

## Following in Footsteps of The Great Trigonometrical Survey of India

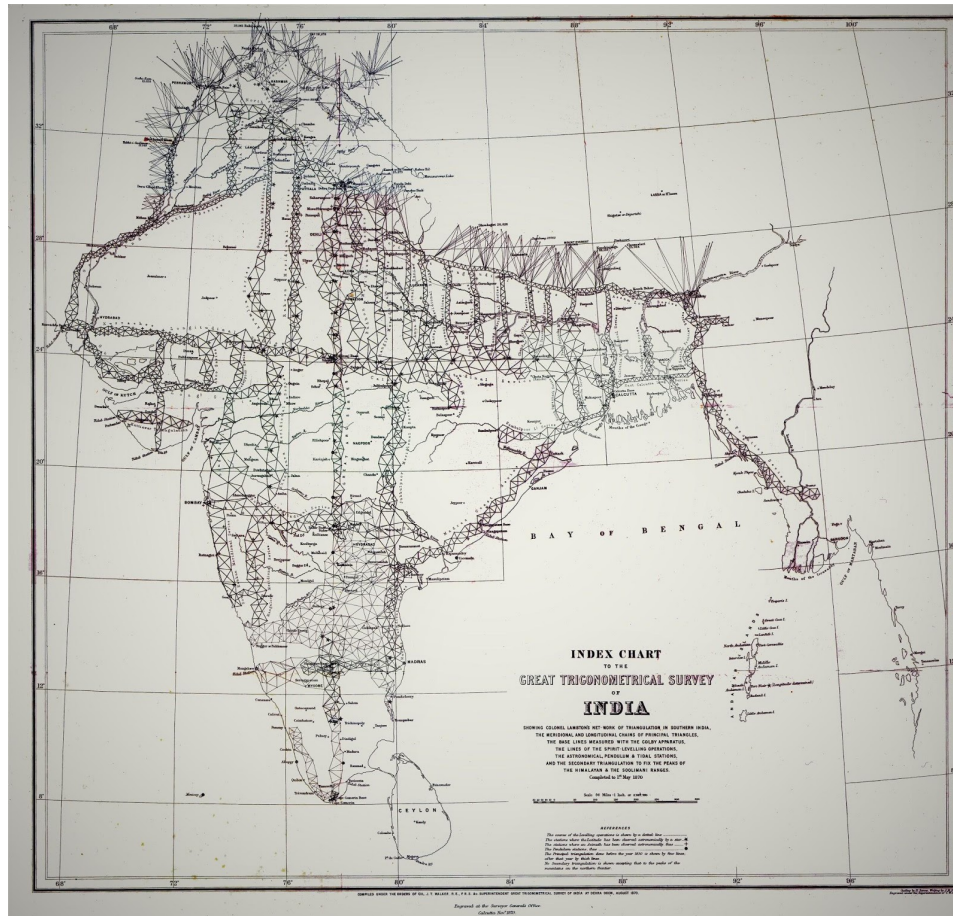
Land surveyors at some point in their career wind up researching historic field notes, land records or plats from some earlier era. Depending on area of practice, research may include GLO field notes, NGS control surveys, Native American tribal lands, Spanish or Mexican Land Grants, metes and bounds in the Colonial states, grant deeds etc. Researching GLO field notes in my area of California's Central Coast, I'm always drawn to the first couple of pages with the names of long gone surveyors and their crew assignments, i.e. party chief, instrument, compass or chain men, possibly a few axe man, maybe even a hunter and/or a camp keeper(cook). We've all seen the pictures of survey crews from that era, not many smiles.

And before you or any former clients read further, *No billable time was consumed developing the following story. But I digress.....*

As I imagined surveying under these harsh conditions my search for more historical survey information turned up a July 1992 article from [Backsites Magazine](#) about Sir George Everest

and the Survey of India by Mary M. Root. Reading Ms. Root's article about the world's greatest triangulation survey of that era and Sir Everest's relentless pursuit for accuracy, I went looking for more information

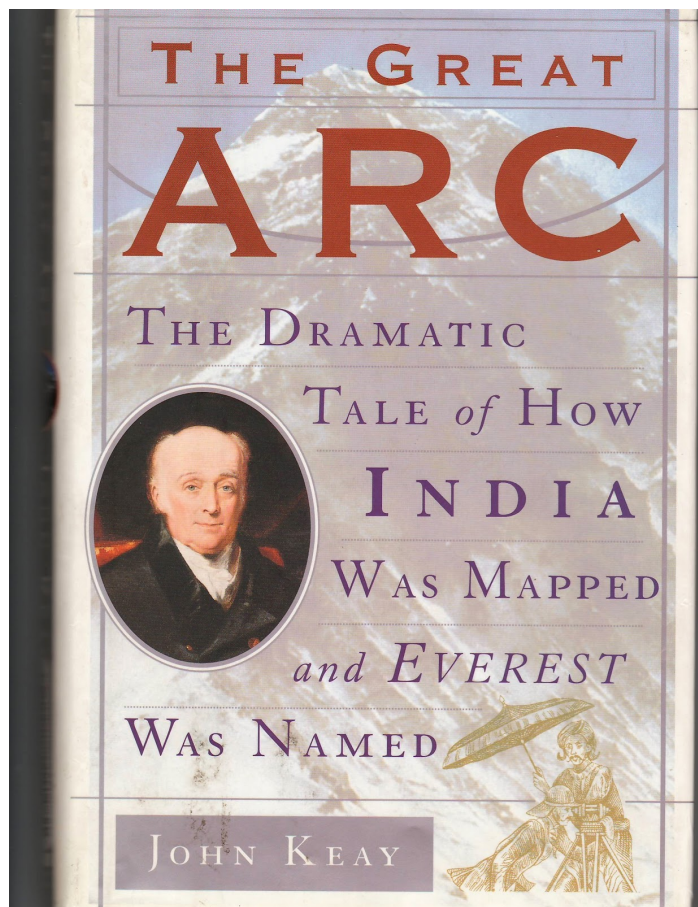
An Amazon book search about this six decade long survey turned up [The Great Arc](#) by John Key, the story of the survey of the Indian subcontinent from 1802 through 1855.



[Index Chart of the Great Trigonometrical Survey of India 1877](#)

This well written and enjoyable book tells the story of the British East India Company's need for mapping as they acquired and colonized the many Indian principalities within that country's vast interior during the 18<sup>th</sup> and 19<sup>th</sup> centuries. Begun by Wm. Lambton in 1802 until his retirement in 1823, the survey was continued by Sir George Everest until his retirement for health reasons in 1843 and completed by Andrew Waugh in 1855.

**The Great Arc Survey** roughly followed the 78<sup>th</sup> East Meridian from Cape Comorin at India's southern tip north to the foothills of the Himalayas. Mr. Keay, though not a surveyor himself, explains geodetic survey principles in an interesting way ( and yes, that is possible!) for readers to get an idea of magnitude and immense difficulties faced during the survey.



Left - [The Great Arc](#) by John Keay  
ISBN 0-06-019518-5

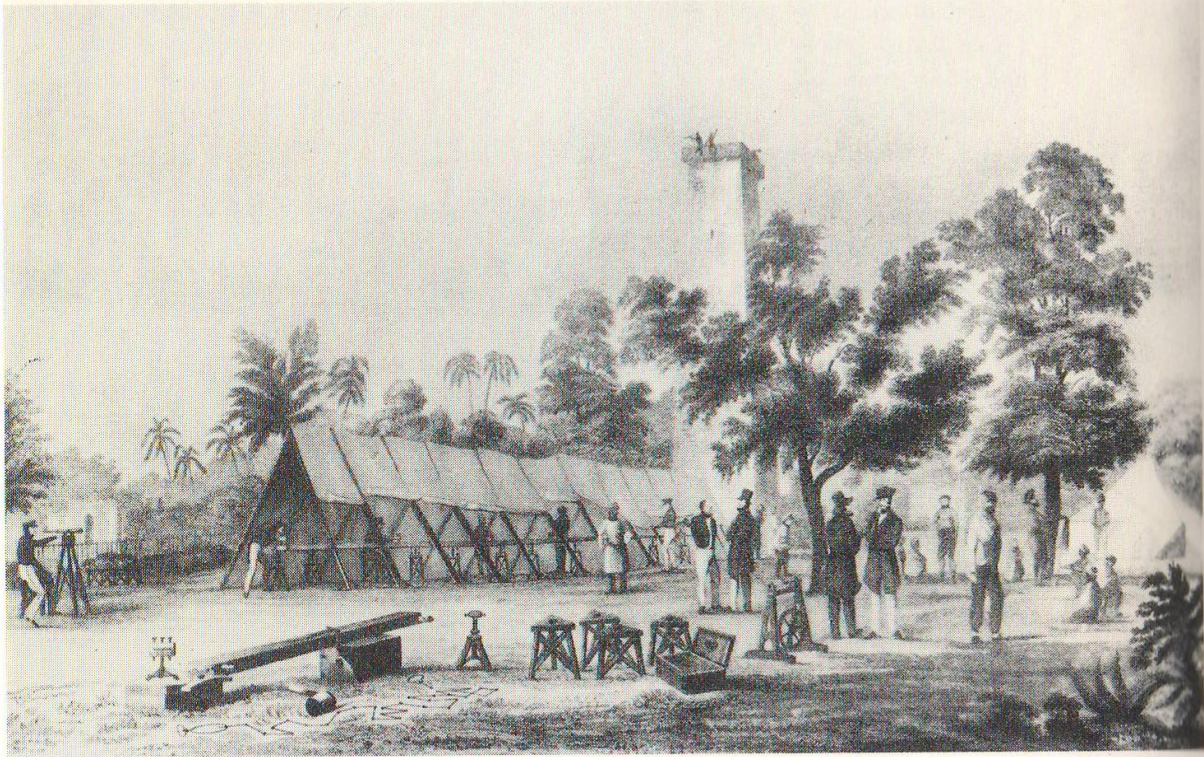
I began to understand the magnitude of **The Great Arc Survey** with the book's description of the first base line.

Lambton's crew began the survey taking 58 days to complete a 7 ½ mile long precision base line (measured with a 100' chain) near the southern beginning of the survey route with additional baselines throughout the network for adjustment purposes. Principle triangulation points throughout the network were selected for astronomical observations and geodetic positioning.

Triangulation lengths varied according

to terrain with 20 miles being the desired length of the 1600 mile survey, sometimes with weeks passing by waiting for crews to establish signal towers on a distant hill or ridge with the possibility of additional delays waiting for suitable observation weather.

If these guys just could have waited a couple of hundred of years or so, it would have been so much easier!



The 1831 measurement of a base-line at Calcutta attracted influential spectators for whose delectation 'an elegant breakfast was laid out in tents'. The awning in James Prinsep's drawing shades the first set of compensation bars. Note in the background the survey tower, one of the first to be built.

[Picture from \*The Great Arc\*](#)

Theodolites weighing half a ton were hoisted to the top of bamboo or stone towers, the tops of temples or mountain tops with weather ranging from blistering heat and humidity in the jungle lowlands to blizzard conditions in the Himalaya Mountains near the northern border with Tibet and China. Malaria, yellow fever and other diseases wiped out entire survey crews while marauding tigers, scorpions and cobras pecked away at individual surveyors.

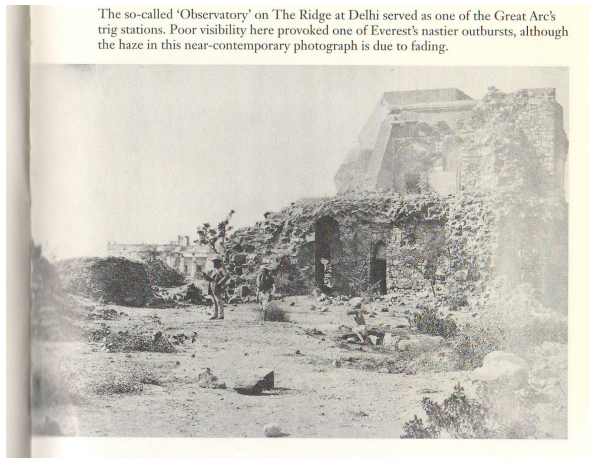
The survey of **The Great Arc** made possible the development of harbors, roads, railways and telegraph networks defining India as we know it today.

**The Great Arc** also made possible the first accurate measurement of major Himalayan peaks including Mt. Everest, K2, Dhauligiri and more importantly new accurate values for the curvature and shape of the earth. The sheer size of the survey included logarithmic calculations for spherical excess, effects of the geoid on precise leveling and atmospheric refraction.

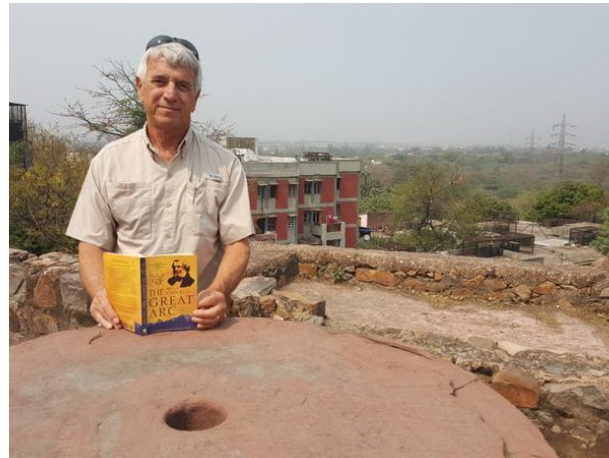
Following the sale of our business in 2015, my wife Chris and I booked a month long tour of Rajasthan, India during February 2016 including an additional week to further explore Delhi on our own.

Rereading John Keay's *The Great Arc* prior to our trip, there was a picture taken years ago of a 13th century structure used by Everest as a triangulation station within an area known as The

Ridge, northwest of Delhi's city center. On our final day in Delhi, we hired a car to see if we could locate this station aided by clues from Keay's book ("adjacent to the Hindu Rao Hospital"), and Google Earth. With more than a little luck, we found the hospital on the ridge. Asking around the hospital offices on a Sunday morning, we were sent from office to office until finding an administrator who, although taking an interest in our request, explained that we would have to come back on Monday when senior administration was in office. Explaining that we were headed home that night, he called a maintenance man that knew what we were searching for, walked us to a fenced off area, unlocked the gate and left us to wander around the structure. The structure is an Indian national monument which doesn't appear to be visited often.



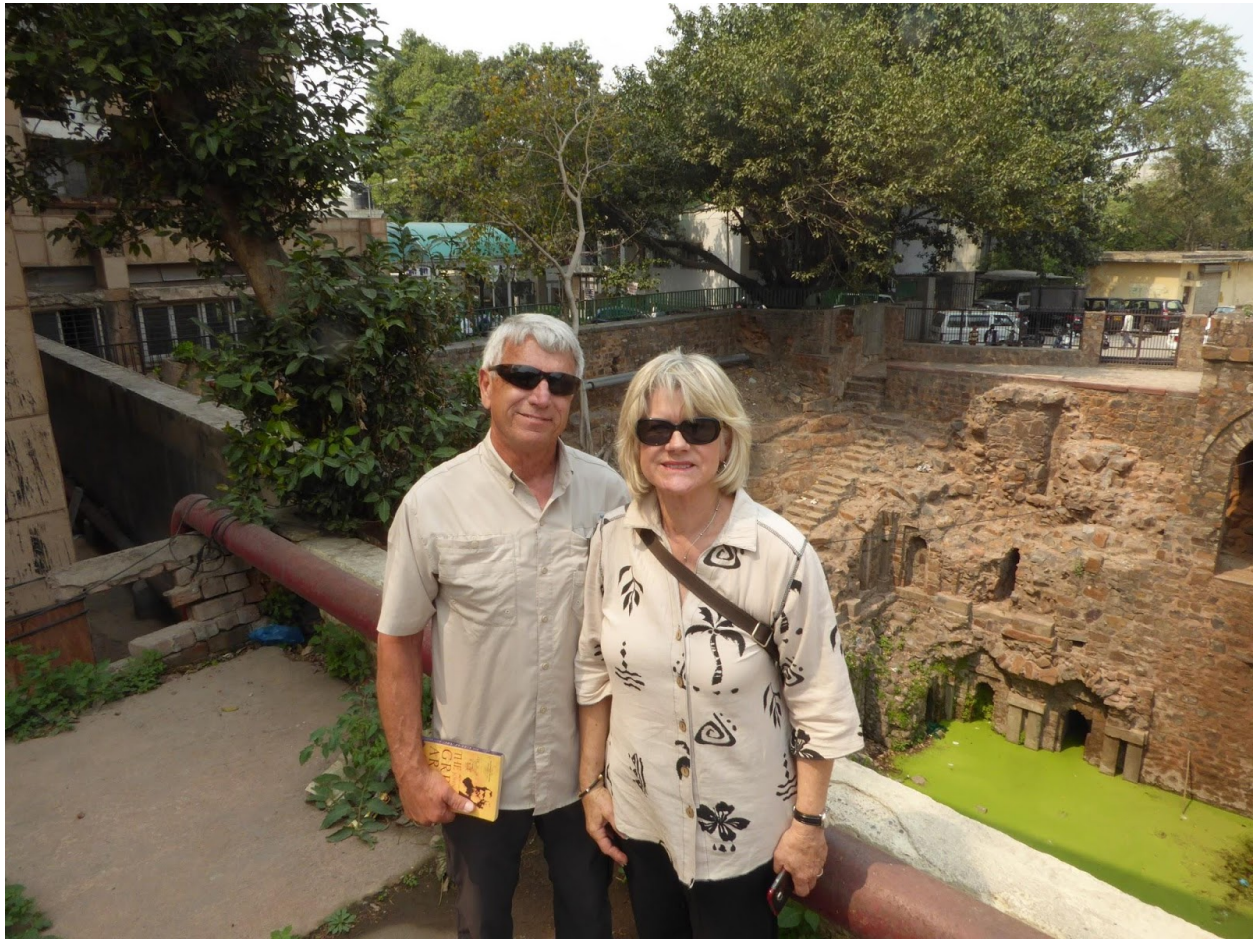
[Triangulation structure from early photograph](#)



[Everest's Theodolite Pedestal](#)



[Triangulation structure February 2016](#)



**Right – Chris and I before climbing to the top.**

Climbing up a steep stairway to the top, we find the remains of a large mortared pad for Everest's theodolite with a vertical hole through the roof and, according to the book, a monument on the floor below. There were squatters occupying the structure so we stopped short of looking for the actual monument. This was an exciting end to a great month in India and created more personal interest with Everest's career long survey.

Mr. Keay's book included photos of instruments used by Lambton, Everest and others during the survey located within a Museum at the Survey of India facility in Dehra Dun India where Everest had established the agency's permanent offices in the 1830's. I daydreamed about visiting the museum.

Returning to the Indian subcontinent in September 2016 to join a trekking group in Nepal, I wondered about my chances of visiting the offices of the Survey of India (India's NGS) in Dehra Dun following completion of my trek. The Survey of India campus is not only India's Defense Mapping Agency, it is also a university campus training all of India's land surveyors, photogrammetric surveyors and land information professionals.

I planned a three day stay in Dehra Dun to see what I could find, visit the museum, the Survey of India (SOI) office and possibly Everest's house which is an hour's drive north into the Himalayan foothills. Email efforts to contact anyone in the Survey of India office before leaving home were not successful... *or so I thought.*

With departure time fast approaching, Chris suggested I try contacting the author John Keay. Despite a surveyor's normal skepticism with any idea alternative to their own, I emailed Mr. Keay explaining my wishes. Within hours I received a pleasant reply with suggestions for my visit including contact information for a Sikh lady that was the SOI historian years ago during Keay's research for his book. Two days later I was on my way from SFO to Kolkota, India, still with no word from the Survey of India offices.

Three weeks later following travels through West Bengal and my Nepal trek finished, I flew from Kathmandu to Delhi with a connection flight on to Dehra Dun, still with no word from the SOI. I checked into a local hotel walking distance from the SOI Campus with hopes for good luck the next day. Talking to the hotel manager that evening, I learned the SOI Campus is a secure environment because of perpetual hostilities along the nearby border with Pakistan and China and may be difficult to gain access. Not what I wanted to hear but not surprising as the SOI is also India's Defense Mapping Agency.

After breakfast, with my feet still killing me after last weeks Nepal trek, I walk the hour or so to the main gate and am stopped by armed guards who explain to me that access for anyone, especially a foreigner, is impossible without written permission from the Surveyor General of India's office. Recalling Mr. Keay's suggestion to be *persistent*, I was finally escorted by armed guard to an interior office after surrendering my ID, passport, camera & phone. The gate closed and locked behind me and I'm inside with no idea of what will happen next.



Taken to the office of Mr. R.M. Ghildayl Supervising Office Surveyor, I explain why I'm there, my interest in the early survey and that I would like to visit the facility museum.

Above – [Mr. R.M. Ghildayl and I having tea.](#)

Mr. Ghildayl pleasantly explains to me that he is very busy, has no knowledge of historical data related to Everest's work and would be quite happy if I would maybe just go away. Not wanting to be brushed off at this stage, I'm trying everything I could think of, finally playing my only trump card and mention Mr. Keay's recommendation of the nice Sikh lady historian. Mr. Ghildayl lights up and instantly becomes very friendly. He explains that she has since retired and shares her mobile number with me. The ice broken, he pushes a doorbell button on his desk and an older gentleman shuffles in and sits on the floor to brew us both a cup of tea.

We talk about survey experiences, in particular his field work in the 1970's along the Nepal and West Bengal border in the Himalayas. Very interesting, we have similar stories about techniques and equipment from an earlier time. A half hour later, Mr. Ghildayl escorts me to the door, wishes me luck and returns to his work. Signing out at the main gate, I walk back to my hotel with the feeling that I might have my foot in the door.

Following lunch at the hotel restaurant, I decided to book a hired car the next day to travel to Mussoorie in the Himalaya foothills and see if I can locate Sir George Everest's home. I wasn't sure if a visit to the museum would ever be possible. The gentleman at the front desk arranges for a driver to pick me up in the morning, 2800 Rps (\$43.50 US) for 5 hours.

I know the Everest residence from the 1830's is an Indian National Monument but no one I've spoken to locally seems to have any knowledge of it. That evening I called the Sikh lady's mobile number, she is very pleasant and says she will try to meet with me tomorrow but she is very busy. I fill the rest of the day with a walkabout of the old city core including the clock tower from the early days of the British Raj.

#### [Scooter repair shop](#)



#### [Mobile barber shop , walk ins welcome!](#)





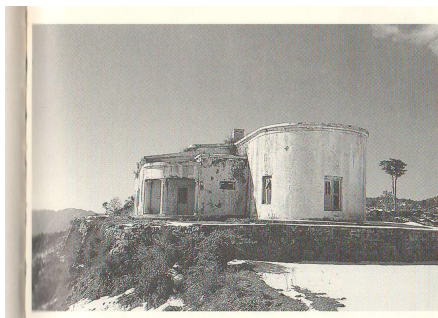
[Typical lunch potato pakora, spicy curry & chai](#)



[Local delivery van](#)

*Following is from a journal that I kept during the trip;*

**05:30** *The best day of this trip begins.* Breakfast in the hotel restaurant, a shower, writing in this journal, email and I'm ready. My driver, Sandeep Kamar shows up 09:00 sharp and we're off. Clearing Dehra Dun morning traffic in the first half hour, the acrid smog of the Gangetic plain stayed with us until we reached higher elevations in the Himalayan foothills. I had researched the Everest residence location before leaving home as well as John Keay's reference to the structure in his book and felt confident we could navigate our way there. Nearing Mussoorie we stop several times to ask for directions and noticed that the Indian government had put up small signs to assist. We finally reached what remains of his residence at 9:45. A beautiful day high above the heavy smog of the city, I spent an hour exploring the grounds and it's not difficult to imagine what Everest would have liked about this area.



LEFT Hathipaon House, near Mussoorie and at the edge of the Himalayas, was where George Everest set up home and headquarters during the final years of the Great Arc. He left in 1843 and the house became derelict soon after; it remains so.

[Everest residence earlier times](#)



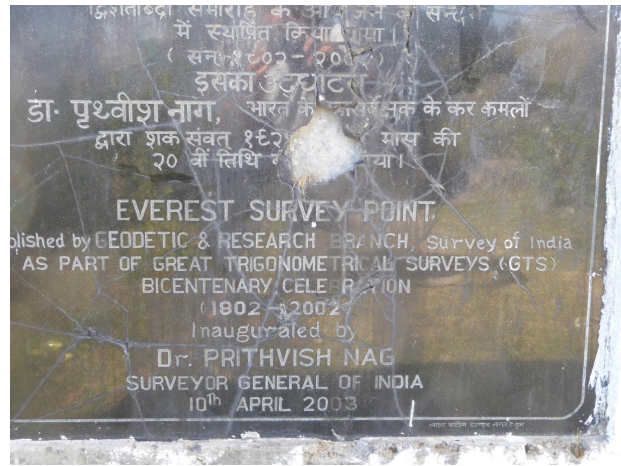
[Everest residence October 2016](#)

A masonry structure with iron gates and bars on the doors and windows, it was dilapidated but not bad considering it has been here for close to 200 years. 5 fireplaces to counter the tough winters at this elevation 6,500' MSL, the house sits in a high saddle with views to the south of the Gangetic Plain and glimpses to the north of the high Himalayas beyond the nearby foothills.

On a knoll to the west is a poured concrete foundation 3 feet above ground with a plaque commemorating the 150 year celebration of Everest's dedication to the great survey.



[Waited in a short line to read the plaque](#)



[2002 Bicentenary celebration Great Trig Survey](#)

The plaque was erected by the SOI group in 2007, 150 years after the survey was commenced. I spent an hour relaxing there with a cup of chai tea from the inevitable tea stand that was nearby. Not many visitors while I was there, maybe it gets more visitors on the weekend?



[Contemplation time](#)



[Sandeep and I having tea](#)

**11:30** Sandeep drops me off in the center of Mussoorie to wander around, I will call him on his mobile when finished to pick me up. After 45 minutes I'm done, I called, he picks me up and we race back down the hill to Dehra Dun. On the way we listen to Indian rap music and spend what seems like half of the time on the wrong side of the road passing cars and trucks on blind curves with his horn at full blast. For the first time on this trip, I'm liking being on the left hand side of the road.....as far away from what remains of the guardrail on the right as possible

On the way down, I call the Sikh lady to see if it will be possible to meet, she explains that she is too busy and I sense her reluctance to meet. I'm disappointed but understand given my phone call out of the blue with no prior introduction.

It's still early and I ask Sandeep to see if we could try again to find the museum that I had tried to gain access to yesterday. No problem, Sandeep takes one hand off the steering wheel and makes a call to authorize more time. His office directs him to take me to another older Survey of India campus than the one that I'd walked to yesterday. I'm relieved when Sandeep ends the call and puts both hands back on the steering wheel.

**13:30** *We arrive at the old campus, check into the security office only to find out the museum is closed to the public and, once again as a foreigner, I will need a letter of authorization from the Surveyor General of India's office to gain access. Great!! They said permission usually takes several weeks and I figured that was the end of my search. Then I recalled John Keay's advice to *be persistent*. I asked Sandeep to ask where the Surveyor General's office is and we were off again to a different section of the new SOI campus that I'd walked to yesterday.*

**13:50** *We arrive at a guard shack at a different gate to the new SOI campus. The guard checks my passport information against his clipboard. He says my name is on a printed list of names of approved visitors. I'm stunned!! The guard says the people that I need to speak with are at lunch and I will need to wait. No problem. I ask Sandeep to wait until the meeting. Sandeep, who's on the clock also says, "No problem" and returns to his car for a nap.*

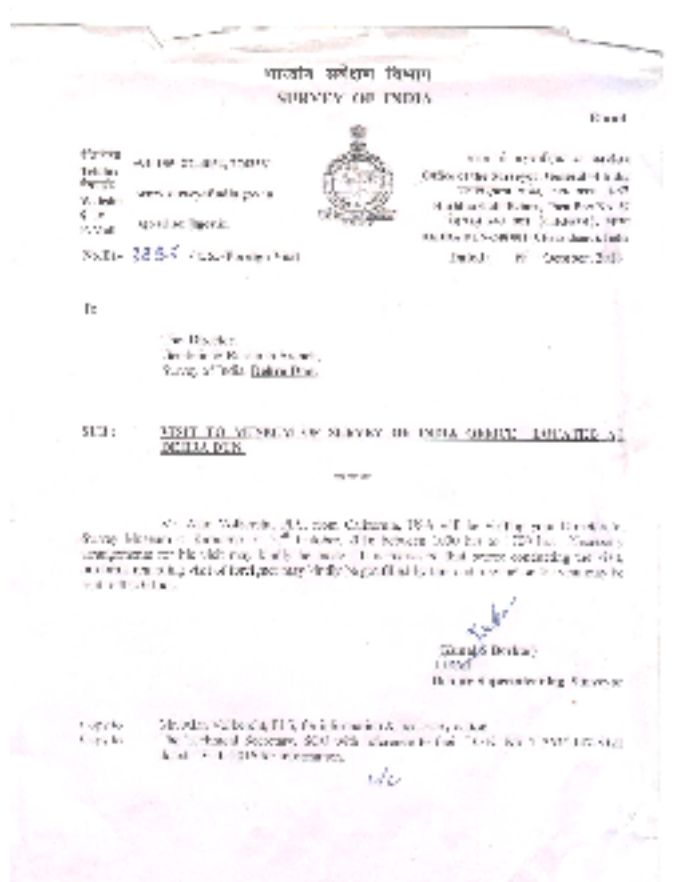
**14:10** *I'm asked to accompany a guard into the office of the Deputy Surveyor General of India. First I have to surrender all ID, phone and camera and sign another ledger. I'm excited to put it mildly and wish that I'd dressed a bit differently for the occasion. In the large hall leading to the Deputy Surveyor's office is a [\(below left\)](#) large display area with the theodolite used by William Lambton, George Everest's predecessor on the Great Survey of India. The guard allows me to have my mobile phone back for a couple of photos with the theodolite and we continue to the Deputy's office.*



I continue into the Deputy Surveyor's office to meet Lt. Col. Kumal Borkar. A friendly Indian Army officer, Col. Borkar explains that his wife worked for a tech firm in the San Jose area before he met her. Pleasantries aside, Col. Borkar orders tea for us both and presents me with my permission letter for access to the campus and museum. The letter has been ready for several days and they have been holding it until my arrival. *I'm ecstatic!!* We finish tea and he sends my passport out to be scanned for the umpteenth time. I sign several more forms and the ubiquitous Indian log book and we say goodbye. Col. Borkar also calls the museum curator to tell him that I'm on my way.

With the afternoon getting short, I hurry out to the parking lot to meet Sandeep who is still fast asleep in the back seat of our car. We drive back to the old SOI campus near the center of Dehra Dun. Asking Sandeep to drive faster than usual is not necessary. He has one speed.

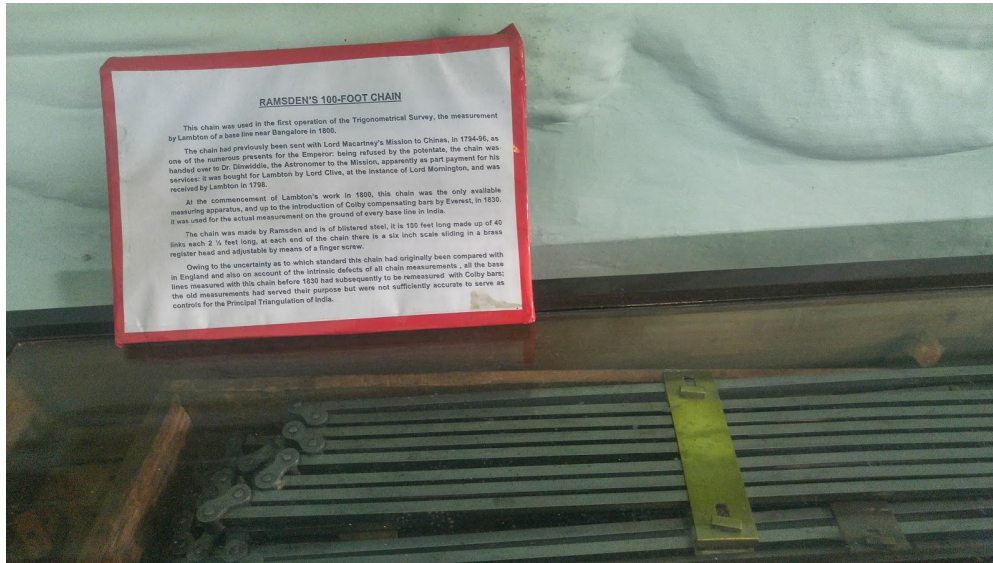
Arriving at the gate, I present my [authorization letter](#) ( **below left** ) to the guard, fill out a few



more forms, have my passport scanned again, sign another log book and am escorted across the center of the SOI campus to the museum.

**Above right - Arun Kamar**, curator and chief historian of the Indian National Survey Museum greets me at the entrance. Arun had assumed the historian position after the Sikh lady had retired several years ago. Since the museum is closed to the general public, Arun escorts me on a 2 hour personalized tour of all of the museum exhibits including overall history and political intrigue associated with the trigonometric survey. Arun's presentation included the training of mapping spies employed by the British East India Company to explore and map route possibilities through the Himalayan mountain passes that might be used by Russian military units as part of the "Great Game" between Russia and England at that time. Arun is enthusiastic and this is obviously more than just a job for him. For more info read [The Great Game](#) by Peter Hopkirk. ISBN 1-56836-022-3.

Smithsonian quality exhibits available to touch. **Surveyor geek heaven!**



Above is [Lambton's original 100 foot chain](#), 40 hinged bimetal links each 2.5 feet in length. It looks heavy.

Not only am I allowed to see all of the instruments associated with the original trigonometrical survey, I had to resist the temptation to touch them. Arun is a former field surveyor and while touring the museum he filled me in on more of the SOI's long history of the mapping of India for the British East India Company and the situation in India following independence in 1947. Arun remembered John Keay when he was present researching his book about the Trigonometric Survey.

Everest's obsession with accuracy, precision and expediency led him to refine or redesign much of the equipment used by his crews. An example below is the astronomical instrument used by Everest and others to determine geodetic positions at various control stations. This particular instrument originally built in England in 1830 had its 24" vertical circle re-divided by Everest at his workshop in Mussoorie. He also was involved in the design of many smaller theodolites for local mapping surveys within the country. Everyone including Everest suffered the effects of malaria, cholera, dysentery and other diseases during their time in the country.



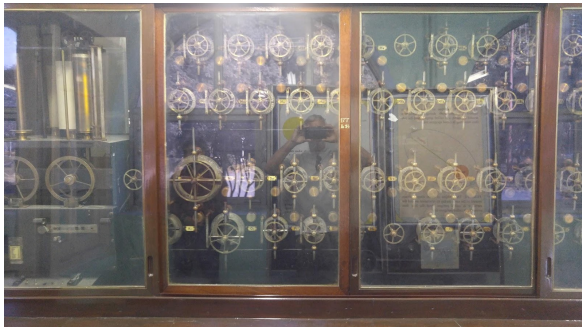
Ill much of the time, Everest was forced to return to England in 1830 for 5 years to recover his health. As with most of the British posted to the East India Company in that era, Everest remained in poor health from his years in India until passing in 1866. **Left - [Astronomical instrument](#) used by Everest and others for determination of geodetic locations.**

The Survey of India was and still is also responsible for tidal measurement and tide table predictions for mariners, particularly important given India's many ports along the Indian Ocean and Arabian Sea coastlines. This project included years of spirit level leveling between tide



gauges along both coasts with ties to the trigonometrical control survey network. Our tour included multiple mechanical computers designed to ease the burden of calculations and tide table preparations.

**Left - 24 component [tide predicting machine](#) in use by the SOI from 1877 to 1952.**



Finally judged to not be accurate enough for maritime service it was replaced by a 32 component machine that was used until being replaced by computers in 1977.

**Left - [32 Component tide predicting machine](#)**

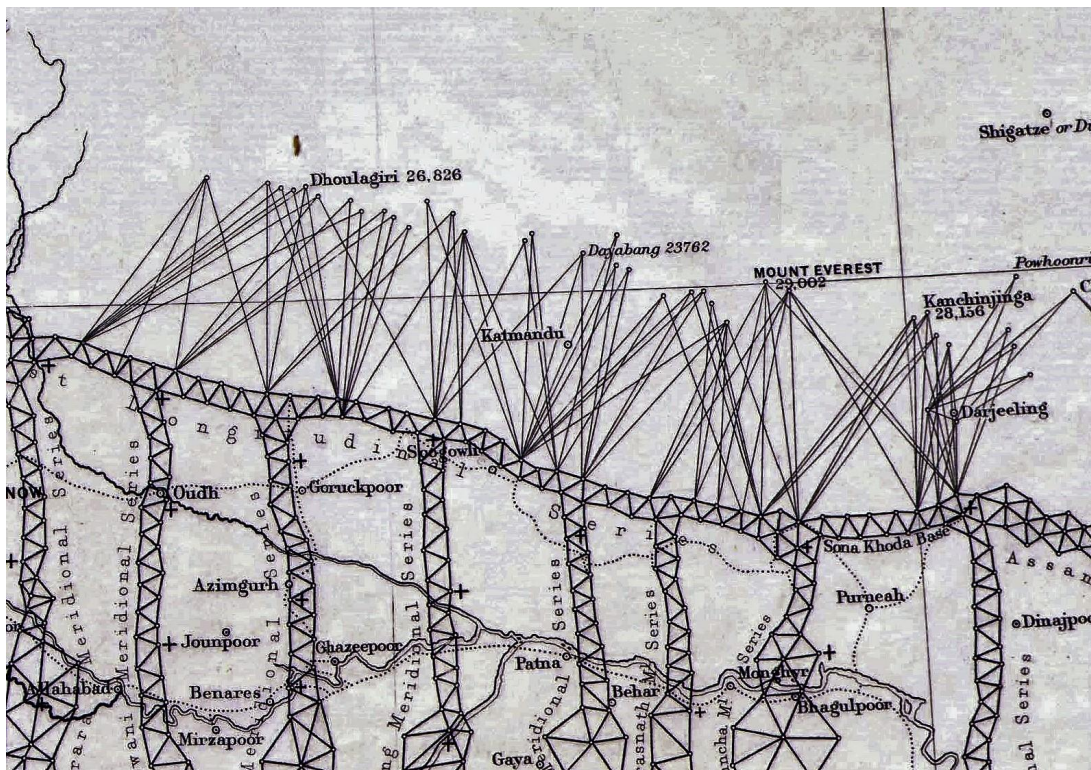
Moving on, we visited a library containing hundreds of field books and maps most bound and wrapped in cloth. I wasn't invited to look at any of them and didn't ask, looking back I wish that I had.

With his health an issue, Sir George Everest was succeeded by Andrew Waugh in 1843 as Surveyor General. Prior to his advancement, Waugh had spent his years in the field including determination of the heights of the highest peaks in the Himalaya and Karakoram Mountains. Peak locations and heights were determined by trigonometric methods from multiple points within a network along the foothills to the south. Peaks were observed from multiple points most of which were 100 or more miles distant from each peak. I tried to imagine how a surveyor could spend weeks traveling between observation points along the network to make redundant observations of each of the prominent peaks and keep them straight with earlier observations by others.

Several weeks earlier on this trip I passed within the shadow of one of the peaks measured by Waugh in 1843, Dhaulagiri measured at 26,826' MSL in 1822 and noted as 26,795' MSL today. Mount Everest, then known as Mt. XV was determined to be 29,002' MSL in 1847, today's value reported as 29,029' MSL.

Interesting to note that the 1847 value calculated by the SOI's Chief Computer Radhanath Sikdhar was calculated to be 29,000 but he added 2 feet to that value thinking no one would believe his work if he reported it as such an even number.

All in all, comparing today's values with results from 150 or more years ago, certainly is a testament to the great care taken by these earlier surveyors.



**Enlargement of 1877 map.** My Nepal trek passed through a final high pass at 18,000 feet in the shadow of Dhaulagiri shown above. It was all I could do to haul myself over these passes, I can't imagine spending weeks trying to function at this elevation.

Two hours passes quickly, we say goodbye and I'm sure Sandeep isn't sorry to drop me off back at the Hotel President. I drop my bag in my room and enjoy a final dinner in the hotel restaurant watching a national cricket tournament between India and New Zealand with my waiter trying to explain the game to me.

I'm leaving Dehra Dun tomorrow and continuing my trip to the northwest, a 10 hour ride by car to Shimla before continuing on to the India/Pakistan border by train several days later. As much as I would like to spend more time in the Dehra Dun area, I'm anxious to travel on.

Shimla was the summer capital of the British Raj government to escape the unbearable summer heat of Kolkata (Calcutta). I was thinking of traveling by bus to Shimla but decided to hire a car instead.

I ask the gent at the hotel desk to call Sandeep's office to see if he was available to drive me tomorrow, he is and we agree on 5800 Rps ( \$90.00) for the trip. Quite a bit more than the bus fare but the schedule was much better and I sensed that if we survived the trip, it would be far more interesting than the bus ride. I wasn't disappointed! I'm hoping Sandeep shows up well rested because now I know what to expect with his driving.

***20:30** I'm in bed early again, exhausted but elated how this long day has worked out. As fantastic as this trip has been, today was the highlight.*

India is a fantastic country to visit, it is stimulating to say the least. The food is great, the people are wonderful and there is a very rich and complicated history that predates European history.

John Keay says it best in an earlier book, [Into India](#) *"Even a few weeks in India has a way of closing one's credibility gap. The improbable becomes commonplace and the fantastic just the noteworthy"*