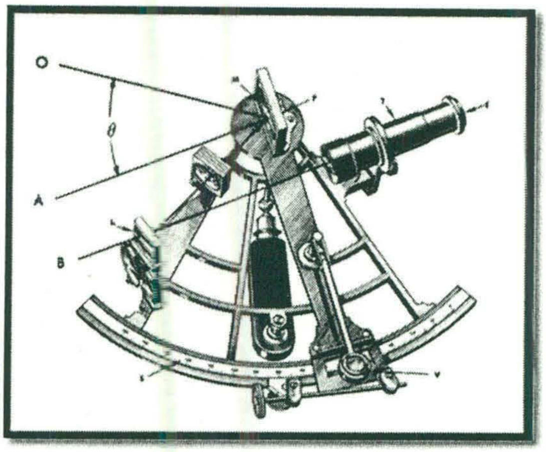

Figure7: Sextants (Google images)

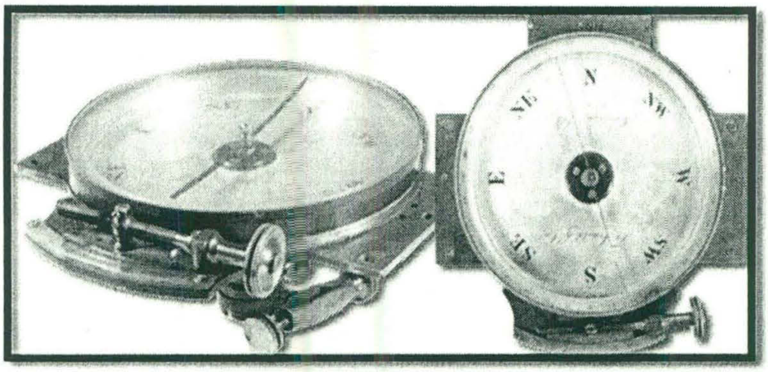

Figure 8: Chronometers (Google images)

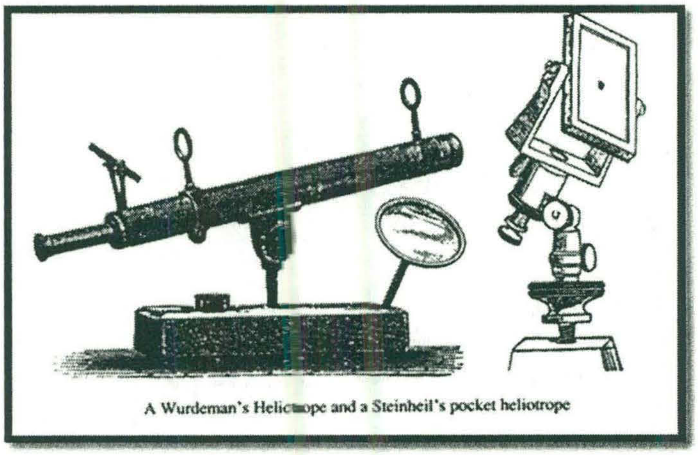

Figure 8: A Heliotrope (Google images)

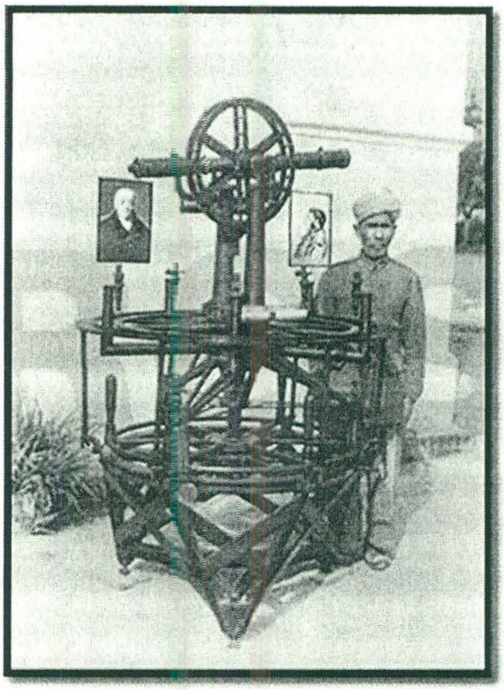

Figure 10: Colonel Lambton's Theodolite (www.images.rgs.org)

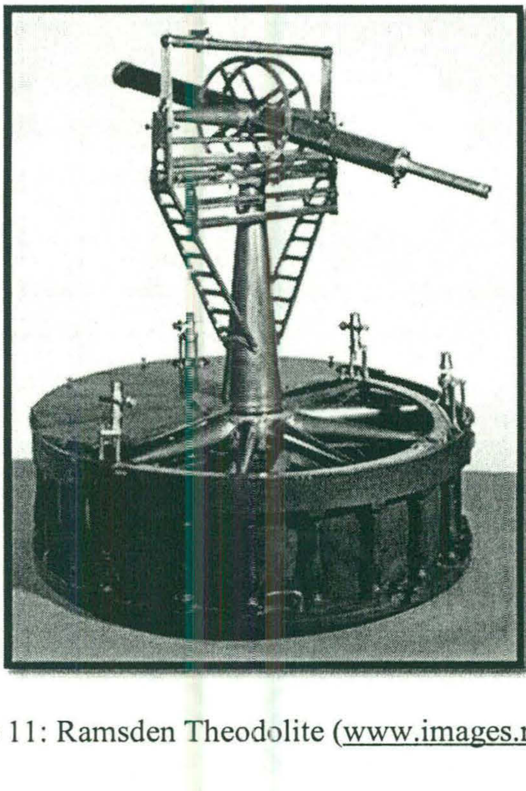

Figure 11: Ramsden Theodolite (www.images.rgs.org)

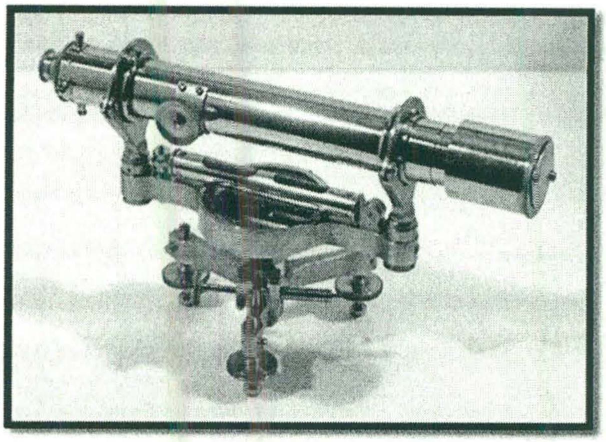

Figure 12: The Troughton And Simms Theodolite (www.images.rgs.org)

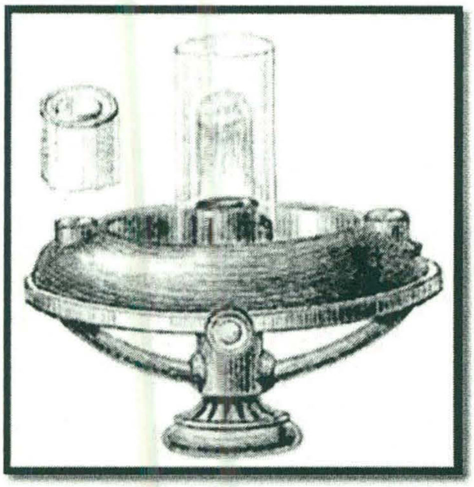

Figure 13: Argand Lamps (Google Images)

Figure 14: Stamps brought out by the Deutsch Republic Showing Surveying Operations (Google images)

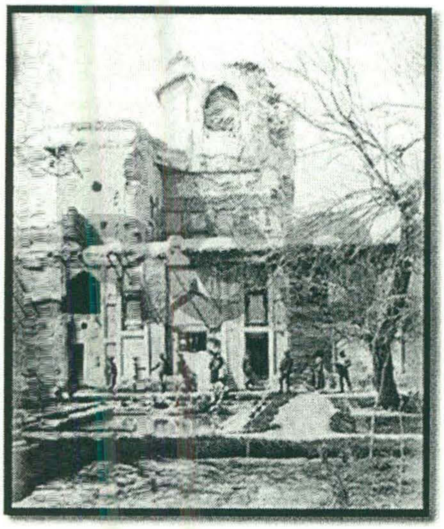

Figure 15: Permanent Masonary Towers In Kandahar (www.images.rgs.org)

Figure 16: Masonary Towers In Kandahar (www.images.rgs.org)

Figure17: Night Time Observation Using Theodolites (www.images.rgs.org)

Figure18: Painting of *Khalashis* (Thullier: A Manual of Surveying)

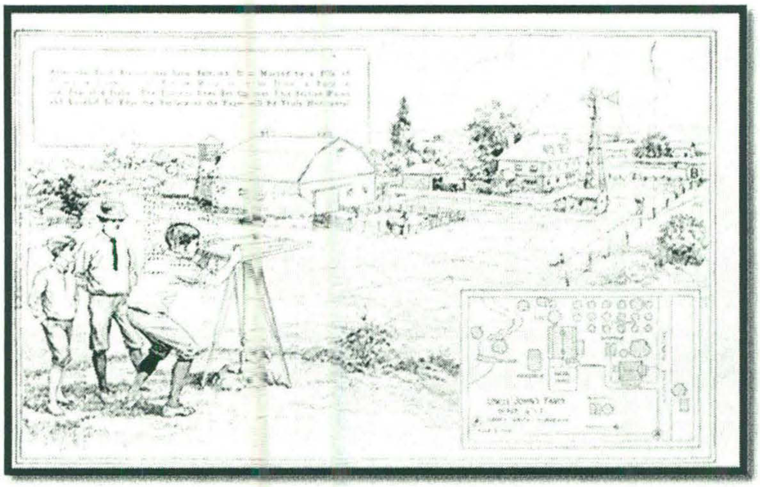

Figure19: Instance Of a Plane Table Survey in England (www.images.rgs.org)

Figure 20: Astrolabe used in GTSI (The Great Arc: Pritwish Nag)

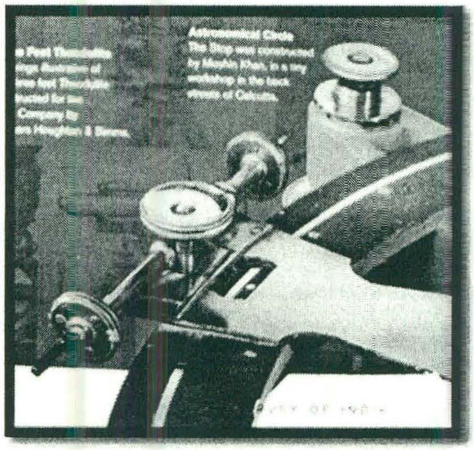

Figure 21: Astronomical Circ.e repaired by Mohsin Hussain (The Great Arc: Pritwish Nag)

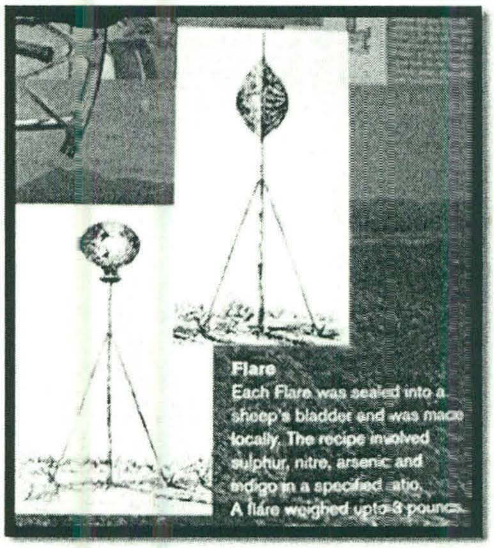

Figure 22: Flares used for Signalling and taking readings (The Great Arc: Pritwish Nag)

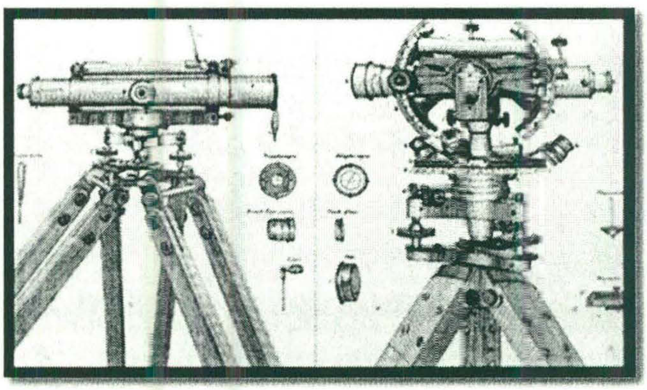

Figure 23: Levelling Instruments (The Great Arc: Pritwish Nag)

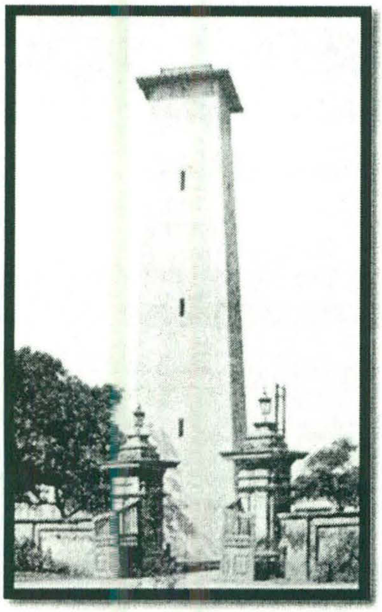

Figure 24: The Brick Masonary Tower at Barrackpore, West Bengal (John Keay: The Great Arc)

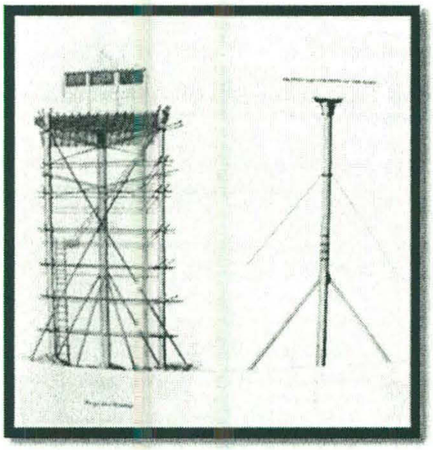

Figure 25: Observatory tower and masts (John Keay: The Great Arc)

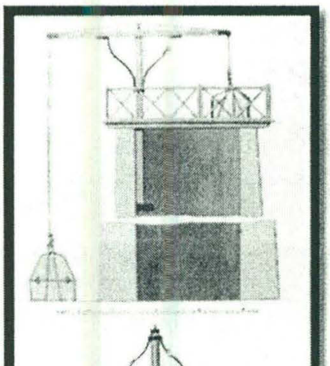

Figure 26: Pulleys: (John Keay: The Great Arc)

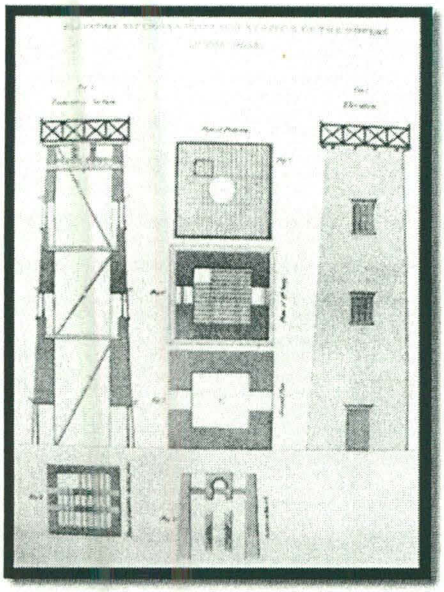

Figure 26: Cross section of the Observatories at Kaliana (John Keay: The Great Arc)

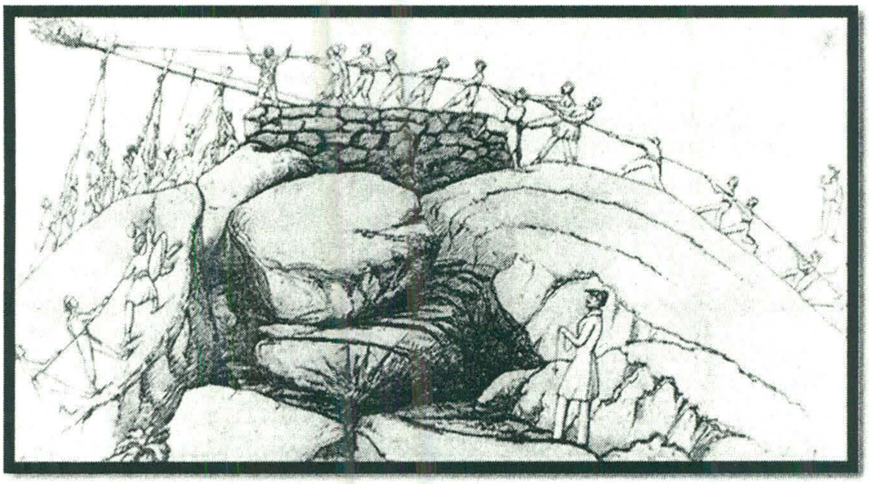

Figure 27: natives hoisting the mast while the English Surveyor looks on with a plumb-line (John Keay: The Great Arc)

CHAPTER FOUR:

Chapter 4: Indian Collaboration and The Great Trigonometrical Survey

The higher authorities were reluctant to employ any but their own European servants on surveying teams. By 1830 however, with Lord William Bentinck as the Governor General, both the Court Of Directors in England and the local governments in India were ready to encourage the employment of suitably educated Indians. By this time the term "native" had gone out of use and the survey rolls reserved the term for Indians alone, describing others born in India as European or when of mixed race, East – Indian. Though Everest had an immense devotion and admiration for the lascars, followers and skilled artisans who worked so devotedly for the Great Trigonometrical Survey, he was at first sceptical of the worth of any individual Indian professional work in the field for he regarded them as lacking the capacity either for high precision or self – sacrificing zeal.[135]

These views were considerably modified by the influence of two particular individuals who served him so well and faithfully and revealed so much of his own passion for the cause that he regarded each in his own line as incomparable. The first was the Bengali Computor Radhanath Sikhdar who had come direct from the Hindoo College with so much understanding of advanced mathematics and principles of geodesy that Everest was able to teach him. He also proved himself hardy and active in the field and was a first class observer with all the instruments. The second was the mechanic Syed Mir Mohsin Hussain, who from humble beginnings had acquired great skill in the construction of high class instruments and dealt with the troubles of the GTSI with immediate exactness and precision. So far we have looked into the making of a surveyor and the relevance and the questions around the tools of survey. The purpose of this chapter is to make a focussed study of two individuals. However a lot depended on the operational skills of this collaboration of the Indians with the British surveying officers.

[135] Phillimore, vol P 401

Radhanath Sikhdar

Civilian assistants used to be recruited as young school boys from eastern India of mixed patronage or from Europeans.[136] On the Trigonometrical side, though a number of young educated Bengalis were employed in the service as Computors, only one of them, Radhanath Sikhdar proved a useful field surveyor.

The instruments of the GTS produced masses of geographical data. However, the data was useless without the extensive analysis that occurred after a field season. The mathematics necessary for the GTS were extremely complex and at that time were at the very forefront of European mathematical practice. Geodetic measurements were especially complicated, but all parts of the survey required intense mathematical work. In order to ensure that the surveys were as error free as possible the mathematical determinations of the triangles were compared against the measurements taken with compensation bars on the ground. This two-fold process was the central part of the GTS. Constant checking and rechecking greatly increased the persuasiveness of the accuracy of the GTS. Everest did not do all of the mathematics. Radhanath Sikhdar, a direct pupil of Derozio in the Hindu College, was his right hand in managing the calculating part of the surveying. In the latter half of his life, he was an employee of the Survey Department working directly under the orders of the Surveyor Generals of India. He particularly is remembered in the memoirs of the Surveyors of the Great Trigonometrical Survey as the chief calculator and *Computor* of Sir George Everest, and my argument here is that he did not spend a very happy time in carrying out orders blindly as laid down by the department.

The word " *Computor*" definitely did not carry the post - modernist connotation it carries today in the 21st century. The word Computor in 1800-1880 meant a person fluent in his knowledge of astronomy, physics, mathematics and geodesy, employed directly under the Surveyor General's Office in the computations branch.[137]

Sikhdar however remains a neglected figure in the historiography of surveying itself. He was an expert in geodetic surveying and in meteorology, so much so that Everest

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136 Phillimore, vol p 403

137 Phillimore Pg 340-341

while appointing him on 19th December, 1831 as sub-assistant in the GTS declared that – "*The ablest student that the Hindu College has yet produced, his mathematical acquirements being of superior order*".[138] Inspite of being the Head of the Computing Branch of the GTSI, Sikhdar's name had been removed from the prefaces of British publications. While all valuable matter written by the man was been retained, there was no acknowledgement as to the authorship.[139] Sadly, he remains a tragic figure encapsulated in a few lines in the pages of Phillimore's voluminous *Historical Records of the Survey of India*, and is mentioned quite simply in the various memoirs of the Survey Of India. Whether or not he is truly tragic, whether or not the purposeful silence about this 'man Computor' in history has any hidden agenda is a question. Whatever the truth, it requires more delving into.

Early beginnings

Radhanath Sikhdar was the man who first showed that the peak which we now know as Mount Everest was the tallest in the world. After his primary education at the *Firangi School* at Jorasanko in Calcutta, Radhanath's father sent him to the Hindu College where he hoped Radhanath would learn sufficiently to become one of the clerks at a merchant house. Instead Radhanath turned out to be such a exceptionally brilliant student that his father was reluctant to take him away from the institution.[140] Radhanath, along with few of the most important figures, like Ramtanu Lahiri, Dakhsinaranjan Mitra, Peary Chand Mitra and Krishnamohan Banerjee whom we identify as the firebrand derozians, were direct pupils of Henry Louis Vivian Derozio in 1831. Each one of the members of the *Young Bengal* turned towards either social reform or education but not Radhanath He was the only student who had acquired this urge to immerse himself in Baconian empiricism from Derozio and the practical applications and lessons he received from Dr. Tytler and Dr. Ross in mathematics and practical astronomy. [141]

[138] Phillimore Pg 376

[139] R.C Sanyal, Pg 564

[140] Ashis lahiri, page 15

[141] The *Hindoo Patriot* Noted In Radhanath's Obituary That Dr.Tytler Professor In Mathematics Thought Highly Of Him And He And Rajnarayan Bysack Were The First Hindu Who Received Instruction From Him In Newton's *Principia*. He Was The First Bengali Youth To Have Learnt The

Sikhdar and the GTSI

The immediate task of the Great Trigonometrical Survey was the accurate determination of the position of the important points of the country which form the basis for geographical and other surveys and maps.[142] Although the GTSI was supported as a great scientific endeavour the Government of India had other pragmatic interests. The administration needed geographical information and small scale maps for ruling and exploiting the country. The purpose in the 1820 Atlas of India project was established. The project aimed at compilation of maps at a medium scale of 1 inch to 4 miles, which would bring together all the topographical surveys in order to create a definite cartographic representation of India. Map making was integral to the British empire in India.

For carrying out this formidable task, Everest was on the look-out for talented natives, proficient in mathematics and trigonometry. In those days it was quite difficult to find such men. It was then that Dr. Tytler recommended Radhanath Sikhdar as eminently suited for the purpose. He used to take pride in his student's mathematical proficiency. At the bidding of his mentor and also to help his cash strapped father, the brilliant nineteen year final year college student left his studies to join the Surveyor General's Office at Calcutta with Rs 30 per month as his salary. [143] As soon his genius became evident he was sent to Dehradun office to work as a " *Computor*", the first Indian to be so placed into such a high ranking government service. He wrote in his diary:

> "*On being employed as a Computor at the office of the Great Trigonometrical Survey of India I started studying many other books on mathematics. Now 7th October 1832, I shall leave Calcutta on 15th October to start work as a surveyor at the Sironj base line*"[144]

Mathematics Invented By Newton And Laplace And Accomplished Great Things In Science And Astronomy, May 23, 1870.

[142] The Great Trigonometrical Survey Of India, K.S.Sivaswami, GIS@Development, September 2000

[143] Ashis Lahiri pg 17

[144] Jogendranath Bandyopadhyay Vidyabhushan (Ed.), Arya Darshan, Kolakata 1884

We have seen that Sironj and Dehradun were among the significant baselines chosen by Everest.

Radhanath proved to be of invaluable asset to the Survey of India. His investigative mind quickly grasped the astronomical methods required for geodetic surveying. He also devised his own working formulae from the first principles whenever required and applied these in practice with admirable mathematical precision. He published his work, *A Set of Tables Facilitating the Computation of Trigonometrical Survey and the Projection of Maps for India*[145] Everest had remarked in 1840 that " *Computors compared to Radhanath cannot be hired at a price less than a guinea per diem*". He also observed that Sikhdar was a hardy energetic young man, ready to undergo any fatigue and had acquired a practical knowledge of all the parts of his profession. "*There are a few instruments that he cannot manage and none of my computations of which he is not thoroughly master. He can not only apply the formulae but also investigate them.*"[146] As a later chronicler had remarked, "*allocades so fulsome would rarely spill spontaneously from the pen of Everest*" to whom giving credit to subordinates would not come naturally".[147] British historian John Keay, observed that mathematical skills were essential for Sikhdar's work and he was acknowledged by George Everest as a mathematician of rare genius. It may be remembered that there was no institutional arrangement to teach advanced maths and higher mathematics till the end of the 19th century in British India. Radhanath's mastery of higher mathematics and science was achieved by his own "unremitting self cultivation", as Col. Andrew Waugh, Everest's successor as Surveyor General put it. It is also a measure of the strong foundations of the basics he inculcated during his student days at the Hindu College.

Radhanath: The Computor

Radhanath was elevated to the *Chief Computor* in Survey of India in 1851 after a service of nearly 20 years and posted back to Calcutta. The responsibility of this

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[145] A.K.Chakravarty, *Three Nineteenth Century Calcutta Astronomers*, Indian Journal Of History Of Science", 30(2-4) 1995

[146] BBC NEWS: http://news.bbc.co.uk/go/pr/fr//2hi/south_asia/3193576.stm, published 2003/10/20

[147] Lahiri, pg 17

office was to derive the ground reality from the raw geodetic survey data collected during the fieldwork by using complex formulae and equations. It was Waugh who had asked Radhanath to devise suitable formulae for computing geographical positions and altitudes of snow peaks observed from "distances of over 100 miles". His access to the peak was however limited due to unclear border divides between Nepal and India around peak xv. Using a theodolite from 150 miles away Sikhdar was able to estimate Peak XV's height at exactly 29,000 feet so as to avoid implication of having only a rounded estimate. In 1855 a second survey team did a second round of measurements using a second theodolite from closer to the base of the mountain and determined the height of the mountain to be 29,029 feet. Radhanath's computations provided the first clear proof that Peak XV as it was known then was higher than any other mountain in the world hithero measured. His conclusion was based on computations made on observations made from six different stations. No less than Meghnad Saha paid tribute to him for this. *"In 1854 Radhanath sikhdar the head Computor of the trigonometric survey and an accomplished mathematician found from mathematical reduction of the observations made some years earlier on an obscure looking peak of the Himalayas that this was actually the highest peak in the world."*[148]

John Keay writes '*his greatest contribution to the computation was in the working out and applying the allowance to be made for a phenomenon called refraction – the bending of straight lines by the density of the earth's atmosphere.*' Atmospheric refraction is the deviation of light or other electromagnetic waves from a straight line as it passes through the atmosphere due to the variation in air density as a function of altitude. Atmospheric refraction near the ground produces mirages and can make distant objects appear to shimmer or ripple. It is however possible to equip a telescope with control systems to compensate for the shift caused by the refraction.

Peak XV had been identified as a plausible contender for the world's highest peak in 1847 when surveyors glimpsed from Darjeeling. Different survey parties recorded several observations over the next three years. The announcement that it was the highest, thanks to Sikhdar's efforts was delayed till the final observations were made

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148 M.N.Saha, Progress Of Physics In The Past 25 Years http://library.du.ac.in/dspace/bitstream

and calculations checked repeatedly.[149] Keay seems eager to make amends here. For in his book, '*The Great Arc*', "Radhanath finds passing mention only thrice although with the sobriquet – "mathematical genius" every time'.[150] In this context it is interesting to note that Radhanath's mathematical expertise won him in 1864 a Corresponding Membership of the Society of Natural History, Bavaria – a rare honour in those days to be given to a foreigner, by the highly conservative German Philosophical Society. Not that colonel Waugh was not appreciative of Radhanath's ability, "*talking of the loyal, zealous and energetic body of men forming the civil establishment of the survey department, he sad – among them may be mentioned as most conspicuous for the ability Babu Radhanath Sikhdar, a native of brahmanical extraction whose mathematical acquirements are of highest order*" (Report of the GTSI, submitted to the House Of Commons, 15th April 1851).[151] Ironically this same Waugh true to the imperial tradition of ignoring the scientific contribution of its subjects proposed the naming of the Peak XV as Mount Everest after his predecessor.

Radhanath and Meteorology

It was Radhanath who laid the foundation for accurate and systematic meteorological observations as well as their methodological processing in this country. He was truly the pioneer Indian meteorologist. Sporadic meteorological observations had started in India from 1785 onwards as an adjunct to surveying. To give due importance to atmospherical conditions on surveying data, a full fledged meteorological observatory was set up in the premises of the office of the Superintendent in 1829. In November 1852 while still serving as Chief Computor at the Survey Of India, Radhanath was given additional charge as the superintendent of this observatory. On assuming charge Radhanath lost no time in correcting everything. He immediately started reducing the raw barometer observations to a standard temperature. It may be mentioned here that temperature reducing has to be applied to barometric readings to assess the real changes in atmospheric pressure. Temperature affects barometric readings on two counts – the thermal expansion of the brass scale attached to the barometer and the

[149] See footnote 10.

[150] John Keay, pg 68

[151] Phillimore pg 431

dilation of the mercury column itself in the tube.[152] Formulae for reducing barometric observations to 32 degree Fahrenheit already in use in Europe were not available to Radhanath; he had to build his own reduction table from the first principles. A note describing Sikhdar's formula was communicated to the Journal of the Asiatic Society of Bengal, by Deputy Surveyor General Col.H.L.Thullier and it was published by the Journal in 1852 (Vol. 21, no.4, pp 329-332)

Radhanath introduced the system of hourly observations right from December 1852. From 1853 he started regular compiling and publishing of abstracts of hourly, daily, and monthly means of all the observations as well as the derived elements along with their extremes and monthly ranges. This series was the first ever scientifically recorded set of meteorological data in India and was the basis of the first ever work on the climatology of an Indian city, in this case, Calcutta, the capital of British India. The prime mover of the Indian Meteorological Department, Mr.H.F.Blanford wrote in his first administrative report that the 24 years data from 1853 to 1877 of the Surveyor General's observatory "are the finest piece of our knowledge of the climate of Calcutta". A complete grasp of the subject along with his unparalleled innovative ability had made Radhanath the most valuable asset of the survey of India till he retired in 1862. Many publications like the surveying manuals and computational tables authored by him remained indispensible to the Indian surveyors throughout the 19th century.

Trials and tribulations

However his relations with the department seemed to have been unhappy. Within five years of his joining the survey of India, he had applied for the post of a deputy collector along with a number of Hindu College recruits in the Computing Department but Everest would not release him. Not only did he refuse to ever write a letter of recommendation for Radhanath, he also persuaded the Government to issue a general notice that henceforth no other government employee could apply for any other post in the service without the prior permission of the current departmental head. Everest, as we have seen, was utterly convinced of Radhanath's indispensability to the GTS. In a letter to Radhanath's father he fondly wrote, '*I wish I could have*

[152] Phillimore vol 4, pg 264

persuaded you to come to Dehradun for not only would it have given me the greatest pleasure to show you personally how much I honour you for having such a son as Radhanath but you would yourself have I am sure been infinitely be proud and gratified at witness in the high esteem in which he is held by his superiors and equals" (Dehradun ,3rd July 1840) - this was high praise indeed.

Yet when in 1850 the post of a Magistrate fell vacant in Calcutta, Radhanath well aware of the strict regulations, applied for it. By that time, Everest had retired and Andrew Waugh was his employer. Waugh took a very different strategy. He recommended that Radhanath's pay be increased substantially because,

'*...the masterly character of the papers contributed by Radhanath to the 'Manual Of Surveying' has been acknowledged in the Calcutta Review as well as the remarkable purity of a style of writing and severe accuracy of language so different from the exuberance of Orientalism*'[153].

These incidents bring out clearly the ambivalent relations between Radhanath and the GTS. While the GTS was generous in their acclaim for the quality of his work, he was not happy with the authorities. One reason was pay, which was incommensurate with the highly specialized nature of his work. The other, one can conjecture, was the inescapability of working under the colonial masters.

Despite the high praise showered on Radhanath whenever he threatened to leave, he must have been a pain in the neck in the GTS. Otherwise how can one account for the attempts to erase his name from the survey records? The act of Col.Thullier the Deputy Surveyor Director of the GTSI under Waugh and apparently a friend of Sikhdar's is a sordid pointer in this respect. In 1851, he along with Col. F. Smyth brought out *The Manual of Surveying for India.*

In Part III (on Surveying), the *Computors* have been lamely assisted by Radhanath Sikhda. The chapters 15 - 21, and the whole part IV were his entirely written by Radhanath. Besides he compiled a set of auxiliary tables for the surveying department which were found to be greatly useful. Part V consisted of practical astronomy and its application to surveying. The book was reissued in 1855 with the preface intact. In

153 Hindoo Patriot, April 1851, quoted from *The Hills*

1862, Sikhdar retired and died in 1870. The third edition of *The Manual* came out in 1875 without the acknowledgements. Scandalized, a section of Englishmen protested against this. In an article in "*The Friend Of India*", Col. J. Macdonald condemned this as a "*cowardly sin*" and the "*robbery of the dead*". He further wrote in the hope of rescuing the name of one of the greatest mathematicians and proudest sons from being lost in the dregs of a amorally construed history[154]

In an Editorial on 16th August 1876, "*The Friend of India*" wrote, "*Radhanath, had he been alive, we would have left him to fight this own battle*". Clearly, the newspaper knew that Sikhdar had in the past fought other such battles of his own. Enraged at Col.Macdonald's insolence the Governor General Lord Lytton immediately suspended him from service. The relevant notice reads – *the decision of the Government Of India is that Lt. Col. Macdonald shall be suspended from departmental duty... demoted to the Deputy superintendents of revenue survey immediately below Lt. Col. Oakes on a salary of Rs. 1,327 per month*. It is further the desire of the Governor General in Council that Lt. Col. Wouldn't be employed at headquarters without the special sanction of the government.[155]

Ram Gopal Sanyal in his "*Reminiscences And Anecdotes*" had a similar tale to tell, which Pramathanath Bose quotes at length – in his *History Of The Hindu Civilization Under The British Rule Vol III* Sanyal states that in a letter to the *Friend Of India* Col. Sherwill (an old revenue surveyor who used the *Manual* for a quarter of a century and an acquaintance of Sikhdar), wrote from Germany that he was quite ashamed to be informed that this much respected name of Sikhdar that did so much to enrich the early editions of the *Manual* had been removed from the third edition while at the same time, all valuable matter written by him had been reframed without any prior acknowledgement as to their original authority – authorship.

The fact that after Sikhdar took pension no other native was employed in this department also points to some specific anti-native sentiment at play. Writing in 1884, the *Arya Darshan* observed '*at present natives has no access to this department. A few days back before leaving India, Lord Ripon has given permission that natives can*

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[154] Friend Of India, 24th June, 1876).

[155] Radhanath Sikhdar, Beyond the Peak, Ashis Lahiri, Boi Chitra, Kolkata p21

be employed in the Survey Of India Department. But no one knows what the authorities will do'. The Journa further observes that from 1802 - 1884 only two Indian natives had been employed in this department in a high position. One was Syed Mohsin Hussain and the other Indian was Radhanath Sikhdar. We also learnt that a few contemporaries of Radhanath had entered the department but left midway without completing service. They suffered from physical disability arising from excessive labour. Further the climates of various places did not suit them. Even the iron constitution of many Europeans gave way and they died.

Among the contemporaries who joined and left the Survey Department were Radhanath's younger brother – Srinath Sikhdar, also a product of The Hindu College and Shib Chunder Deb, another fellow Derozian.

In this regard Pramathanath Bose's writings present a clearer picture. Talking about the mid 1880s, Bose quotes from a memorandum submitted to the Public Service Commission by the then Surveyor General that speaks volumes about the colonizer – colonized mentality:

> *It is suicidal for the Europeans to admit that the natives can do anything better than themselves ... in my old parties I never permitted a native to touch a theodolite or an original computation, on the principle that the triangulation or scientific work was the prerogative of highly paid Europeans. and the reservation of the scientific work was the only way by which I could keep up a distinction so as to justify the different figures of pay respectively drawn by the two classes*

How bizarre yet so true. Pramathnath Bose aptly remarks that 'it is seldom that we have such frank admissions.' The reason usually given was of Indians' alleged incapacities for higher intellectual work.

Establishment of the post of the *Computor* by Everest

Everest's fight with the help of his Court Of Directors in England was to evolve a practical system of geodetic work of the highest accuracy adapted to Indian conditions that could be extended over the length and breadth of the subcontinent. To have this in effect, what Everest required was a dedicated establishment of officers, native Indians, Computors, labourers, draftsmen, engineers, civilians, and a hoard of men soaked in the principles that he had initiated with innovative surveyors who could carry on the good work while preserving its standards. Everest had to face a huge problem: the organization of an efficient body of Computors, not only for current work but also to shore up arrears from the last years of Lambton's work. (1820-1823) Lambton had never kept any separate staff of Computors because he used to carry out even minor calculations himself! Radhanath's main job was as Computor, to make computations from the baselines of the Survey, which in North India were mainly Delhi, Agra, and Sironj.

A separate computing establishment distinct from the field staff became very important though each field party was be expected to take out their angles and set up their triangles. In order to have everything accurately up-to-date, Everest requested the appointment of A Head Computor and a Deputy Computor with the commensurate remuneration. He also requested for the engagement and training of a certain number of young native Computors at salaries ranging from Rs. 30 – 100. In the beginning, Lt, Joshua De Penning, the Head of the Great Trigonometrical Survey under Lambton was chosen by Everest to be the Head Computor under him. Offers of employment were sent out to a number of Bengali students on probation for prospective posts of a principal Computor, a deputy Computor and six individual Computors. Chief Peyton was Penning's Deputy in the Calcutta Office.

De penning soon got the office ship-shape, and the eight Computors were young Bengali students fresh out of the Hindu College, namely, Shivsundar Deva, Rajnarain Bysack, Madhubechunder Mullick, Judubh Chaunder Set, Kallycoomer Bose, Radhanath Bose, Nilcoomul Ghose and Gooroochurn Dass. They were extremely efficient in computing and filling up the forms for latitude, azimuths, completing many in a single day.

Everest was however scandalized at their dress during the monsoons, "*it is not considered amongst the English, consistent with decorum to enter an apartment destined for office or domestic work without such dress as is simply sufficient to cover the nakedness of the person.*" He almost called them "*indecently*" dressed! Within a few months, Everest declared that Radhanath had grown to be in high favour with everybody in the GTS and had become universally loved by all and sundry. He had changed a lot as well, no longer being the puny "stripling" of a man, but a sturdy energetic man ready to undergo any amount of fatigue and acquire extreme practical knowledge in all the parts of his profession.

Resistance

Suddenly however in 1843 Radhanath applied to Everest for permanent leave from the GTS. Everest was most distressed when Radhanath wanted to leave to accept a profitable post as teacher in a public institution. He begged the Government to increase Radhanath's pay substantially, to lure him to stay on. He made it quite clear that he could not afford to lose Radhanath. As a Computor he was indefeasible and there was no second person in the survey department who was skilful enough to compute those calculations, or in the applications of the various formulae. Everest called Radhanath '*shrewd*' along with "*clear headed and intelligent*".

Being a true Derozian meant that Radhanath took up crucial social causes for reform and it was right in the middle of the survey that he got entangled in a significant case which proved to be a turning point in his life as employee of the British government. He took up the cause of the downtrodden labourers in the surveying institution - the hill porters. Many of the European officers and engineers used to beat up the porters and Radhanath had consistently opposed this practice. There was a incident where he directly stood up against one such European officer resulting in the launch of a heated criminal case against him immediately. No doubt he lost the case but became a hero in the eyes of both the downtrodden hill porters as well as the entire *Young Bengal* group.

The Englishman observes, "*A very respectable body comprising the present magistracy is not altogether exempt from these failings which have been supposed to disqualify others form holding similar appointments*"[156]

On 5th may 1843, six paharis were forcibly and unjustly worked by two officers namely Messers Clarkson and Keelan for their reluctance to comply with their

[156] The Bengal Spectator Of Sept 1, 1843

demands. So they had to pass the house occupied by their masters. Radhanath caused them to deposit the contents of their heads in the house in order to discover to whom the property belonged to. This produced an immediate effect. The owner himself appeared at Radhanath's house and he turned out to be the magistrate Lieutenant Vansittart. Vansittart heatedly broke out in an argument with Radhanath charging him as to what right he had to detain his personal property to which Radhanath had heatedly replied that "*just as much as you had in pressing and maltreating my people to convey your baggage and I intend to take legal measures*". [157]

Mr. Vansittart confessed that he had ordered his people to procure coolies but not to press private servants and claimed the restoration of his property. Radhanath refused outright to comply with his request unless the owner was ready give him his written acknowledgement that the property detained was his. To this, the magistrate declined. Radhanath's intention of acquiring the voucher would later prove that the property was not only Vansittart's but he was also responsible for the unlawful employment of the coolies. Capt. P.Patterson who had accompanied the magistrate to the Sikhdar's house, talked to him in such an insulting manner unbecoming of a gentleman. Radhanath restored the property to the *jamadar* on the reclaim of the written acknowledgement from. Vansittart. [158]

This case placed Vansittart in a very humiliating position considering his standing both as a gentleman as well as a magistrate. As a gentleman, he could have simply apologized to Radhanath and Messers Keelan and Clarkson for the unlawful seizure of their *paharees* and the flogging and forcible oppression exercised over the *chaprasis*. However he denied having ordered private servants to do his personal work.[159] The crux of Radhanath s offence was that he not only detained the goods belonging to Vansittart and Lieut. Patterson but also insisted on a written order for their delivery. Hence arose two crimes, first the forcible seizure of the goods and second, the contempt and disobedience of the magistrate's orders. Radhanath could have acted wisely if he had sent the goods back at once to Thana, but keeping them at his own house, fully resolving to make them over to the magistrate the next morning

[157]Radhanath Sikhdar, Beyond the Peak, Ashis Lahiri, Boi Chitra, Kolkata, p25

[158] The Bengal Spectator, May 17, 1843

[159] The Bengal Spectator Of Sept 16, 1843

admitting the possession thereof, the next evening they were received and intimating his readiness to restore them ever and ever as being furnished with a parwana we do not see how he forcibly retained the goods. If they had not been delivered, it would still have proven to be a disobedience and contempt of Vansittart.

Vansittart made a case for himself by "*putting questions as were calculated, far from being a complete statement of the transaction of the oath*".[160] To which Radhanath added that the magistrate was being unfair basically trying to put the words into Radhanath's mouth most often and would not give him much time to reply to the whole question at a time. On the closing of Radhanath's evidence, Mr. Vansittart said that he would submit the whole case to the government. On 8th may Vansittart directed Radhanath to attend the court without getting into the details of the case.[161] He disposed of it by merely imposing upon him the fines already mentioned. The matter ended thus in a very solemn way. '*oh judgement thou art lied to brutish beasts*'[162]

Baboo Radhanath appealed against the magistrate's decision to the commissioner who made the case over to the judge, submits it to the Sudder court in Allahabad. Points he made out –

- Forcible seizure and employment of Mr. Vansittart's paharees,
- Vansittart's ordering his *jamadar* to seize me and maltreat me in court,
- his warrant on 6th may desiring the apprehension of my person,
- the examination of the witness in the private quarters of the surveyor general, without specifying reason,
- making Radhanath attend camp on Sunday at Thana, 15 miles from home, directing a warrant without sufficient proof and reason,
- Refusing to receive a written declaration and cunningly making out a case for himself.

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160 The Bengal Spectator Of Sept 1, 1843

161 Ibid

162 Radhanath To The Bengal Spectator, 1843 May 6

Finally, the bills of the 17th may 1843 show us that Mr. Vansittart and lieutenant Patterson had brought charges against baboo Radhanath and Messers Clarke and Keelan and the charges brought against them before in the court of a Mr. Harvey the magistrate of Shaharanpur, and that the trial commenced on the 4th of August.[163]

Harvey found Radhanath guilty upon the fullest proof of illegal seizure and detention of property of Mr. Vansittart superintendent of Dehradun and of Captain Paterson and of defying the police and refusing Mr. Vansittart's orders as magistrate given before witnesses and in the presence of the police. This misbehaviour of authority and illegal exercise of judicial authority was criminal under the spirit and letter of every regulation upon the subject 1793 onwards and that the section XXVI, regulation XX - 1817[164] and its provisions warrant the order and as Radhanath was tenacious of his opinion that he had the right to seizure, and obtain property not his own, thus taking matters into his own hands, he would be sentenced to a penalty of 200 ruppees or an imprisonment of 6 months.

> *The examination of witness in the private dwelling of colonel Everest and in my absence by Mr. Vansittart who himself was a party to my case*

Another question which Ashish Lahiri brings to the fore is that Radhanath retired from service only at the young age of 49, at 1862. Was this the norm or was it an abbreation from the norm, one will never find out because there is no written evidence which documents the action.[165]

The first modern scientist

According to Pramathnath Bose there were in India, a few departments which used to be maintained chiefly for scientific research and a few larger departments for which a scientific training was necessary.[166] In a footnote he clarifies that research is carried

[163] The Bengal Spectator, 1st September 1843

[164] The Bengal Spectator, 1st September 1843

[165] Radhanath Sikhdar, Beyond the Peak, Ashis Lahiri, Boi Chitra, Kolkata p37

[166] Bose, pp 232

on by these departments in botany, geology, zoology, meteorology etc". However both these classes of departments are almost exclusively officered by Europeans.

With regard to the departments of scientific research, it used to argued that the Indians were incapable of acquiring whatever the European education might impart. If this had been the situation in 1896 India what might have been the prospect of a young man in the 1830s to fashion a career for himself.

The word scientist had not been in use when Radhanath was already engaging in scientific pursuits for eight years in the GTS. Whewell first used the word *scientist* in 1840 in his '*Philosohohy Of The Inductive Sciences*'. We need to describe a cultivator of science in general. Ashish Lahiri calls Sikhdar a scientist.[167] Bernal further elucidates the perceived idea of a scientist as a person who engages in empirical research in their own esoteric world. In this sense Radhanath Sikhdar was certainly a professional scientist. He had acquired a solid theoretical training in mathematics and physics before he entered the world of science professionally. He also worked in the Great Trigonometrical Survey department that depended a great deal on scientific observations made with the help of customized sophisticated instruments made for these observations. He earned his living by pursuing science.

Isolation

Sikhdar's defiant nature was typical of him. Residing away from Bengal had possibly made him a mite unpopular with his previous friends and acquaintances. Even his manners had become anglicized, according to Sivanath Shashtri. Most of his fellow Derozians and become respectable gentlemen and worthy pillars of British ruled society. Almost all of them had fallen to prey to some sort of religious spiritualism, in total contrast of what Derozio had taught. Nor did they spearhead any social rebellion. Ramtanu Lahiri had become saintly and would dread to speak of God without due reverence of his faith. Krishna Mohan Banerjee believed that the doctrines of the church were more biblical. He became the bishop's honorary chaplain. Shiv Chandra Dev was the president of the Sadharan Bhahmo Samaj till he died in 1890. Peary

[167] Jogesh Chandra Bahal, Unabingsha Shatabdir Bangla, Ranjan Publishing House, Kolkata 1942, p190

Chand Mitra took to the study of spiritualism and joined the Theosophical Society of Madam Blavatsky. Radhanath was the only person who stood out amidst this entire genre. He never betrayed the ideals which Derozio had taught them in the Hindu College.

Whatever might be the reason the mantle for bringing about social change had now fallen upon a different set of persons. Modern scientific ideas could not strike root in a society divorced from active scientific thinking. It was the age of Ishwarchandra Vidyasagar, Akhshaykumar Data and Rajendralal Mitra. All of them were staunch Baconians since they were trying to create against heavy odds, an environment of rationalist empiricist secular scientific enquiry through the exploration of popular Bengali prose. Sikhdar felt a bit alienated by this highly sophisticated, newly formed structure of Bengal society. But at the same time he realized how important a role vernacular played in the making of their identity. But he rebelled against the sanskritized Bengali of Vidyasagar. "*What good is a piece of Bengali writing if a common household wife cannot grasp it*", he used to say. With Peary Chand he founded and edited the "*Mashik Patrika*" for women and encouraged the writing of articles in a lucid language. None of the activists at that point of time were interested even remotely in writing about the knowledge of science. It was also interesting that he possibly thought the scientific matters should be left to the English savvy *bhadrolok*. Like many scientists he was not an enthusiast for popularizing science. His passion for accuracy was well known and maybe he feared matters of science would become diluted in the imprecise Bengali prose of the times.

This also possibly explains why Radhanath despite possessing a comprehensive mind, built on the union rather than a separation of the two cultures could leave virtually no impression on society, so far as scientific thinking was concerned. This was a peculiar situation. On one hand the colonial administration was determined to erase his name from the records while on the other hand he would neither write anything about his experiences nor he speak of his own achievements in his vernacular. Even his autobiography whose mention and reference we find in scattered articles in *Modern Review* issues was never published in English.[168] He did not seem to realize that without scientific rationalistic thinking, all social reforms, including the woman's

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cause were destined to fall apart. A communion of minds like that of Vidyasagar, Akshaykumar Dutta, Rajendralal Mitra and Radhanath Sikhdar could have worked wonders but owing to some unexplored and unexplained factors, it never did. Radhanath thus remained an isolated figure and the rationalized scientific regeneration of the bhadralok Bengali society had to be started anew by new founders.

Syed Mohsin (Syed Mir Mohsin Husain)

For Everest and the other men working on the GTS the instruments with which they measured distances and calculated angles were objects of the greatest importance. Without advanced instruments, surveys could not be conducted in greater detail much greater than those of earlier surveyors. The most important instruments, compensation bars and theodolites, were designed and built in England and shipped to India. In his writings about the GTS, Everest spends large passages going into minute detail about the instruments and equipment used during the survey. In his account of *Surveying Part of the Arc of the Meridian* Everest often describes the problems with his instruments as "evils" and spends large sections of the work describing his surveying tools.[169] Due to the highly sensitive nature of the equipment, even small flaws could lead to large errors in the survey data.[170] The surveys could not operate if there was a question as to the accuracy of the measurements produced by their instruments. The machines needed constant supervision to ensure that they operated correctly, and Everest and others were continually looking to improve their instruments or obtain new instruments to replace those that were approaching obsolescence. The equipment Everest began his surveys with was inherited from his mentor Lambton. Unfortunately most of the equipment was aging and in dire need of repair. Of particular importance was the 36 inch (Great) Theodolite which was rapidly falling into extreme disrepair as it had been in use since 1808.[171]

[169] Introduction to Everest's Measurement of the Arc of the meridian, Quoted from Arya Darshan, Kolkata 1884

[170] ibid

[171] Edney 241-2

Everest dealt with this problem during his convalescence in England (1835), purchasing and testing new surveying equipment for the GTS. After calibrating and testing the tools in London, Everest transported them back to India to commence a new round of surveys. However the environments of London and India treat survey equipment very differently and stresses appeared during actual survey work that Everest could not simulate in London parks. Consequently the equipment was often in need of minor repairs and maintenance, and sometimes in need of overhaul and reconstruction.

Early in the survey, these tasks were neglected or done in the field because repairing the equipment meant shipping it back to the manufacturer in London. Everest desired to change the policies of the survey and find someone who could repair the equipment in India to the same degree that it could be repaired in London. After negotiating with his superiors Everest was allowed funds to hire a craftsman that could perform the intricate work needed on the survey equipment. The first man to enter this position was Mr. Barrow, who travelled to India with Everest in 1830.[172] Everest and Barrow did not get along and often exchanged angry letters concerning the progress and manner of the work on the instruments.[173] Barrow could not contend with Everest's constant demands for progress and after a particularly difficult time, working to repair the large theodolite in 1837, Everest requested that Barrow be sent away from the survey camp and back to Calcutta [174] After this incident Barrow retired and the responsibility of maintaining the equipment of the survey was given to Seid Mohsin, an assistant of Barrow that Everest had developed a liking for.

Mohsin began as an instrument repairer in 1824 and was appointed as a Sub-Assistant to the GTS in 1836. Everest recommended Mohsin for the promotion as "peculiarly remarkable for his inventive talent, the facility with which he comprehends all mechanical arrangements, and the readiness with which he enters into all the new ideas of others."[175] Everest made it very clear in his writings that he would not be able to operate if Mohsin were not a part of the survey, at least at the rank of a Sub-

[172] Phillimore IV 418

[173] Phillimore IV 418

[174] Phillimore IV 419

[175] Phillimore IV 458

Assistant. This was a high rank for a native Indian to reach and allowed Mohsin privileges beyond many other workers on the GTS, of any race. In one particular instance mentioned by Everest, Mohsin and Everest's chief Computor Radhanath Sikhdar were meeting in the survey's observatory; Barrow entered and had to wait two hours for Everest to finish with his Sub-Assistants before he could approach him.[176]

In his capacity as a sub-assistant Mohsin performed a great deal of repair and maintenance on the GTS instruments. Mohsin also travelled with the survey as it moved, in order to repair equipment that broke in the field. In 1839 Mohsin was with Everest and succeeded in performing a delicate procedure on one of the Theodolites, a task that Barrow had refused to perform, thinking it to be too difficult. This was a particularly important accomplishment as it required someone like Mohsin to design new equipment of his own to complete the job. This was not a complicated repair but was the division of the measuring circles of the theodolite into equally spaced units. The division had to be perfectly consistent around the entire circumference of the circle or all of the measurements taken would have been incorrect. Mohsin completed the procedure to the satisfaction of Everest, a demanding overseer, and the theodolite was soon returned to use.

Due to this, in 1842, Everest recommended Mohsin for a further salary increase, and a further promotion to the post of Mathematical Instrument Maker, the spot formerly held by Barrow.[177] Also Mohsin was rewarded £200 also at Everest's suggestion, as it was the fee that any skilled London craftsman would have charged for a similar operation.[178] The directors of the company promoted Mohsin but created a new title for his position, "*Head Artificer to the Department of Scientific Instruments*". [179] Everest was disappointed with the title saying that it was "*a source of deep personal mortification*," and in 1843 successfully petitioned for it to be changed to the original one that Barrow had held.[180] In Everest's 1847 account of a survey of a part of line of

[176] Phillimore IV 419

[177] Phillimore IV 458

[178] Phillimore IV 458

[179] Ibid page 458

[180] Ibid 458

the meridian he mentions Mohsin as his indispensable "*native artist.*" and in one footnote writes a small biography of him describing how he "*found him on my arrival in 1830 and perceiving that he was a person of great original talent, I took him by the hand, and did all in my power to develop his natural genius.*"[181] Mohsin continued to work for the survey and was granted a personal allowance of Rs. 150 per month.[182] He died on February 11th 1864.

Hussain and Sikhdar: A Comparison

Mohsin and Sikhdar share a unique position in Everest's administration. Everest's effusive praise for the men and a lack of any mention of a situation where they did not meet his expectations show their position in the Survey was both secure and well deserved. The biographies of the two men make it clear of their special positions in the survey and also what was necessary for Mohsin and Sikhdar to reach their positions of heightened esteem. Each man was responsible for an important part of the knowledge creation and collection by the survey. Mohsin and Sikhdar were also examples of the most Europeanized of the Indian workers in the Survey. This perhaps is due to both their own decisions and Everest's influence. As mentioned in the complaint of Mr. Barrow above, he once had to wait while Everest consulted with Mohsin and Sikhdar. While this situation is telling as to the power dynamic in the survey administration, what is more interesting than the meeting is that while Barrow was reprimanded for not removing his hat as he waited, the sub-assistants both continued to wear their hats and smoked cigars with Everest while they consulted.[183] It is clear from this anecdote that Mohsin and Sikhdar had developed some European habits while working for the survey. This was probably encouraged by Everest, who often seems uncomfortable with overt or excessive displays of native sentiment or identity in his office. From available evidence, both men knew English. Mohsin signed his name with his title printed in English underneath, and Sikhdar was proficient enough to compose an autobiography in English that has since disappeared. While Mohsin did not have any officially recognized schooling Sikhdar was a

[181] Ibid 459

[182] Ibid 411

[183] Phillimore IV 340

graduate of the Hindu College, which provided many other recruits to the GTS. While addressing a group of later graduates Everest exhorted them to improve themselves using Sikhdar as an example. By working to be like Sikhdar, who was "universally loved," they could also advance the image of their race. Everest hoped that Sikhdar will eventually furnish a convincing proof that the aptitude of Indians for the practical, as well as the theoretical, parts of mathematics is in no way inferior to that of Europeans.[184] Sikhdar is presented as an example not just because of his skill but also because of the status he held with the British. I. Barrow cites a mention of Sikhdar by A. Waugh in which Waugh praise Sikhdar as a "'brilliant success' because he had become 'thoroughly Europeanised' and had 'surrendered his caste and prejudices.'" [185]

Sikhdar integrated as well as possible into the GTS hierarchy and was consistently noted as a complementary addition to the survey. This is not to say that Sikhdar's place in the GTS was without complications. As stated above, Sikhdar's adoption of a European diet and seating position at the dining table initially confused and upset Everest. Because of his exceptiona position and the singular nature of the skills required, Mohsin was not presented as often an example to others. His participation in the GTS was more complicated than of Sikhdar. Mohsin's career in the GTS more fully demonstrated the tensions between the recognition of his useful abilities and the difficult process of establishing an Indian in a highly visible role in the survey. The complicated presentation of Mohsin's title demonstrated the uncomfortable nature of Mohsin's rise through the survey establishment. From his position as a sub-assistant Everest recommended his promotion.

Mohsin's race is very closely related to the changes in title involved in his advancement. The new title labelled him as an "Artificer" rather than an "Instrument Maker," as well as removing the person in the position from a direct relationship to mathematical or scientific authority. Even through the word "scientific" is present in Mohsin's first title it is only the title of the department which has authority over him. There is no connection between the person doing the work and his possession of

[184] Phillimore IV 340

[185] Barrow 137

mathematical or scientific knowledge. The organization possesses the knowledge required for working with the GTS instruments not the individual. Only the skill of artifice, a characteristic with extremely complicated connotations, applies to his position. For the government administration an Indian working with such complicated scientific tools must be proceeding without any actual working scientific knowledge of the instruments. The work then is a result of art and instinct, not science or knowledge. Everest's desire to change the title of the position back may indicate his personal unease with the addition of an Indian at such a high level.

While the government was reluctant to recognize the possession of scientific knowledge in an Indian subject, Everest may have been wary of a man working in his office recognized solely for his "artifice." The insulation provided by the more scientific vocabulary of the original title was sufficient to make up for the presence of a non-European in the position. Everest's ultimate allegiance was to his work. He made his decisions with an eye to how they would improve or hurt the GTS. Everest was not acting on Mohsin's behalf out of his enlightened view of Indians but because of his own overriding desire to totally control his surveys to ensure their success. Though he was ultimately concerned with the scientific progress of his survey Everest should not be seen as an unprejudiced *meritocrat*, only concerned with the practical and scientific abilities of his subordinates.

As the multiple sides of the above biographies make clear, Everest was working in a colonial environment and his requirements for his subalterns bear the mark of his colonial values and prejudices. Sikhdar and Mohsin allowed Everest to survey more effectively and produce more accurate data from the surveys. However they also increased the ability of the Government to demonstrate British power over India. Sikhdar and Mohsin further increased the strength with which the colonial state could control knowledge with the skills they brought to the survey and the example of their presence. Their presence served as a physical indication and reminder of British control over the Indian people. Their acquiescence to British colonial policies within the GTS was a powerful tool to show other Indians the manner in which they should approach the British state. The British could not fully recognize the contributions of the two men without making apparent their lack of knowledge and expertise. Mohsin and Sikhdar worked within dual characterizations. They were both important and valued members of the survey project while at the same time being strangely inappropriate presences in the British power structure. Despite their accolades showered, they were written about in a different manner from the other British or European, workers in the survey.

In the excerpts mentioning Sikhdar or Mohsin words like "peculiar" appear frequently as do other specific notations of their race.[186] Their presence is discussed very often in the manner of how it reflects on the relative lack of skill or intelligence in the rest of the Indian population. Despite their skill they could not escape the colonial prejudices concerning Indians. Even in Everest s supposedly scientific organization, the ideals of colony have full weight. The conflict and confusion of the knowledge creation project carries on through the primary personalities of the GTS and into the entire organization. Indications of the tension and confusion of the project appear throughout its complex hierarchy.

These tensions reveal the incomplete control of the survey and knowledge creation project and also serve as an show case of the difficulties within the entire colonial system. Power was never fully within British control, every aspect of the project was a sequence of compromises and col aborations. While the British could conceive of their survey project as thoroughly monitored and controlled, and therefore producing fully acceptable results, the fact was, that the presence of Indians within the survey establishment altered the project. The British could characterize their information as inviolable and unproblematic but the characterization would only rest on the surface of a complicated arrangement of interactions and negotiations.

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[186] Sivanath Sastri, AHistory of the Renaissance in Bengal,translated from the Bengali 'Ramtanu Lahiri o Shekalin Banga Samaj by Sir Roper Lethbridge , 1907, Kolkata , P129

Illustrations:

Figure 1: Postal Department of India showing Pandit Nain Singh and Radhanath Sikhdar

Figure 2: Postal Department of India commemorating Radhanath Sikhdar

Conclusion

This dissertation has tried to draw attention to the making of a surveyor, the tools with which he worked and has a specific instance of Indian contribution in this area. The great Trigonometrical survey can be seen as an instrument of control in itself.

Today, India has been redefined. All its prominent features are in focus. The cities, the rivers and mountains are seen in their exact latitude and longitude. Virtually following the footsteps of the Great Arc had come a great surge of nation building development as though the Great Arc had stimulated the nerve endings of the nation, stroking out roads, canals, bridges, and railway and telegraph lines. What emerged was a triumphant and cohesive picture of India unified east to west, north to south, a subcontinent completely in possession of itself.

My aim ideally was to study the Great Trigonometrical Survey as a separate phenomena which helped shape colonial India by mapping the terrain and people and also the nexus of relationships between each and every crevice of the survey department under the headship of the Surveyor General which will give us a nuanced understanding of *the social history of the people who actually mapped India by surveying it,* but remain invisible to the eyes even today. Accuracy had been the obsession. Under George Everest and Andrew Waugh, the great arc was completed in 1866. The conclusion made by Clement R. Markham in his memoirs on the GTS was "*the story of the Great Trigonometrical Survey when fittingly told will form one of the proudest pages in the history of English domination in the east*".

If one looks back at GTS, 200 years after it was conceptualized and 135 years after its completion in part, certain interesting features emerge. The immediate task of the Great Trigonometrical Survey had been the accurate determination of the position of important points over the country which forms the basis for geographical and other surveys and maps. Lambton also wanted to determine, by actual measurement, the magnitude and figure of the earth, a contribution to the geodetic science. He measured an arc of the meridian from Cape Comorin to 180 N, the longest geodetic arc ever measured so close to equator and he completed the results. Later Everest extended it up to Himalayas. These measurements did form the basis for the determination of the ellipsoids. The Everest Ellipsoid is still used not only by India but also by the rest of the south Asian countries.

The other primary objective of GTS - the accurate determination of the position of important points over the country, which would form the basis of Trigonometrical and other surveys - was never achieved. Mathew H. Edney outlines the reasons behind this shortcoming of GTS. A triangulation may be simple in concept, but its implementation has always been difficult. It is slow and costly. The relationship between a triangulation extent and its cost is non-linear. The governments can only undertake it. Every state failed to incorporate a cadastre into systematic topographic surveys - the cartographic ideal before 1880. The progress of the comprehensive mapping was quite irregular. The British surveys did not follow the proper sequence. The triangulation has to be completed, computed and corrected before any detailed surveys could begin.

Almost all topographical and cadastral surveys in India were undertaken before the general triangulation could reach respective region. But at that time, a single, coherent survey organisation that would properly implement a systematic survey did not exist. All British survey activities were supposedly unified in 1878 to form the Survey of India, of which the GTS became the "Geodetic Branch". Subsequently, the Indian survey committee was convened in 1904-'05 to effect substantial reform in the various mapping activities. Later in the 19th century much of the triangulation of the GTS was resurveyed.

Although GTS was supported as a great scientific endeavour, the Government of India had other pragmatic interests. The administration needed geographic information and small-scale maps for ruling and exploiting the country. For this purpose, in the 1820s Atlas of India project was established. The project aimed at compilation of maps at medium scale of four miles which "would bring together all the topographic surveys and warp them to fit GTS in order to create a definite cartographic representation of India" [187]The Atlas embodied the British view of India in 1820, fixed, eternal, imperial and known to British through scientific observation". This view continued

[187] Mathew H. Edney p.30

through the 19th century into the 20th century. Even after independence the preparation of 1:250,000 maps was given due importance. According to Edney, "Map making was integral to British imperialism in India. The surveys and maps together transformed the subcontinent from exotic and largely unknown region into a well-defined and knowable geographial entity. The empire might have defined the map's extent but mapping defined the empire's nature".

We have seen that the British rulers were not interested in science as such, .but in using science to further their interests. Whenever their practical needs pointed a finger towards a particular branch of science, attention was paid to that science, be it the revenue and Trigonometrical surveys, the discovery of fossil fuels and mineralogy and the exploration of the flora and fauna leading to the botanical surveys. Harnessing science enriches it. Thus in the process of empire building, India was added as a laboratory to the edifice of modern science. Introduction of Indians to science came about when they were assigned the role of laboratory assistants.

The history of the Great Trigonometrical Survey is relevant at present when technological thrust replaces conventional map making methods. GTS was considered the best scientific way of mapping India. In spite of its ardent supporters from the highest eclon of British Empire, it could not fully satisfy the mapping requirement of India. As a concept it was ideal but in practice it was riddled with insurmountable problems. Now GIS and GPS throw up such great expectation as GTS did in the nineteenth century. Time alone will tell how well these expectations are fulfilled.

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