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THE SPATIALIZATION OF KNOWLEDGE AND POWER
AT THE ASTRONOMICAL OBSERVATORIES OF
SAWAI JAI SINGH II, C. 1721-1743 CE

BY

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DISSERTATION

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ABSTRACT

This dissertation is about the production of astronomical knowledge in northern India during the eighteenth century and the specific architectural elements and landscape configurations that affected the mobility and utility of that knowledge. Centered on a group of five astronomical observatories built between 1721 and 1743 CE under the patronage of the Maharaja Dhiraja of Jaipur and Amer, Sawai Jai Singh II, this project is an analysis of the relationship between patron, architecture, and space, and as such, represents an alternative approach to the writing of history. My project embraces the spatial and the material, and argues that architecture and landscape are not simply witnesses to history but participants in the process of change and transformation. This project starts from the position that our understanding of the spatial and intellectual relationships among the observatories has been shaped by colonial historiography and pushes for a reading of the historical landscape that recognizes both the power and the limitations of the agency of the local patron and populace. In this study, I demonstrate that the observatory outside the walls of Shahjahanabad functioned as the primary site for scientific production for several years before Sawai Jai Singh directed his attentions toward the observatory in Jaipur c. 1728 CE. A close reading of the plan and architecture of Jaipur reveals the multiple types of knowledge that were emplaced in the local landscape as a result of the construction of the observatory and shows that while the ostensible goal of the observatory was the production of astronomical knowledge, ancillary knowledge—accounting, building, political—was privileged in the intellectual institutions of the city. My analysis of the relationship between these institutions and the greater urban fabric disentangles the complexity of labor divisions at the observatory and highlights Sawai Jai Singh's desire to consolidate his intellectual wealth into a single locale—the scholar's village of Bhramapurī—at the periphery of

the capital. This discussion also considers the stretch and limitations of Sawai Jai Singh's power and reputation. Sawai Jai Singh made three separate attempts to re-settle European experts close to his most active observatory. In doing so, he appropriated the infrastructure of the Society of Jesus and used it to circumvent the hardships impressed upon travelers by the north Indian landscape in order to bring representatives of European science back to his capital city. However, in spite of the strength of his political and economic position in northern India, the natural landscape and the particularities of the Jesuit rule combined to thwart him in these endeavors. This project concludes with a consideration of the dominant themes in contemporary heritage discourse as they relate to the observatories and current practices of academic history writing. By turning away from the conventional archive, and examining instead the built environment and landscapes of northern India during the first half of the eighteenth century, my work offers an alternative narrative of the history of observatories, one that is underpinned by motion, exchange, adaptation, and creativity.

For Mom and Dad

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LIST OF ABBREVIATIONS

AI	<i>Aṭhsaṭhī Imāratī Sawai Jaipur</i>
DK	<i>Dastūr Kaumwār</i>
DNP	<i>Daftar Nasūkhā Punya</i>
JK	<i>Jamā Karc Imāratī Sawai Jaipur</i>
PK	<i>Pothīkhāna Roznāma Sawai Jaipur</i>
RI	<i>Roznāma Imāratī Sawai Jaipur</i>
RSA	Rajasthan State Archives
SH	<i>Syāha Hazūr</i>
SI	<i>Tozī Syāha Imāratī Sawai Jaipur</i>

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² Unless noted, all maps were created by the author.

CHAPTER ONE

INTRODUCTION

This dissertation is about the production of astronomical knowledge in northern India during the eighteenth century and the specific architectural elements and landscape configurations that affected the mobility and utility of that knowledge. Centered on a group of five astronomical observatories built between 1721 and 1743 CE under the patronage of the Maharaja Dhiraja of Amer (Amber) and Jaipur, Sawai Jai Singh II, this project draws its intellectual strength from a cross-disciplinary approach to its analysis of the ways in which knowledge inhabits local and regional landscapes.¹ Drawing on theoretical work produced across a variety of academic disciplines—architecture, art history, landscape architecture, geography, history, and cultural heritage studies—this dissertation offers a reconsideration of the ways in which colonial approaches to history writing have shaped our understanding of the observatories, and a demonstration as to how subsequent interpretations of these spaces conspired to elide all indications of a dynamic agency on the part of the local patrons and populace. As a reconceptualization of the design and working relationships among, and the landscapes shaped by, the observatories in Jaipur, Shahjahanabad (Delhi), Ujjain, Mathura, and Varanasi (Benares/Banaras), this dissertation opens up new possibilities for the critical interpretation of early modern scientific landscapes of India. When freed from the limitations of the colonial imagination, and read against archival materials produced in local South Asian

¹ In order to avoid the all-too-common confusion in the historical literature of generations and family names, I will refer to the ruler of Amer and Jaipur (1699-1743 CE) as “Sawai Jai Singh II,” and his great-great grandfather as Mirza Raja Jai Singh I. The title “Maharaja Dhiraja” was conferred on Sawai Jai Singh by the Mughal emperor Muhammad Shah on June 12, 1723 CE. This title represented an increase in rank over his earlier position as Maharaja Sawai Jai Singh. All of the archival records produced in association with the construction of the observatory at Jaipur are marked with the honorific “Maharaja Dhiraja.” P. K. Gode, “Two Contemporary Tributes to Minister Vidyādhara, the Bengālī Architect of Jaipur at the Court of Sawai Jaising of Amber (A.D. 1699-1743),” *Indological Studies* Dr. C. Kunhan Raja Presentation Volume (1946): 287.

languages by local scribes, the observatories tell a story of activity and experiment, adaptation and growth. This deliberate step away from colonial restrictions provides a clearer view of the cultural landscapes in which the observatories operated, and offers an opportunity to investigate the ways in which the scientific agenda advanced by the observatories' patron failed to meet expectations, not due to the indigenous lethargy and superstition assumed by colonial administrators in Varanasi, but because of an unexpected instability introduced into the workings of the observatories through the combined forces of nature, landscape, and imperialism.

1.1 Sites of Study

Sawai Jai Singh II was born on November 3, 1688 CE (Kāti Sūdi 10 VS 1745) to the Maharaja of Amer, Bishan (Vishan) Singh, and a Rathor queen, Indra Kamvari.² While the early history of the ruling clan of Amer has been obscured somewhat by origin chronicles commissioned by later clan leaders, Sawai Jai Singh and his ancestors claimed to be of Rajput Kacchawāhā lineage, and traced their roots back to the solar dynasty of Surya.³ Historians generally agree that the Kacchawāhās migrated from Gwalior or Narwar and established themselves on the Dhundhar plain in eastern Rajasthan during the late tenth century CE. By

² The dates noted in this dissertation reflect the calendars used in the primary sources. While the political communications between Sawai Jai Singh and the Mughal court were dated according to the Islamic Hijri (Hegira) calendar, records produced for internal use followed the Vikram Samvat (VS) calendar established to commemorate King Vikramāditya's defeat of the Sakas in 57 CE. The application of the VS calendar varied according to region, but Sawai Jai Singh followed a *pūrṇimānta* calendar, meaning that it ended each 30-day cycle at the full moon. The month began with the waning half moon (15 days of *kṛṣṇa pakṣa*, or *vadi*, in the local dialect), and ended the second half with the full moon (15 days of *śukla pakṣa* or *sūdi*). The first/last month of the VS year, *Caitra*, was split across year's end, meaning that the first fifteen days of the month (*Caitra Vadi*) fell in one year, and the last fifteen days of the month (*Caitra Sūdi*) fell in the next year. The revenue year, which ran from Bhādvā Sūdi 3 to Bhādvā Sūdi 2, began four to five months after the first day of the calendar year, depending on the inclusion of leap days and months in any given year. My conversions between the Gregorian and Vikram Samvat calendars are based on the tables from Sewell and Dikshit, and were aided by Professor Michio Yano at Kyoto Sangyo University. Robert Sewell and Sankara Bālkrishna Dikshit, *The Indian Calendar* (London: Swan Sonenschein & Co., Ltd., 1896).

³ Kacchāhā-ki-Vamśāvalī (Pedigree of Kacchawāhā Rajputs), Bhādrapada Śūdi 13 VS 1867, 81, fol. 181b-87a, Royal Asiatic Society, Tod Manuscripts, London; Hakikat (A Chronicle of the Maharajas of Jaipur down to the reign of Jagat Singh), 1800, 9, fol. 1-52, Royal Asiatic Society, Tod Manuscripts, London; Kacchāhā-ki-Vamśāvalī (Metrical History of the Kacchawahas), 1800, 131, fol. 1-43, Royal Asiatic Society, Tod Manuscripts, London. See also Harish Chandra Tikkiwal, *Jaipur and the Later Mughals (1707-1803 A.D.): A Study in Political Relations* (Jaipur: Hema Printers, 1974), 1.

1036 CE, the head of the clan had captured the town of Amer from the local Mina tribe. Located on a high point in the Aravalli Hills, Amer afforded the Kacchawāhās a great deal of protection and allowed them to resist all challenges made to their territorial claims until the invasion of the Mughals under Babur in 1527 CE.⁴ Babur's incursion into the region forced the Kacchawāhās to react and adapt to a lingering Mughal presence. Sometimes hostile, sometimes conciliatory, the Rajputs of Amer recognized Mughal suzerainty in 1556 CE and remained involved in Mughal affairs well into the eighteenth century.⁵ Indeed, from the reign of Emperor Akbar (r. 1556-1605 CE) forward, the Mughals and the Kacchawāhās negotiated their relationships through both political and familial ties. In 1592 CE, Harkha, the eldest daughter of Raja Bihar Mal, was married off by her father to Akbar.⁶ The union between the emperor and the Rajput princess resulted in the birth of a son, Prince Salim, the future Emperor Jahangir. These and similar alliances through marriage helped but did not guarantee amicable relations between the Kacchawāhās and the Mughals. There was established a pattern of hostility followed by a period of negotiation and compromise well before the year of Sawai Jai Singh's birth.

Sawai Jai Singh's formal participation in the rituals and politics of Mughal court life began at a very early age. Before his ninth birthday, he was charged with representing Amer's interests at the imperial court, perhaps because his father was always somewhat out of favor with the emperor.⁷ It was during the prince's first audience with Aurangzeb in 1699 CE that his notorious exchange of wit with the ruler took place, leading to the formal recognition of the Rajput as "Sawai," or as good as "one-and-a-quarter" men.⁸ The favor showed to Sawai Jai

⁴ Mirja Juntunen, "The Town Plan of Jaipur: Its Sources and Narrations" (Stockholm University 2004), 23-24.

⁵ Ibid., 24; V. S. Bhatnagar, *Life and Times of Sawai Jai Singh, 1688-1743* (Delhi: Impex India, 1974), 8; Tikkiwal, 3.

⁶ Tikkiwal, 3.

⁷ Ibid., 14, 17-18.

⁸ Ibid., 16. Although Aurangzeb is credited with first characterizing Jai Singh as "Sawai," the title was not formalized until July 1713 CE, during the reign of Farrukhsiyar.

Singh might have gone unnoticed in the annals of Indian history had the young prince's father lived a longer life, but the unexpected death of Bishan Singh that same year rushed the prince of Amer into a position of even greater political responsibility. After observing the customary period of mourning, Sawai Jai Singh II, at the age of eleven years, formally ascended the cushion throne of Amer on January 25, 1700 CE (Māgh Sūdi 5 VS 1756). Just a few days later, Aurangzeb awarded to him the honorary title of Raja and increased his *mansab* (office) from 1000/800 to 1500/1200, marking the beginning of his uneven ascent through the imperial ministry.⁹

Sawai Jai Singh inherited his father's (and great-grandfather's) troubled relationship with the Mughal government, alternately gaining and losing favor with Aurangzeb. The emperor sent him to protect the Mughal interests in the Deccan wars just three months after he received the title of Raja, a move that ensured the new king would be forced to govern his home state from a distance, just as his father had been forced to do. On the occasion of Aurangzeb's death, Sawai Jai Singh unfortunately backed the wrong heir in the wars of succession. He subsequently lost the right to govern the state of Amer to his brother, a state of affairs that continued until 1708 CE. During the following decade or so, it was difficult to tell exactly who was taking care of Mughal interests, as no fewer than seven individuals attempted to declare themselves emperor in the twelve year interregnum between Aurangzeb and Muhammad Shah. However, in 1719 CE, Muhammad Shah, with the help of the Sayyid brothers, solidified his base of power and took control of the empire, providing Sawai Jai Singh his best opportunity to forge a strong

⁹ Ibid., 19. In the administrative system introduced by Akbar, a *mansab* was the rank of a governing or bureaucratic official, or *mansabdār*. The rank of a *mansabdār* was usually expressed in a pair of numbers ranging from 10 to 12,000 (for instance, one individual might carry the *mansab* of 1000/1000). The first number of the pair was the *zāt*, which indicated the number of troops the *mansabdār* was obligated to provide in support of the emperor. The second number was the *sawār*, which indicated the number of horses provided for imperial service by the *mansabdār*.

connection with the central government.¹⁰ Although he had taken advantage of the short period of political stability offered by the reign of Farrukhsiyar to shore up the supports of his crumbling kingdom, it was not until Muhammad Shah climbed to the imperial throne that Sawai Jai Singh was able to turn his full attention toward the economic and political rehabilitation of the severely attenuated state of Amer.

Conventionally, the reach of Sawai Jai Singh's power has been considered to have been limited by the eighteenth-century boundaries of the hereditary state of Amer (map 1.1), and his greatest acts of patronage, such as the wholesale construction of a city on the Dhundhar plain below his family seat, were undertaken well within the bounds of his homeland. However, he also sponsored a multitude of building projects throughout northern India, including the renovation of temples, the construction of caravansarais, the rehabilitation of bathing ghats, and the design of several astronomical observatories.¹¹ Most of the schemes completed under his auspices were entirely typical; it was common for a new ruler to make his or her mark on the built environment by sponsoring the tomb of a predecessor, a ceremonial gateway, or a public shrine, and the majority of Sawai Jai Singh's proposals were congruent with the works completed by rulers of other princely states. However, his decision to design and build not one, but five, astronomical observatories in major Indian cities set him apart from his peers. All imperial and princely governments in South Asia maintained some interest in the conjoined practices of astrology and astronomy, partly for reasons of statecraft, partly for reasons of tradition, and newly seated emperors frequently took advantage of their positions to call for new

¹⁰ Bhatnagar, 8-22; Ashim K. Roy, *History of the Jaipur City* (New Delhi: Manohar Publishers & Distributors, 1978), 3-6.

¹¹ According to Jonathon Scott, the translator of the *Tārīkh i Irādat Khān*, Sawai Jai Singh "erected a caravanserai and market in every province for the convenience of travelers, at his own expense." Irādat Khan, *Tārīkh i Irādat Khān: A translation of the memoirs of Eradut Khan, a nobleman of Hindustan, containing interesting anecdotes of the Emperor Aulumgeer Aurungzebe, and his successors, Shaw Aulum and Jehaundar Shaw; in which are displayed the causes of the very precipitate decline of the Mogual Empire in India*, trans. Jonathon Scott (London: John Stockdale, 1786), 18. See also J. P. Stratton, *The Jaypur-Amber Family and State* (Jaipur: n.p., 1885), 44.

calendars and astronomical charts with epoch dates based on their reigns. For instance, Akbar commissioned a recension of the *Zīj Ulugh Begī*, known as the *Tashīl-i-Zīj Ulugh Begī*, from Mullā Chānd ibn Bahā' al Dīn, and Shah Jahan (r. 1627-1658 CE) charged Farīd al-Dīn Mas'ūd ibn Ibrāhīm al-Dihlawī with the task of compiling the *Zīj-i Shāhjahānī* such that it corresponded to the date of his ascension to the throne.¹² All of these *azyāj* (tables and calendars, sing. *zīj*) relied on existing versions of the tables, and it was not until the era of Sawai Jai Singh that an Indian ruler felt the need to reevaluate completely the data on which should be based the imperial *zīj*.¹³ In order to accomplish this more ambitious intellectual goal, a network of astronomical observatories was designed and implemented under order of the Maharaja Dhiraja of Amer.

Of the five observatories completed as part of this plan, only the one built in the city of Jaipur fell within territory under Sawai Jai Singh's direct rule; the remaining four, though constructed on land traditionally associated with the Kacchawāha clan, were located either in cities formally controlled by the Mughal court (Shahjahanabad, Mathura, Varanasi), or in regions under contention (Ujjain) (map 1.2). Outside the state of Amer, the observatory closest to Sawai Jai Singh's seat of power was constructed c. 1721 CE near the city of Shahjahanabad (map 1.3).¹⁴ Surrounded today by a low masonry wall capped with an iron fence, this observatory stood once on an open plain approximately 12 kilometers south of the imperial capital (figure 1.1). The stone instruments of this observatory were sizable and sturdy, and though their functional components lacked the fine finish they possess today, they undoubtedly caused many

¹²¹² S. A. Khan Ghorī, "Development of Zīj Literature in India," in *History of Astronomy in India*, ed. S. N. Sen and K. S. Shukla (New Delhi: Indian National Science Academy, 1985), 33-35.

¹³ The content and form of *azyāj* are discussed more thoroughly in Chapters Two and Four. See also E.S. Kennedy, "A Survey of Islamic Astronomical Tables," *Transactions of the American Philosophical Society New Series*, 46, no. 2 (May 1956): 123-77.

¹⁴ Today, both the Jaipur and Delhi observatories are referred to as the *jantar mantar*, a phrase that roughly translates to "hocus pocus" in English. This colloquial appellation first appeared in the English-language historiography of the observatories in W. Franklin, "Present State of Delhi," *Asiatick Researches* 4 (1807): 431.

a head to turn during the early years of their lives.¹⁵ In concept, the instruments at the observatory in Shahjahanabad were quite simple, in that they were meant to mark the coordinates of celestial objects in reference to both horizontal and equatorial systems.¹⁶ In design, they were quite complex. The stoneworkers at the observatories employed traditional construction methods to produce the instruments—rubble cores dressed with finish stone and plaster, or mortarless ashlar masonry—but the forms to which they shaped these conventional materials were far less ordinary. Most of the instruments were immense, built at a scale expected of architecture, not tools of astronomy. While the size of the observatories was not without precedent in Asia—stone instruments were erected during the thirteenth century CE in Maragha (Iran) and Denfeng (China), and during the fifteenth century CE in Samarkand (Uzbekistan)—the massiveness exhibited by instruments marked a departure from the small-scale brass mechanisms then

¹⁵ The instruments at Delhi have been subjected to several attempts at restoration over the past two centuries, and today are finished with a plaster and wash of “imperial red.” In 1852 CE, the Archaeological Society of Delhi made repairs to the Samrāt Yantra. In 1909-10 CE, Gokul Bhavan restored all of instruments except the Samrāt Yantra. In 1951 CE, the Astronomer Royal of Jaipur oversaw the restoration of at least a portion of the Mīśra Yantra. In 1993, the Astronomical Society of India proposed an extensive restoration of the Delhi instruments, and since that time, the Archaeological Survey of India has made several small scale repairs to the instruments and grounds. See “3rd October 1850,” *Journal of the Archaeological Society of Delhi* (January 1853): 67-68; “3rd June, 1852,” *Journal of the Archaeological Society of Delhi* (January 1853): 71; “6th January, 1853,” *Journal of the Archaeological Society of Delhi* (January 1853): 74; Joseph H. Garcin de Tassy, “Description des monuments de Delhi en 1852, d’après le texte Hindoustani de Saiyid Ahmad Khan,” *Journal Asiatique* Tome 16, no. Cinquieme Serie (December 1860): 539; G. S. D. Babu and V. R. Venugopal, “Programme for the Restoration of the Masonry Instruments at Delhi Jantar Mantar,” *Bulletin of the Astronomical Society of India* 21, no. 3-4 (9 1993): 481-83; Virendra Nath Sharma, *Sawai Jai Singh and his Astronomy* (Delhi: Motilal Banarsidass Publishers, 1995), 97-98; Dhananjay Mahapatra, “ASI to restore Jantar Mantar, preserve antiquity,” *The Times of India*, December 21, 2007, 5; Richi Verma, “Conservation plan soon for yantras,” *The Times of India*, December 21, 2007, 5.

¹⁶ The horizontal system maps the sky according to the horizon, with the observer’s local horizon assigned an altitude of 0°. An object directly overhead (at zenith) is assigned an altitude of 90°. In this system, the azimuth of an object is determined in relation to the observer’s north point as projected on the horizon. If an object is located due north of the observer, it is assumed to have an azimuth of 0°. If it is located due east, it is assumed to have an azimuth of 90°; due south, 180°; and due west, 270°. The equatorial system takes the celestial equator (the projection of the earth’s equator onto an imaginary celestial sphere) as the fundamental plane. In this system, the locations of celestial objects are marked according to right ascension and declination. Right ascension measures the longitude of an object in reference to the zero point on the celestial equator. While the zero point for longitude on the terrestrial equator is the prime meridian that runs through Greenwich, for the celestial sphere, the zero point is assigned from the vernal equinox point (the place where the sun crosses the celestial equinox in March). Declination measures the latitude of an object above or below the celestial equator.

popular at the imperial court.¹⁷ The gnomon of the tallest instrument at Shahjahanabad, the Samrāt Yantra (“Supreme Instrument,” an equinoctial sundial), loomed some 21.3 meters above the earth, on a base that stretched to a length of 34.6 meters (figure 1.2).¹⁸ The radii of the quadrants of the Samrāt Yantra measured approximately fifteen meters, meaning that they, when taken together with the gnomon that rose between them, spanned well over thirty meters (figure 1.3). The terminus of the eastern quadrant of the Samrāt Yantra contained the stone chamber of the Śaṣṭhāmsa Yantra (“60-Degree Instrument”), a mural sextant with a radius of 8.25 meters. At the top of a long flight of stairs that climbed in concert with the gnomon of the Samrāt Yantra was the Agrā Yantra (“Principal Instrument”), a horizontal sundial with a height of 1.5 meters and a diameter of 1.47 meters (figure 1.4). This instrument was easily visible to anyone given access to the stairs of the gnomon; otherwise, it could be viewed only obliquely and from a distance.

Two additional instruments were built in Shahjahanabad at the time of the observatory’s founding: the Jaya Prakāśa Yantra (“Light of Victory Instrument”) and the Rāma Yantra (“Ram’s Instrument”). While they were not quite so imposing in terms of size, they were still remarkable in their design. The superstructures of these instruments were broken into complementary pieces to allow the human body to move in and out alignment with the planes of observation. The gaps in the architecture permitted an astronomer—or a group of astronomers

¹⁷ M. C. Bulatov, “Observatoriya Ulugbeka (Observatory of Ulugh Beg),” *Arkhitektura SSSR* (January-February 1985): 91-93; ———, “Predshestvennitsa Observatorii Ulugbeka (Precedent of the Observatory of Ulugh Beg),” *Arkhitektura i Stroitel'stvo Uzbekistana* 11 (1986): 11-12; P. Vardjavand, “Un Observatoire Astronomique du XIIIe Siecle,” *Archeologia* 151 (February 1981): 46-53; Jitai Zhang, “Dengfeng Guanxingtai he Yuanchu tianwen guanze de chengjiao (The Observatory in Dengfeng and early Yuan astronomy),” *Kaogu* 2 (1976): 95-102.

¹⁸ Instrument dimensions are adapted from Sharma, *passim*. There are a few large discrepancies between Sharma’s measurements and those published by G. R. Kaye in 1918 CE. In addition to human or instrumental error, one possible explanation for the differences can be attributed to Kaye’s preference for English units of measurements, rounded to the nearest half-inch. Further, renovations completed at all of the sites during the past century have undoubtedly changed the diameters and heights of some the instruments by as many as two to three inches. For dimensions given by Kaye for the Samrāt Yantras at Delhi, Jaipur, Ujjain and Varanasi, see George Rusby Kaye, *The Astronomical Observatories of Jai Singh* (Calcutta: Superintendent Government Printing, 1918), 36.

working together—to position an eye at the edge of the viewing plane, visually aligning the star or planet with the scaled surface during the process of observation. This observational principle governed the plan and placement of the two complementary stone bowls of the Jaya Prakāśa Yantra, which stood directly to the south of the Samrāt Yantra (figure 1.5, map 1.4).

Approached by short flights of stairs that led to viewing positions both above and below grade, these etched concavities, each of which had a diameter of more than eight meters, were intended to measure local time and the coordinates of celestial objects (figure 1.6). Springing up to the southwest of the Jaya Prakāśa Yantra were the dual rings of the Rāma Yantra, an arcaded structure that resembled nothing so much as the Roman Colosseum. Together, the complementary structures of the Rāma Yantra, each standing 7.5 meters high, with an inside diameter of 16.65 meters, were intended to measure altitude, zenith distance, and azimuth of celestial objects (figure 1.7).¹⁹

The observatory was visible not just to the inhabitants of the surrounding suburban village, but to anyone who traveled along the Qutb Road, one of the main routes into the capital city of Muhammad Shah (map 1.5). This prominent visibility was also characteristic of the observatory erected in the city of Jaipur. Standing approximately 260 kilometers southwest of Shahjahanabad, the instruments formed a subset of a larger building project, the City Palace, which was in turn the central component of an even greater project, the wholesale planning and construction of Jaipur, a new capital city for the state of Amer. While the boundaries of the observatory were clearly delineated from adjacent parts of the City Palace by a low wall, the scale of the enclosed instruments ensured maximum visibility for anyone allowed within the

¹⁹ There is one additional instrument at Shahjahanabad, the Miśra Yantra, a “mixed instrument” that consists of a Dakṣiṇottara Bhatti Yantra, Karkarāśi Valaya, Niyata Cakras, and Samrāt Yantra. Although images of the Miśra Yantra are often used to represent the observatory in academic and popular publications, this instrument almost certainly dates to a time period after the death of Sawai Jai Singh. See Sharma, 96.

quasi-public spaces of the palace complex (map 1.6). Even as late as the year of Sawai Jai Singh's death (1743 CE), only the Maharaja's new residential palace, the Chandra Mahal, would have rivaled the 22-meter Large Samrāt Yantra in height (figure 1.8).²⁰ The instruments erected in Jaipur were functionally similar to those built outside Shahjahanabad, in that most were designed to mark the locations of celestial objects according to horizontal and equatorial systems of measure. However, in terms of number, the Jaipur instruments clearly outdid their counterparts in Shahjahanabad. In addition to the Large Samrāt Yantra (figure 1.9), the Jaipur observatory included the Rāma Yantra (figures 1.10, 1.11), the Jaya Prakāśa Yantra (figures 1.12, 1.13), the Kapāla Yantra (a close cousin to the Jaya Prakāśa Yantra) (figure 1.14), and four Śaṣṭhāmśa Yantras (map 1.7).²¹ New at the Jaipur observatory was the Digamśa Yantra ("Azimuth Instrument"), which consisted of two concentric scaled masonry circles surrounding a central pier (figure 1.15). Also new at, and unique to, the Jaipur observatory were the Rāśivalayas ("Zodiac Instruments"), a set of twelve instruments that on first sight appeared to be the spawn of the Samrāt Yantra (figures 1.16, 1.17). The intent behind these more modest stone instruments was not clearly documented when they were first designed, but today they can be used to measure the latitude and longitude of a celestial object.²² There existed also a Dakṣinottara Bhatti Yantra ("Meridian Wall Instrument"), a transit instrument for measuring the

²⁰ There is also a Small Samrāt Yantra at the Jaipur observatory, but opinions differ as to whether it is original to the site. V. N. Sharma points out that the instrument, or one very similar to it, was depicted on an observatory map he dates to c. 1728 CE. However, Garrett and Soonawala date the existing Small Samrāt Yantra to 1876 CE. See Ibid., 142; Arthur ff. Garrett and Chandradhar Guleri, *The Jaipur Observatory and Its Builder* (Allahabad: Pioneer Press, 1902), 43; M. F. Soonawala, *Maharaja Sawai Jai Singh II of Jaipur and his Observatories* (Jaipur: Jaipur Astronomical Society, 1952), 30.

²¹ The second bowl of the Kapāla Yantra is the only instrument at any of the five observatories designed as a calculator, rather than a tool of measure. The bowl is designed to allow for the conversion of coordinates from the horizontal system to the equatorial system, and vice versa.

²² The Rāśivalayas were in a ruinous state before they reconstructed/reoriented in 1901 CE so that they could be used to measure the longitude and latitude of the leading star of a given zodiacal sign when it arrived at meridian. See Garrett and Guleri, 43-45.

zenith and altitude of the midday sun, or the zenith distance of the meridian moon.²³ Finally, the collection at Jaipur included a number of brass tools—represented today by the Great Astrolabe, a massive instrument oriented to the latitude of Jaipur and designed to calculate the rising and setting of zodiacal constellations among other things—and a few ancillary structures such as a thatched porch, and a well with Persian wheel.²⁴

Although the observatory would have been at least partially occluded from view at ground level after the erection of the protective walls of the City Palace, any of its instruments would have been visible to traders descending from the Aravalli Hills to the plains of Jaipur, and the very diversity of instrumentation must have been striking to visitors (figure 1.18). As was the case in Shahjahanabad, the Jaipur observatory was proximately located to a major thoroughfare—in this case, the north-south Amer-Sanganer trading route—ensuring a regular but mobile audience for the construction project. In addition, the Agra-Ajmer road, a pilgrimage route connecting the city of Agra with the tombs of the Chishti saints in Fatehpur-Sikri and Ajmer, ran east-west along the southern perimeter of the new city walls, only a kilometer south of the observatory (map 1.8). Not every citizen of the city was granted access to the observatory, but those who did have viewing privileges could reach it easily, particularly during the first five years of its life, before the Maharaja Dhiraja took up permanent residence in the Chandra Mahal of the City Palace.

Because the observatories in Shahjahanabad and Jaipur were so impressive in size and scope, it is tempting to assume that the instruments in Ujjain, Varanasi, and Mathura also stood out in their respective environments. However, the obvious monumentality of the

²³ The existing Dakṣinottara Bhatti Yantra was added to the observatory in 1876 CE, apparently to replace the original which was inconveniently located and decayed beyond repair. See Sharma, 130.

²⁴ Virendra Nath Sharma, “The Great Astrolabe of Jaipur and its Sister Unit,” *Journal for the History of Astronomy Supplement* 15 (January 1, 1984): S126-S128.

Shahjahanabad and Jaipur observatories was only partially replicated in Ujjain, then capital of the Mughal province of Malwa. Located some 500 kilometers distant from Jaipur, Ujjain represented the farthest reach of Sawai Jai Singh's cultural and military influence to the south. The observatory was constructed several kilometers southwest of the ancient city center, on the banks of the Kshipra River in a section of the imperial *purā* (village) that had been awarded to the Maharaja Dhiraja after his appointment as governor of Malwa in November 1712 CE (map 1.9).²⁵ The fortified *purā* occupied both banks of the river, with movement between the two divisions facilitated by a bridge (map 1.10). The instruments formed a tight cluster on the north bank of the waterway. The same methods that had been used for the instruments in Shahjahanabad and Jaipur were employed here, but to meet more modest ends. The Ujjain instruments had rubble cores and were finished with plaster and mortarless ashlar masonry, but they lacked the drama and loftiness so readily apparent in the northern observatories. While the gnomons of the Jaipur and Shahjahanabad Samrāt Yantras were between twenty-one to twenty-two meters tall, the gnomon of the Samrāt Yantra in Ujjain came in at just under seven meters, a height much more in line with the scale of the human body (figure 1.19). The instrumentation in Ujjain was also limited in number, with only four major apparatuses completed on site—a Samrāt Yantra, a Digamśa Yantra, a Dakṣinottara Bhatti Yantra, and a Nādīvalaya (“Hemispheric Sundial”) (figures 1.20-22, map 1.11).²⁶ Conceivably, the observatory could have drawn the attention of anyone living or working in the *purā*, or of any pilgrim taking passage on the river.²⁷ However, there is little evidence to suggest that permanent residents, much less representative

²⁵ Bhatnagar, 96.

²⁶ The Śanku Yantra at Ujjain was added in 1938 by the astronomer Govinda Sadāśiva Apte. See Sharma, *Sawai Jai Singh and his Astronomy*, 217.

²⁷ Remnants of the bridge, which were misidentified by G. R. Kaye as wells exposed by erosion, are visible in early twentieth-century photographs. See Kaye, fig. 60.

members of the itinerant population, were as aware of the observatory's instruments as they would have been had they lived in or traveled through Shahjahanabad or Jaipur.

The observatories in Ujjain, Shahjahanabad, and Jaipur were built on previously undeveloped land under bureaucratic control of the Kacchawāhā clan. This makes them quite different in plan from their counterparts in the pilgrimage cities of Mathura and Varanasi, where the instruments were constructed on the roofs of existing buildings. The instruments of the Varanasi observatory were distributed across the split roofs of the Mān Mahal, a palace built c. 1600 CE by Man Singh I of Amer on the Mānmandir Ghat on the banks of the Ganges River (map 1.12).²⁸ We might expect to find fewer instruments in Varanasi due to limitations imposed by the rooftop location, but in fact, the decking held the same size, number, and type of instruments as were found at the Ujjain observatory with the addition of two: a small stone Samrāt Yantra and a brass Cākra Yantra ("Wheel Instrument") (figures 1.23-29, map 1.13). Because of the elevation of the observatory above ground level, the bulk of the instruments has always been hidden from public view. The side wall of the Digamśa Yantra was visible to anyone approaching the ghat from the river; however, it presented itself as just that, a curving wall, and not an astronomical instrument (figure 1.30). An approach from the north at street level offered only an oblique view of the Samrāt Yantra, while an approach from the south offered the pedestrian not even a glimpse of the observatory (figure 1.31).

²⁸ The *pakka* stone ghats we see in Varanasi today date to the last three centuries, and were built primarily under the patronage of the Marathas in the eighteenth and nineteenth centuries. When Man Singh built his private mansion, it would have been one of only a half dozen or so similar structures standing on the banks of the Ganges. This would have been true during the era of Sawai Jai Singh as well. For example, the stones of the neighboring Dashashwamedh Ghat were placed c. 1765 CE, and photos dating to the last half of the nineteenth century still depict a swath of undeveloped bank standing between the Dashashwamedh and Man Mandir Ghats. See C. A. Bayly, *Rulers, Townsmen and Bazaars: North Indian Society in the Age of British Expansion, 1770-1870* (Cambridge: Cambridge University Press, 1988), 137; Diana Eck, *Banaras: City of Light* (New York: Knopf, 1982), 222; Madhuri Desai, "Resurrecting Banaras: Urban Space, Architecture and Religious Boundaries" (University of California, Berkeley, 2007), 282-86.

The fifth observatory built by order of Sawai Jai Singh was located just 150 kilometers south of Shahjahanabad in Mathura, a temple town crowded between the imperial highway and the Yamuna River. The four instruments at Mathura—a modest Samrāṭ Yantra, an Agrā Yantra, a Dakṣinottara Bhatti Yantra, and a Śanku (“Horizontal Sundial”)—reportedly occupied a terrace on top of the city fort, Kans ka Kilā (figure 1.32). Only a handful of foreign visitors described this observatory before it was destroyed during the first half of the nineteenth century, but each implied that though Kans ka Kilā dominated the Mathura skyline, looming above the Yamuna River, the observatory itself was impossible to see from ground level, or even from the river approach to the fort (figure 1.33).

Taken together, the observatories covered a wide geography, stretching from the deserts of Rajasthan in the west, to the riverine city of Varanasi to the east, and from the imperial capital city of Shahjahanabad in the north, to the contested territory of Ujjain to the south. Although at least three of the observatories lay beyond Sawai Jai Singh’s immediate control, as a patron, he managed to establish a baseline model for the instrumentation to be constructed at each site. Yet, in spite of their functional similarities, each of the observatories possessed an aesthetic and spatial uniqueness. For instance at Varanasi, the scales were inscribed on gray sandstone rather than on a lime plaster finish, as was certainly the case in Jaipur and Shahjahanabad. Each observatory followed its own organizational logic. While the instruments themselves were obviously aligned with regard to the latitude, celestial equator, or ecliptic, only the observatories at Shahjahanabad and Ujjain showed any sort of axiality in plan, and even then, it was quite limited in application.²⁹ The instruments at Varanasi appear to have been positioned to make the

²⁹ The Jāya Prakāśa Yantra at Shahjahanabad appears to have been aligned with the gnomon of the Samrāṭ Yantra from the outset. Similarly, the Nāḍīvalaya at Ujjain is aligned with the gnomon of that Samrāṭ Yantra. Neither of these arrangements were demanded by observational practices.

most of a limited space, and the instruments at Jaipur seem to have followed no plan whatsoever, but were scattered rather haphazardly across an open space.

Still, in purpose, the observatories were directed toward a single end product, the compilation of a *zīj* based not on data borrowed from existing tables produced in Central Asia or Europe, but on observations made in India. In practice, this activity was congruent with that followed by astronomers working in various locales around the world. For instance, in London, the first royal astronomer, John Flamsteed (b. 1646-d. 1719), was conducting a similar observational program in pursuit of a similar goal, the publication of a massive star catalogue with accompanying constellation charts.³⁰ Like Sawai Jai Singh, Flamsteed directed his energy into instrument design and the gathering of observational data in a manner deeply inflected with Baconian empiricism. And like Flamsteed, Sawai Jai Singh embraced familiar tools of measure (both astronomers relied on mural quadrants/sextants) in order to achieve his goals, while simultaneously pushing for the development of better, more accurate, instrumentation. At least superficially, the scientific practices followed by Sawai Jai Singh were not dramatically different than those used by his European counterparts, despite the scale of the observatories at

³⁰ John Flamsteed's aspirations as an astronomer were well documented in his personal and professional correspondence. As the result of many years work by a dedicated group of scholars, most of Flamsteed's extant letters can now be consulted in Eric G. Forbes, Lesley Murdin, and Frances Willmoth, eds., *The Correspondence of John Flamsteed, the First Astronomer Royal*, vol. 1 (1666-1682) (Bristol: Institute of Physics Publishing, 1995); —, eds., *The Correspondence of John Flamsteed, the First Astronomer Royal*, vol. 2 (1682-1703) (Bristol: Institute of Physics Publishing, 1997); —, eds., *The Correspondence of John Flamsteed, the First Astronomer Royal*, vol. 3 (1703-1719) (Bristol: Institute of Physics Publishing, 2002). Flamsteed's published work exists in several forms. A pirated edition of his *Historia Coelestis Britannica* was published at the behest of Isaac Newton in 1712 CE. The authoritative version of the *Historia Coelestis* was published in 1725 CE. Flamsteed's final work, the *Atlas Coelestis*, a collection of twenty-six star maps and two planispheres, was published posthumously, in 1729 CE. For the earliest analysis of Flamsteed's work at the Royal Observatory, see Francis Baily, *An Account of the Reverend John Flamsteed, the First Astronomer-Royal; compiled from his own manuscripts, and other authentic documents never before published* (London: Lord Commissioners of the Admiralty, 1835). For a clear description of the differences between the 1712 and 1725 CE edition of the *Historia Coelestis*, see Alan Cook in Frances Willmoth, ed. *Flamsteed's Stars: New Perspectives on the Life and Work of the first Astronomer Royal (1646-1719)* (Woodbridge, Suffolk: Boydell Press, 1997), 167-87. For the most recent consideration of the history of Flamsteed's publishing agenda and his troubles with piracy, see Adrian Johns, *The Nature of the Book: Print and Knowledge in the Making* (Chicago: University of Chicago Press, 1998).

Shahjahanabad, Jaipur, Ujjain, Mathura, and Varanasi. However, the fact remains that the observatories of Sawai Jai Singh were assigned a completely different role in the history of astronomy than those occupied by Flamsteed in London or Cassini in Paris. In contrast to his European contemporaries, Sawai Jai Singh was denied a place in the history of science, and his instruments were deigned to be little more than monstrosities of medievalism, or defined as belonging to an unsophisticated Stone Age.³¹ Subsequently, the observatories have been received as oddities, and while these assessments can be attributed in part to the aesthetics and size of the instruments, as we will see in the historiographical discussion below, this limited understanding of the sites also owes a great deal to the lingering effects of colonialism. We, as historians of science, architecture, and landscape, have inherited and accepted a specific set of colonial assumptions, depending on them today as foundational texts in our analyses of the observatory spaces.

1.2 Literature Review

An evaluation of the observatories' historiography makes clear the need for a reassessment of the relationship between the landscape, patronage, and scientific knowledge in eighteenth-century India. While we have a handful of Sanskrit astronomy manuscripts describing the construction and use of the instruments, several descriptions of the astronomical instruments written in French, German, and Latin by European visitors to the observatories, and a single programmatic statement written in Persian and attributed to Sawai Jai Singh himself, the most influential histories of the observatories were produced under the close watch of English colonial institutions of knowledge. More precisely, most contemporary evaluations of the

³¹ See, for instance, the most recent comparison of Sawai Jai Singh's observatories to Neolithic structures in John David North, *Cosmos: An Illustrated History of Astronomy and Cosmology* (Chicago: University of Chicago Press, 2008), 181.

observatories rely on three articles printed in the leading publications of British institutional science during the last quarter of the eighteenth century, a period during which the colonial government was working to consolidate its political power in India. Authored by Robert Barker, John Williams, and William Hunter, these essays painted an image of Sawai Jai Singh's observatories as Hindu in origin, ancient in age, and unchanging in structure and purpose.³² A fuller accounting of these articles will be made in the following chapter; however, the impact made by this intellectual trio was so great that no historiographic discussion would be complete without a sustained consideration of their seminal articles.

Robert Barker, a commander in the Bengal Army and an elected Fellow of the Royal Society in London, made his initial inquiries into the history of the observatory in Varanasi almost by way of accident.³³ The stated intention of his research was to demonstrate that the "ancient Bramins" of India had a certain level of knowledge of astronomy, and that they had passed this knowledge, unchanged, to the "present Bramins" of the city of Benares.³⁴ That he ended up surveying the instruments at the Mān Mahal was due more to the fact that he was incapable of reading the texts proffered by the local *pandits* as proof of their knowledge than to any deep interest in the observatory itself.³⁵ And, in fact, Barker was mistaken in many of his conclusions about the observatory and its instruments: contrary to his assertion, the observatory had not been built by order of the Mughal emperor Akbar, nor was it constructed by artisans so

³² Robert Barker, "An Account of the Bramin's Observatory at Benares," *Philosophical Transactions of the Royal Society of London* 67 (1777): 598-607; William Hunter, "Some Account of the Astronomical Labours of Jayasinha, Rajah of Ambhere, or Jayanagar," *Asiatick Researches* 5 (1799): 141-63; John Lloyd Williams, "Further Particulars Respecting the Observatory at Benares, of Which Account, with Plates, is Given by Sir Robert Barker, in the LXVIIth Vol. of the Philosophical Transactions. In a Letter to William Marsden, Esq. F.R.S. from John Lloyd Williams, Esq. of Benares," *Philosophical Transactions of the Royal Society of London* 83 (1793): 45-49.

³³ Barker, Sir Robert, 1774, EC/1745/13, GB 117, Certificates of Election and Candidature, Royal Society, London.

³⁴ Barker, "An Account of the Bramin's Observatory at Benares," 598, 605.

³⁵ Ibid., "An Account of the Bramin's Observatory at Benares," 599.

much more talented than those working in Benares at the time of his residence.³⁶ At the time of his visit, the observatory was no more than fifty years old, and indeed, as John Williams would confirm later, the construction of the observatory fell within the era of living memory.³⁷ Still, Barker's use of the observatory as evidence that "the manners and customs of the Gentoo religion are such as to preclude them from admitting the smallest innovation in their institutions," combined with his assertion that the observatory was an example of ancient building design, laid the foundation for two centuries of historical interpretation that relied on an assumption of indigenous intellectual stagnancy.

Barker's depiction of the observatory as both ancient and unchanging was re-confirmed by the pen of John Williams, a member of the East India Company's Medical Service and a resident of Benares.³⁸ Williams submitted that the observatory in Benares "was built more for ostentation, than for the promotion of useful knowledge," and yet he expended a great deal of energy in detailing the particulars of the instruments in order to provide some suggestion of their utility. Drawing on the "eye-witness" expertise of magistrate Ali Ibrahim Khan, Williams double-checked Barker's assessment, measuring each instrument as precisely as he could given the limitations of available tools. He also corrected Barker's erroneous attribution, noting that the observatory was built by "the Rajah Jeysing," and not Akbar, but did little to contradict the notion that the observatory was proof of the torpidity of "Gentoo" institutions. In fact, what little extraneous commentary Williams did provide was aimed toward situating the observatory in an environment both ancient and religious, noting that the lower parts of the building on which the observatory rested "were built many years ago, of which there remains no chronological account,

³⁶ Ibid., "An Account of the Bramin's Observatory at Benares," 600, 04.

³⁷ Williams, 49.

³⁸ Williams, John Lloyd, 1801, EC/1801/09, GB 117, Certificates of Election and Candidature, Royal Society, London.

by the Rajah Maunsing, for the repose of holy men, and pilgrims, who come to perform their ablutions in the Ganges, on the banks on which the building stands.”³⁹ The suggestion is subtle, yet palpable: in Williams’ narrative, the patronage of Man Singh (r. 1646-1671 CE) existed outside the boundaries of knowable history, and the observatory, built in the same tradition as the Mān Mahal, operated within this same model of inscrutability.

This depiction of the observatory and its context shaped the reading public’s understanding of the observatories as unproductive sites existing outside the flow of progressive history. Certainly it affected the work of William Hunter, the author of what has become the most cited study of the observatories during the past 200 years. Hunter, a surgeon with the East India Company and a secretary to the Asiatic Society of Bengal, produced a lengthy explanation of the astronomical instruments after visiting four of the observatories in 1796 CE. He was explicit in his intellectual debt to Barker and Williams, acknowledging that his assessment relied on their earlier documentation and interpretations of the instruments at Varanasi. Unlike his predecessors, however, Hunter seemed willing to award Sawai Jai Singh and his work a place in time, noting that that the Maharaja Dhiraja of Amer and Jaipur possessed a “superior genius and zeal,” and a deep understanding of the mathematical sciences.⁴⁰ However, much of this praise stemmed from his belief that Sawai Jai Singh preferred the European sciences to those developed in his own country. To wit, while in Ujjain, Hunter allegedly crossed paths with Kevelrāma, the grandson of the first royal astronomer of Jaipur. The grandson (to whom Hunter never referred by proper name) had taken ownership of “several European works, executed under the orders of Jayasinha,” and “had inherited the spirit of Jayasinha in such a degree, as to see and

³⁹Williams, “Further Particulars Respecting the Observatory at Benares,” 49.

⁴⁰ Hunter, 177-78.

acknowledge the superiority of European science.”⁴¹ In Hunter’s estimation, it was not the initiative taken to build five observatories, but the extent to which those sites conformed to directions taken in European science, that marked Sawai Jai Singh’s labors as brilliant. Hunter concluded his study with a heartfelt lament, claiming that after the death of Kevelrāma’s grandson, the “genius of Jayasimha became extinct,” because there was no longer any hope of inculcating “the Eastern nations” in “a taste for European science.”⁴² While he might have been willing to credit Sawai Jai Singh with a certain level of intellectual capability, Hunter saw no possibility for a similar predilection in any of his descendents or countrymen. In this assessment, the observatories served as a symbol of lost potential, a spark of modernity snuffed out by religious superstition and native torpor.

The portrayal of the observatories as decayed monuments, languishing beyond the reach of time and action, persisted throughout the nineteenth century, largely due to the popularity of publications based on the articles of Barker, Williams, and Hunter. For instance, James Prinsep’s *Benares Illustrated* and M. A. Sherring’s *Benares, the Sacred City of the Hindus in Ancient and Modern Times* relied on these earlier sources in their portrayals of the Varanasi observatory as a space of lethargic decline.⁴³ Joseph Hooker’s report of his 1848 CE visit to the “dirty and ruinous” Varanasi observatory opened with a reference to Hunter’s article, and Fanny Parks’ mid-nineteenth century account of her visit to the tumbled remains of the Delhi observatory could easily be mistaken for a textbook case of plagiarism, so close was it in wording to Hunter’s article.⁴⁴ However, the sharpest echo of eighteenth-century colonial discourse was sounded by

⁴¹ Ibid., 210.

⁴² Ibid.

⁴³ James Prinsep, *Benares Illustrated, in a Series of Drawings* (Calcutta: Baptist Mission Press, 1831-34), unpaginated; M. A. Sherring, *Benares, the Sacred City of the Hindus, in Ancient and Modern Times* (London: Trubner, 1868; reprint, 1975), 130-37.

⁴⁴ Joseph Hooker, *Himalayan Journals; or, Notes of a Naturalist in Bengal, the Sikkim and Nepal Himalayas, the Khasia Mountains, &c.*, vol. 1 (London: J. Murray, 1854), 75-81; Fanny Parks Parlbey, *Wanderings of a Pilgrim in*

the writings of George Rusby Kaye, the archaeologist who can be credited with transporting the biases of Hunter, Williams, and Barker out of the eighteenth, through the nineteenth, and into the twentieth century. Commissioned by the Archaeological Department to measure the observatories at Ujjain, Varanasi, Delhi, and Jaipur, Kaye produced two separate publications detailing the physical and historical fabric of the sites. The first book, *The Astronomical Observatories of Jai Singh*, comprised an extended consideration of Sawai Jai Singh's biography, his instruments, and his publications (i.e., the *Zīj-i Muḥammad Shāhī*), as well as a discussion of the overall value of his astronomical observations.⁴⁵ Although allegedly a new survey of the built environment of the observatories, Kaye's work drew its historical interpretation of the sites directly from Hunter's essay, and ultimately served to confirm the earlier portrayals of the observatories as static and isolated locations brought to a limited form of life only through Kaye's drawings and photographs of the crumbling stone instruments.

From a twenty-first century viewpoint, Kaye's embrace of Orientalist scholarship is not particularly newsworthy. Well into the twentieth century, certain sectors of the British Raj viewed themselves and their position of dominance in India as intellectually and morally impregnable, and Kaye's acceptance of the earlier interpretation of Hindu science probably raised few eyebrows among his readers. However, the attitudes and prejudices first set in type by Barker, Williams, and Hunter, and exploited by the burgeoning colonial state, still shape the portrayal of the observatories today, well beyond the year of India's independence. In fact, it would be a challenge to locate even one article published in the academic disciplines of science, art, and architecture since 1950 CE that did not rely on the analysis of Barker, Williams, or

Search of the Picturesque: During Four-and-Twenty years in the East, 2 vols., vol. 2 (London: P. Richardson, 1850), 209-12.

⁴⁵ See footnote 18. A slighter version of this book was published as George Rusby Kaye, *A Guide to the Old Observatories at Delhi; Jaipur; Ujjain; Benares* (Calcutta: Superintendent Government Printing, 1920).

Hunter (or, more typically, on the opinions of all three). Even the most recent studies of the observatories published in the discipline of science remain decidedly bound to these colonial readings of the observatories in their emphases on the “ancient” or “medieval” nature of the science produced under the watch of Sawai Jai Singh.⁴⁶ And while it is true that the historians of science seem particularly tied to the eighteenth-century interpretations of the instruments and their context, the repetition of colonial paradigms is certainly not limited to this single discipline. Commentaries on the observatories in the fields of art, architecture, and popular astronomy also rely on Barker, Williams, and Hunter, replicating their characterizations of the observatories as empty and ancient wastelands, or using their words to cast them in the role of fantastical objects of art and sculpture with no practical use whatsoever.⁴⁷ In echoing this particular colonial characterization of the observatories as static and unproductive sites, scholars have effectively

⁴⁶ For representative examples of this approach to the observatories from within the discipline of the history of science, see William A. Blanpied, “The Astronomical Program of Raja Sawai Jai Singh II and its Historical Context,” *Japanese Studies in the History of Science* 13 (1974): 81-126; ———, “Raja Sawai Jai Singh II: An 18th Century Medieval Astronomer,” *American Journal of Physics* 43, no. 12 (December 1975): 1025-35; E.G. Forbes, “The European Astronomical Tradition: its Transmission into India, and its Reception by Sawai Jai Singh II,” *Indian Journal of History of Science* 17, no. 2 (November 1982): 234-43; Raymond Mercier, “The Astronomical Tables of Rajah Jai Singh Sawa’i,” *Indian Journal of History of Science* 19 (April 1984): 143-71; ———, “Account by Joseph Dubois of Astronomical Work under Jai Singh Sawa’i,” *Indian Journal of History of Science* 28, no. 2 (1993): 157-66; David Pingree, “Indian and Islamic Astronomy at Jayasimha’s Court,” in *From Deferent to Equant*, ed. David A. King and George Saliba (New York: New York Academy of Sciences, 1987), 313-28; ———, “An Astronomer’s Progress,” *Proceedings of the American Philosophical Society* 143, no. 1 (1999): 73-85; Virendra Nath Sharma, “Jai Singh, His European Astronomers and the Copernican Revolution,” *Indian Journal of History of Science* 18 (1982): 333-44; ———, “Zij-i Muhammad Shahi and the Tables of de La Hire,” *Indian Journal of History of Science* 25 (1990): 33-44; Benno van Dalen, “The Origin of the Mean Motion Tables of Jai Singh,” *Indian Journal of History of Science* 35, no. 1 (2000): 41-66.

⁴⁷ Jamie Facer, “Jantar Mantar—An Ancient Indian Observatory,” *Astronomy Now* 2, no. 12 (1988): 31-33; Erno Goldfinger, “Observatoires aux Indes,” *Aujourd’hui Art et Architecture* 31 (1955): 40-43; Harold Spencer Jones, “The Astronomy of Broddingnag,” *Architectural Review* (March 1948): 111-13; Bonnie G. MacDougall, “Jantar Mantar: Architecture, Astronomy, and Solar Kingship in Princely India,” *Cornell Journal of Architecture* 5 (1996): 16-33; F. Walter Maunder, “Astronomy without a Telescope—A Modern Tycho,” *Knowledge* 25 (May 1902): 102-04; Sten Åke Nilsson, “Jaipur: In the Sign of the Leo,” *Magasin Tessin* 1 (1987): 4-59; ———, “Jaipur—Reflections of a Celestial Order,” in *Aspects of Conservation in Urban India*, ed. Sten Nilsson (Lund: Lund University Press, 1995), 107-28; Isamu Noguchi and W.J.C., “The Observatories of the Maharajah Sawai Jai Singh II,” *Perspecta* 6 (1960): 68-77; Bernardo Rudofsky, “‘architettura astronomiche’ in India,” *Domus* (August 1959): 37-40; Dilip Salwi, “The Wondrous Observatories of Jai Singh,” *New Science* 92 (December 10 1981): 725-30; Andreas Volwahn, *Cosmic Architecture in India: the Astronomical Monuments of Maharaja Jai Singh II* (New York: Prestel, 2001), 103.

immobilized the observatories in time and space, stripping them of any trace of their original productive capabilities as instruments of measure.

The assignation of a specifically Hindu origin to the sites by British colonial administrators has shaped our engagement with the written archive in other ways, as well. For instance, it has sometimes been assumed that because Sawai Jai Singh was a Hindu king, the work completed at the observatories was carried out in an identifiably Hindu manner that privileged an “abstract theological knowledge through numerology” over more mundane uses for numbers and calculations.⁴⁸ This mindset has led to a long-standing tradition of interpreting the observatory and its position in the city of Jaipur as representative of a celestial order based on Sawai Jai Singh’s horoscope, or as symbolic of his lineage as a descendent of the solar Kaccawāhā clan.⁴⁹ As Talbot and Asher note, one problem with this approach is that despite the Maharaja Dhiraja’s personal devotion to particular Hindu deities, he possessed a very complex cultural identity.⁵⁰ He worked closely with Brahmin ministers, maintained mostly good relations with the Mughal court, and welcomed individuals practicing many faiths and representing various political states into his kingdom.⁵¹ As relates to architecture, he was accustomed to residing in spaces reflective of South Asian aesthetic hybridity, as the palace at Amer represented both an accretive style of Rajput defensive architecture, and an open geometry derived from Mughal garden design.⁵² By the second quarter of the eighteenth century, the

⁴⁸ Volwahren, 142.

⁴⁹ For two recent examples of this, see MacDougall, 16-33; Nilsson, “Jaipur—Reflections of a Celestial Order,” 107-28.

⁵⁰ Catherine B. Asher and Cynthia Talbot, *India Before Europe* (Cambridge: Cambridge University Press, 2006), 254.

⁵¹ In fact, this part of his character frustrated Jesuit priests who saw him as an otherwise ideal target for conversion. See Andreas Strobl, “Letter No. 643,” in *Der Neue Weltbott mit allerhand Nachrichten dern Missionariorum Societatis Jesu*, ed. Joseph Stocklein (Augsburg: 1726), 14.

⁵² Bianca Maria Alfieri, *Islamic Architecture of the Indian Subcontinent* (London: Laurence King Publishing, 2000), 286; Ebba Koch, *Mughal Architecture: An Outline of Its History and Development (1526-1858)* (Munich: Prestel, 1991), 69; George Michell and Antonio Martinelli, *The Royal Palaces of India* (London: Thames and Hudson,

distinction between Muslim and Hindu building practices at Amer and Jaipur was artificial. Even so, there exists a commonly held belief that, as a Hindu king, Sawai Jai Singh must have been occupied with more philosophical concerns as transcendent numerology than with keeping track of costs and expenditures while building a new city.⁵³ If such was true, it would not surprise us to discover that no records were kept of the costs, time, and dimensions while the observatories were being built. However, much like the architecture at Amer, the political and financial institutions of the kingdom of Amer and Jaipur could be viewed as an exemplary example of bureaucratic fusion. Archival records prove that Sawai Jai Singh had established an extensive system of managerial and production offices based on the Mughal model of *karkhānas* (workshops) even before he founded the city of Jaipur. Maintained within these *karkhānas* were the court accounting records, and in fact, a good portion of these records were devoted to tracking the expenditures and materials involved in the building the city of Jaipur, including the observatory. In general terms, what this means is that these records provide opportunity to adopt a more holistic approach to Indian history, and to reconsider the constraints inherent in formal analyses and oral traditions divided along communal/religious lines.⁵⁴ In specific terms, we are now able to refine the more speculative analyses regarding construction and labor expenses for

1994), 142-43; G. H. R. Tillotson, *The Rajput Palaces: The Development of an Architectural Style, 1450-1750* (New Haven: Yale University Press, 1987), 93-105.

⁵³ When making this assertion, Volwahren offers Akbar's notations on building, including the prices of building materials and estimates of house building, by way of contrast. Abul Fazl 'Allami, *The Ain I Akbari*, trans. H. Blochmann (Calcutta: Baptist Mission Press, 1873), 222-26; Volwahren, 143. For a reading of Sawai Jai Singh as a Hindu king and the city as a conceptual representation of that identity, see also Vibhuti Sachdev, *Building Jaipur: the Making of an Indian City* (New Delhi: Oxford University Press, 2002), 11-13, 36-69.

⁵⁴ For an analysis of the challenges and benefits of writing history through narrative traditions, see Ramya Sreenivasan, *The Many Lives of a Rajput Queen: Heroic Pasts in India c. 1500-1900* (Seattle: University of Washington Press, 2007), 8-12.

the observatories, and to discuss the city space not in terms of cosmology or religion, but in terms of labor, construction, and institutional relationships.⁵⁵

What this historiographic summary suggests is that, even while alternative readings of the observatories might have been possible at the end of the eighteenth century, our interpretations of the observatories continue to be heavily shaped by a particular configuration of colonial biases, a development which prevents us from envisioning the observatory complexes as participants in an active landscape of knowledge making. However, the observatories were far from lifeless, and in point of fact, participated in the greater landscapes of labor, politics, and power in intriguing and often contradictory ways. The observatories were generative sites of meaning and knowledge, and active participants in the vibrant, changing cultural and physical landscapes of northern India.

1.3 Methodology

In order to excavate the weight of the eighteenth century from the built environment of the observatories, I have relied on a focused discourse analysis, or what Lata Mani describes as “a critical reading strategy.”⁵⁶ Although we can experience the built environment of the observatories in visual, material, and even spatial terms, our historical understanding of these sites has been heavily mediated through a language deeply inflected by a specific formulation of colonialism. Discourse analysis as advocated by Mani is valuable in its ability to reveal the process of knowledge formation employed by colonial powers, but more importantly, in its

⁵⁵ Andreas Volwahn has attempted a cost analysis of the observatories based on data included in Williams’ article on the observatory in Varanasi (Williams reported that *pandits* were paid five rupees per day, workmen received two rupees per day; they also received gifts-in-kind totaling some 300-400 rupees per year), and a Jesuit report that Sawai Jai Singh spent over fifty thousand guilders on a perpetual motion machine. See Andreas Strobl, “Letter No. 644,” in *Der Neue Weltbott mit allerhand Nachrichten dern Missionariorum Societatis Jesu*, ed. Joseph Stocklein (Augsburg: 1726), 15; Volwahn, 143-44; Williams: 49.

⁵⁶ Lata Mani, *Contentious Traditions: the Debate on Sati in Colonial India* (Berkeley: University of California Press, 1998), 1-7, 12-14.

capacity for uncovering interpretations that may have been erased during centuries of colonial history writing. In this case, I have worked to locate those gaps in the archive that mark the silencing of indigenous voices, and endeavored to be attentive to competing voices at various points in the observatories' histories. While difficult to navigate, and even more difficult to interpret, these moments of archival silence reveal the very structure of social and epistemological violence. As my analysis of the fiscal records from the Jaipur observatory indicates, multiple casual acts of oppression through convention served to erase the identities of countless numbers of unskilled laborers from the historic record. This recurrent practice later facilitated colonial depictions of the observatories as devoid of people, and severed these builders from a history of intellectual inquiry and experiment. In order to return the observatories to an environment of growth and experiment, my goal is to recover, if not the voices or identities of those who were erased from the account ledgers, then at least to acknowledge that the stones of the observatories were carried with their hands and upon their backs.

While accounting practices may have marked the first step in removing any signs of local agency, in truth, it is our disciplinary dependency on the English-language colonial archive that prolongs the life of Orientalist stereotypes inherent in our studies of the observatories. In complementary analyses of imperial archives, Betty Joseph and Antoinette Burton indicate that one explanation for the longevity of the colonial mindset is the repeated reliance of historians on the colonial archive.⁵⁷ One goal of this dissertation is to broaden the applicable archive, reaching beyond the constraints of English-language colonial sources to include rarely used material from Indian collections. I rely on records written in Hindi, Rajasthani (Jaipuri),

⁵⁷ Antoinette M. Burton, *Archive Stories: Facts, Fictions, and the Writing of History* (Durham: Duke University Press, 2005), 7; ———, *Dwelling in the Archive: Women Writing House, Home, and History in Late Colonial India* (New York: Oxford University Press, 2003), 4-30; Betty Joseph, *Reading the East India Company, 1720-1840: Colonial Currencies of Gender* (Chicago: University of Chicago, 2004), 1-30.

Sanskrit, Urdu, and Persian to flesh out labor pools, explicate construction methods, and revivify observational practices in Shahjahanabad and Jaipur in particular. On the surface, this seems like a logical first step in writing a multivocal history, one that is attentive to contradictory interpretations of the landscape and architecture of northern India as represented by various participants. On closer inspection, relying on sources written in “local” Indian languages complicates our inquiries into the history of the observatories in unexpected—and intellectually delightful—ways. Sawai Jai Singh was fluent in multiple languages, and he put them all to good use on a daily basis while running his court. To which language should we listen most closely? In his written correspondence with representatives and agents of the Mughal court, the Maharaja Dhiraja communicated in Persian, and the archives are replete with examples of *farmāns*, *vakāl* reports, and *arzdāšts* bearing his seal. On the other hand, the multitude of records stamped with the Hindi version of the seal indicates that he preferred to run his own court in Ḍhūṇḍhārī (Jaipuri), a local dialect of Rajasthani.⁵⁸ Certainly, local laborers communicated in this and other regional dialects (Marwari, Mewari, Mewati, Gujarati), and to make the king’s wishes clear, at least one minister of court needed linguistic versatility. The records of the royal *karkhānas* (workshops) were composed in a mix of Rajasthani and Sanskrit, with occasional forays into Persian (in Devanāgarī script) whenever the scribe made reference to governmental institutions of Mughal origin. The astronomical manuscripts produced at Jaipur were composed in Sanskrit, Jaipuri, and Persian, and the library collection contained scientific treatises in Arabic, Persian, Greek, English, Sanskrit, Latin, and Hindi.⁵⁹ The *Zīj-i Muḥammad Shāhī* (attributed to the mind,

⁵⁸ J. D. Smith, “An Introduction to the Language of the Historical Documents from Rajasthan,” *Modern Asian Studies* 9, no. 4 (1975): 433-64.

⁵⁹ D. A. King, “A Handlist of the Arabic and Persian Astronomical Manuscripts in the Maharaja Mansingh II Library in Jaipur,” *Journal for the History of Arabic Science* 4 (1980): 81-86; Pingree, “Indian and Islamic Astronomy at Jayasimha’s Court,” 313-28; David Pingree, “Sanskrit Translations of Arabic and Persian Astronomical Texts at the Court of Jayasimha of Jayapura,” *Suḥayl* 1 (2000): 101-06; ———, *A Descriptive Catalogue of the Sanskrit Astronomical Manuscripts Preserved at the Maharaja Man Singh II Museum in Jaipur*,

if not the hand, of Sawai Jai Singh) was written originally in Persian and allegedly circulated throughout the subcontinent in Hindi. Simultaneous to all this work conducted in “local” languages, the Maharaja Dhiraja communicated in European languages with representatives hailing originally from Portugal, France, and Bavaria. The languages of these nations were far more likely to be heard at the Kacchawāhā court than the preferred language of the English East India Company. In this cacophony of sound, however, the question becomes: if we cannot trust the histories of the observatories written in colonial English, then to which language should we award precedence? Persian was the language of power and privilege, bringing its speakers closer to the workings of the Mughal court; yet so, too, was Rajasthani, at least when deployed in the courtly spaces of Jaipur. The methodological challenges presented by the linguistic complexity of the written record are not negligible, particularly if we wish to engage with these records within a framework of postcolonial discourse analysis. To do so, we need a fluency so deep we are able to recognize the conventions of courtly languages, to understand the protocols of written communications in multiple institutions, to distinguish the humility topos from sincere respect, to be able to decipher what is on the page, but more importantly, to detect what has been erased, or what was not considered important enough to include from the outset. Further, we need to be able to do this in multiple languages, with English being the least important on a long list of possibilities.

To say that language and the written archive is important to this study is an obvious understatement, but this dissertation works to go beyond the constraints of the conventional archive in its analytic focus. The most significant broadening of the historical archive is, in fact, a consideration of the landscape itself as a container and producer of cultural knowledge. While

India (Philadelphia: American Philosophical Society, 2003), viii-xi; Sharma, *Sawai Jai Singh and his Astronomy*, 329-31.

there is a strong—if small—group of scholars analyzing the built environment from a self-consciously postcolonial viewpoint, the majority of these investigations to date have focused on urban formations and discourses of modernity at play across a larger urban or even global scale.⁶⁰ Much of this published work concentrates on sweeping changes introduced into the cityscape during the nineteenth and twentieth centuries, a period that obviously postdates the era of Sawai Jai Singh's patronage.⁶¹ Even so, these studies can assist us in analyzing the ways in which these later interventions into the urban environment affect our perceptions of the observatories' origins, particularly in the case of the Jaipur observatory. A second trend in postcolonial architectural history has subjected the discipline itself to close scrutiny, producing a literature hinging on the close connections of (post)colonialism and architectural discourse. Questions on the formulation of the canon in U.S. and Indian universities, the challenges of teaching architectural design and history in an ex-colonial nation, and the problems of analyzing a historic record mediated by colonialism, surface again and again in the major journals of the field.⁶² If my reading of the observatories' historiography is correct, if twenty-first century

⁶⁰ The literature on cities, colonialism and modernity runs quite deep, indicating perhaps the usefulness of the large urban scale as an analytic for discursive formations of power and authority. For exemplary analyses of the colonial cityscape (within India and without), Zeynep Çelik, *Urban Forms and Colonial Confrontations: Algiers under French Rule* (Berkeley: University of California Press, 1997); Swati Chattopadhyay, *Representing Calcutta: Modernity, Nationalism, and the Colonial Uncanny* (London: Routledge, 2005); Jyoti Hosagrahar, *Indigenous Modernities: Negotiating Architecture and Urbanism* (London: Routledge, 2005); Anthony D. King, *Colonial Urban Development: Culture, Social Power, and Environment* (London: Routledge & Paul, 1976); ———, *Urbanism, Colonialism, and the World-Economy: Cultural and Spatial Foundations of the World Urban System* (London: Routledge, 1989); Vikramaditya Prakash, "Productions of Identity in (Post)colonial "Indian" Architecture: Hegemony and its Discontents in C19 Jaipur" (Dissertation, Cornell University, 1994); Gwendolyn Wright, *The Politics of Design in French Colonial Urbanism* (Chicago: University of Chicago, 1991); Brenda S. A. Yeoh, *Contesting Space: Power Relations and the Urban Built Environment in Colonial Singapore* (Kuala Lumpur: Oxford University Press, 1996).

⁶¹ Ryan Bishop, John Phillips, and Wei-Wei Yeo, eds., *Postcolonial Urbanism: Southeast Asian Cities and Global Processes* (New York: Routledge, 2003); Nihal Perera, "Contesting Visions: Hybridity, Liminality and Authorship of the Chandigarh Plan," *Planning Perspectives* 19(April 2004): 175-99; Vikramaditya Prakash, *Chandigarh's Le Corbusier: the Struggle for Modernity in Postcolonial India* (Seattle: University of Washington Press, 2002).

⁶² Jyoti Hosagrahar, "South Asia: Looking Back, Moving Ahead-History and Modernization," *Journal of the Society of Architectural Historians* 61, no. 3 (2002): 355-69; Pratima Joshi, "Problems in South Asian Architectural Historiography," *Architecture + Design* 5, no. 4 (1989): 53-9; Gülsüm Baydar Nalbantoglu, "Toward Postcolonial Openings: Rereading Sir Banister Fletcher's History of Architecture," *Assemblage* 35 (1998): 6-17; Panayiota Pyla,

interpretations of the observatories closely reproduce eighteenth-century rhetoric and colonial biases, all of these issues, but particularly the last, need to be taken seriously by myself and other architectural historians interpreting architecture embedded in the ex-colonial environment. Architectural history is something of a new player in the field of postcolonial criticism, perhaps because the earliest challenges to Orientalism and colonialism (and thus a majority of the responses and refinements) came out of disciplines linked closely to textual analyses such as literary studies and history. In a sense, then, postcolonial criticism of the designed environment can be seen as somewhat belated, arriving at the roundtable discussion just at the moment scholars from other disciplines are pushing away from it. This dissertation demonstrates that the lament over the demise of postcolonialism is premature, that rededication to interdisciplinary work will not simply reinvigorate the weary, but will create new and necessary methodologies for analyzing the (post)colonial and what may be hidden beneath it.

To that end, my analysis of the observatories represents both a challenge to and an extension of the growing body of work on the postcolonial within the joint disciplines of architectural and landscape history. It queries the often implicit assumption that architectural representation consists of ideologies or social values rendered legible through the visual characteristics of a building. Formal analyses of the visual components of buildings, construction methods, and styles have long sustained the discipline of architectural history, clearly revealing its shared roots with the discipline of art history. This “tyranny of vision” dominates particularly the architectural histories of India written during the colonial centuries.⁶³

“Historicizing Pedagogy: A Critique of Kostof’s *A History of Architecture*,” *Journal of Architectural Education* 52, no. 4 (May 1999): 216-25; K. R. Sitalakshmi, “Theoretical Constructs: Towards a History of Contemporary Indian Architecture,” *Architecture + Design* 20, no. 3 (May-June 2003): 32-8; Donald M Stadtner, “New Approaches to South Asian Art,” *Art Journal* 49, no. 4 (1990): 350-62.

⁶³ For instance, Havell and Fergusson both sifted and sorted the built environment of India into three general categories (Hindu/Mughal/British) according to ornament and style. Archaeologists such as Cunningham followed a similar descriptive practice, further distinguishing curvilinear forms of Buddhism toposes from the sloping *sikharas* of

As D. Fairchild Ruggles points out, much of the literature vision and representation as it relates to Indian architecture is heavily skewed toward Western models of viewing that privilege the illusionistic depictions of architectural space.⁶⁴ In addition to a post-Renaissance conflation of the representation of landscape with the landscape itself, this Western mode of viewing discourages an experience of the landscape as a viewed space, externally located to the eye of the beholder.⁶⁵ The effect of this largely Western, largely visual, approach to the history of the built environment of India is two-fold: first, little attention has been paid to spatial relationships among buildings, and the ways in which space can be manipulated to produce or thwart social relations and political institutions; and second, even less attention has been paid to the role of the landscape in the production of meaning, or how broader geographies can be read as historical texts themselves, not just as backdrops for buildings, monuments and towns. Following James Corner's assertion that landscape is "less a quantifiable object than it is an *idea*, a cultural way of seeing, and as such it remains open to interpretation, design and transformation," I argue that the observatories function as repositories of history not only as built, material objects, but as sites upon which laborers, observers, and patrons inscribed their own meanings and interpretations.⁶⁶

In other words, an attentive analysis of the observatories considers not just the Maharaja's intentions of spatial or intellectual control, but the ways in which his intentions were mediated,

Hindu temples. For the foundational critique of Cunningham and Fergusson, see Partha Mitter, *Much Maligned Monsters: A History of European Reactions to Indian Art* (Chicago: University of Chicago Press, 1992), 257-67. Otherwise, see Alexander Cunningham, *The Bhilsa topes; or, Buddhist monuments of central India: comprising a brief historical sketch of the rise, progress, and decline of Buddhism; with an account of the opening and examination of the various groups of topes around Bhilsa* (London: Smith, Elder, 1854); James Fergusson, *History of Indian and Eastern architecture* (London: J. Murray, 1876); E. B. Havell, *The Ancient and Medieval Architecture of India: A Study of Indo-Aryan Civilisation* (London: J. Murray, 1915).

⁶⁴ D. Fairchild Ruggles, "Making Vision Manifest: Frame, Screen, and View in Islamic Culture," in *Sites Unseen: Landscape and Vision*, ed. Dianne Harris and D. Fairchild Ruggles (Pittsburgh: University of Pittsburgh Press, 2007), 132.

⁶⁵ *Ibid.*, 150-56. In a subcontinental context the possible conjunction of viewer and viewed was made manifest through the development of perforated stone screens (jaliwork) that simultaneously thwarted and permitted visual access to the landscape.

⁶⁶ James Corner, *Recovering Landscape: Essays in Contemporary Landscape Architecture* (New York: Princeton Architectural Press, 1999), x.

communicated or even resisted by the landscape and other elements of the designed and natural environment. This move away from paper and vision, and toward space and landscape is crucial for these reasons. It is only when we place the observatories back into the living environment from which they have been torn that we can see the ways in which they operated as catalysts in a system intended to create and mobilize several different types of cultural knowledge. This dissertation considers the ways in which the observatories inhabit space at the local and regional levels and works to clarify the spatial relationships not just among the five sites, but between the observatories and an expansive geography that stretched between Lisbon and Calcutta. This study resists the urge to read the instruments as singular aesthetic or architectural objects, and instead considers the observatories as complex sites embedded in a global landscape saturated with motion.

An engagement with the built environment as an archive of motion and exchange offers new insights into issues related to labor practices, construction methods, design processes, mobility, and local configurations of power and patronage. The building strategies employed by Sawai Jai Singh outside the walls of Shahjahanabad indicates that as a patron, he had a certain amount of creative agency and used that agency to apply established construction and building strategies to solve problems associated with the use of brass astronomical instruments. The successful application of a skillset typically held by craftsmen and stone masons as a corrective to a problem in a discipline generally considered to be unrelated to architecture suggests that Sawai Jai Singh was able to facilitate the transfer of knowledge between disparate working groups and sustain a cooperative building project for several years. Further, a comparative analysis of the instruments at this site with those built in Jaipur indicates that Sawai Jai Singh and his astronomers continued to push against the known possibilities of construction

technologies in pursuit of an economizing agenda that resulted in instruments that required fewer material and labor resources to build. Evidence of the successful transfer of built form from Shahjahanabad to Jaipur allows us to posit a means of communication between different work groups at a single site, as well as a larger system capable of sorting the complexities involved in the migration of skilled labor and astronomical knowledge across regions. In drawing craftsmen and knowledge away from one locale and toward another, Sawai Jai Singh demonstrated an access to power that was typically the privilege of Mughal emperors, a group of individuals who seldom hesitated to conscript laborers and materials in support of their large-scale building. While certainly implied in the written archive, this ebb and flow of labor and its coincidental transfer of knowledge, is made much more visible when examined through the traces of its effects on the stone instruments in the observatories.

Although the observatory at Jaipur is sometimes represented as a singular institution, unique in form and history, it was built simultaneous to the city as a whole, and so is most usefully analyzed as a small but significant component of the larger cityscape. The instruments in Jaipur were derived from both brass and stone predecessors at Shahjahanabad, but even so, their final form and disposition owed much to their local environment. First, the instruments adhered to the architectural aesthetic that was thrust upon the city as a whole due to its proximity to and distance from certain material resources. The red sandstone and white marble typically associated with large-scale state building projects was located at a significant distance from Jaipur. This forced Sawai Jai Singh to adapt his aesthetic goals for his capital city and palace complex to take advantage of more readily available materials. For instance, the nearby Amagarh and Nahargarh escarpments were the most convenient quarries for the stone used in the

rubble core of the city's buildings and the observatory's instruments, while the soil pigment used to tint the wash meant to mimic imperial sandstone was mined within ten miles of the city.

The location of the observatory also affected the observatory in less obvious but perhaps more important ways. The observatory, like the City Palace complex and the city itself, was nominally surrounded by stone and plaster walls. However, neither the observatory nor the city operated as a closed system; rather, the walls of the city had a controlled porosity that allowed for people and information to cross and re-cross nominal boundaries. This permeability enabled the establishment of a physical and visual link between the observatory and other institutions in the City Palace such as the Jaleb Chowk, an adjacent courtyard that housed the royal *karkhānas*, and the Chandra Mahal, the residential palace. This link was activated on a regular basis as the royal body of the Maharaja Dhiraja passed from the private spaces of the Chandra Mahal, through the work areas of the Jaleb Chowk, and through the gates of the observatory. As Sawai Jai Singh left the palace and lingered before the shaded workshops the Jaleb Chowk or in the observatory, his presence served as a physical reminder of the connections he had forged between the various political, bureaucratic, and intellectual institutions in the capital.

During the first five years of the construction of Jaipur and the observatory, while Sawai Jai Singh continued to reside in the palace at Amer, the proximate location of the cities, old and new, encouraged a similar spectacular display of power. Sawai Jai Singh made frequent trips between the two locations and the regularized movement of the royal procession through the valley connecting them emphasized the king's presence within a constantly changing landscape. At the time of Jaipur's founding, the transportation corridor from Jaipur to Amer also was being redeveloped to meet the specifications of Sawai Jai Singh's orders. The roadway was lined with fresh construction—havelis, reservoirs, wells, gates, temples, and more. In the same way Sawai

Jai Singh's presence activated the linkages between the institutions of palace, *karkhāna*, and observatory, the ritualized passage of his entourage along the roads of the Kanak Vrindavan valley underlined a convergence of a spectacular display of power coinciding with a rationalization of space as the buildings and walls of the new city of Jaipur rose on the plains of Dhundhar.

While a study of the built environment and landscape reveals much about Sawai Jai Singh's movement in the role of monarch and astronomer, it also highlights his attempts to minimize the motion required of him for the completion of his work at the observatory. Soon after the groundbreaking ceremony at Jaipur, the Maharaja Dhiraja settled the majority of his scientific, religious, and political advisors into the Brahmapurī, or Scholar's Village, at the north edge of the city. In this, he was following a long-standing convention of relocating scholars to a self-contained village close to monarch's permanent residence, an arrangement meant to ensure easy access to court ministers by the seated ruler.⁶⁷ In fact, we might be able to understand Sawai Jai Singh's entire astronomical project as an attempt to emplace knowledge locally by convening an intellectual community at the edge of the city. The scholars at the Brahmapurī represented diverse worldviews and cultural backgrounds, but Sawai Jai Singh worked to add to that diversity by introducing European scholarly traditions as represented by astronomers and mathematicians into the mix. During the last fifteen years of his life, he made no fewer than three attempts to bring Europeans to his court, using the observatory as an intellectual lure. Others have disproved the notion that the instruments at Jaipur were constructed under the advisement of Europeans, but there is still something to be gained by examining his interaction with the European astronomers in India and the particular ways he encouraged them to transverse

⁶⁷ K. V. Sarma, "Brahmapuri, the Scholar's Village Established by Maharaja Sawai Jai Singh," *Indologica Jaipurensia* 2 (1988-1995): 45.

and occupy space. Specifically, his dealings with the Society of Jesus reveal the particularities of configurations of imperial power in India at a time when sovereignty was not necessarily linked to the possession of territory. During the years of Sawai Jai Singh's reign, empire in India consisted mostly of "imperfect geographies": while European governments claimed vast expanses of territory, the reality was that these territories were fragmented and detached, existing as enclaves connected by corridors of greater or lesser security.⁶⁸ Sawai Jai Singh made multiple appeals to the extra-national corporation of the Society of Jesus to act as his proxy in traveling through this fragmented political and physical landscape, relieving himself of the need to secure rights of passage with multiple Indian and European states. This larger cultural landscape was still shaped by motion as a response to Sawai Jai Singh's astronomical research; however, at this scale, the body of the Maharaja Dhiraja was allowed to remain in a position of repose. In charging various Jesuits with the task of travel, and in arranging for priest-astronomers to relocate to the state of Amer and Jaipur, Sawai Jai Singh was freed of many of the financial and physical burdens of travel. Ultimately, however, his goal to permanently bring European astronomers/astronomical approaches to reside in the Jaipur Brahmapurī was hampered by the South Asian geography and climate—monsoon season, inadequate infrastructure—as well as certain aspects of the Jesuit rule that slowed the forward progress of his chosen representatives even he pushed them into motion.

In a sense, this landscape of motion is also reflected in the scientific hybridity of Sawai Jai Singh's astronomical program. Frequent opportunities for cross-cultural and cross-linguistic discussions were precisely what Sawai Jai Singh had in mind when he founded the Brahmapurī on the outskirts of Jaipur. The development of the Scholar's Village was prompted not just by

⁶⁸ Lauren A. Benton, *A Search for Sovereignty: Law and Geography in European Empires, 1400-1900* (Cambridge: Cambridge University Press, 2010), 2.

the need of ready access to expert knowledge but as a deliberate attempt to foster communication between representatives of different worldviews and schools of knowledge.⁶⁹ And although historians of science have attempted to distinguish between schools of origin when discussing the history of astronomy in India, by the era of Sawai Jai Singh's rule, competing astronomical traditions had been fused irreversibly through a centuries-long process of cultural contact and exchange. For example, the Arabic planispheric astrolabe (Arabic *aṣṭurlab*, Sanskrit *ustaralava*), which was widespread in the Islamic world by the eighth century CE and reached Europe (al-'Andalus) by the eleventh century, was introduced into India during the Tughluq era (c. 1320-1398 CE).⁷⁰ This "foreign" instrument remained in popular use on the subcontinent until the end of the seventeenth century CE and continued to be an object of scholarly scrutiny until the end of the nineteenth century CE.⁷¹ The *Dhāt al-Ḥalaqa* (armillary sphere), detailed by Ptolemy in his *Almagest*, was also described in the Indian *Sūrya-Siddhānta* (c. 400 CE) and again in the *Śiṣyadhīvrddhāda Tantra* of Lalla (eighth century BCE).⁷² In addition to these early exchanges, the production and conventions of the Islamic *zīj* was introduced into South Asia well before Sawai Jai Singh's reign.⁷³ This form of ephemeris originated in the Islamic world, yet even before its documented arrival in India, it had been shaped by contact with Indian astronomers, in that the first known *zīj* to be written by an Islamic astronomer, composed by Al-

⁶⁹ Sarma, 45.

⁷⁰ The court astronomer of Firoz Shah Tughluq, Mahendra Sūri, described the astrolabe as early as 1370 CE in the *Yantrarāja*, but it is possible that the astrolabe was introduced to South Asia by Al-Bīrūnī in the eleventh century CE. See Yukio Ohashi, "Sanskrit Texts on Astronomical Instruments during the Delhi Sultanate and Mughal Periods," *Studies in History of Medicine & Science* X-XI (1986-1987): 165; Kim Plofker, "The Astrolabe and Spherical Astronomy in India," *Journal of the History of Astronomy* 31 (2000): 37; K. V. Sarma, "A Survey of Source Materials," in *History of Astronomy in India*, ed. S. N. Sen and K. S. Shukla (New Delhi: Indian National Science Academy, 1985), 19; Virendra Nath Sharma, "Yantrarāja: The Astrolabe in Sanskrit," *Indian Journal of History of Science* 34, no. 2 (1999): 146.

⁷¹ At least fifteen Sanskrit treatises on the construction and use of the astrolabe were written between 1370 and 1870 CE. Sawai Jai Singh wrote a Sanskrit treatise, the *Yantrarājaraṇā* ("Instructions for Instrument Making"), based on the planisphere and also established a foundry and manufactory of Sanskrit astrolabes. Pingree, "Indian and Islamic Astronomy at Jayasimha's Court," 314; Sharma, "Yantrarāja: The Astrolabe in Sanskrit," 149.

⁷² Sharma, *Sawai Jai Singh and his Astronomy*, 32.

⁷³ E. S. Kennedy's work remains the touchstone for the history of Islamic *azyāj*. Kennedy, 123-77.

Fazārī at the court of Caliph Al-Manṣūr (r. 753-744 CE), was based on the *Brāhmasphuṭa-Siddhānta* (c. 628 CE) and recalculated to conform to the Arabic (Hijra) calendar.⁷⁴

The hybrid nature of astronomy in India was not only a matter of manuscript or print culture, however. Although much has been made of the unique nature of Sawai Jai Singh's naked-eye observational program, instrumental astronomy congruent with that practiced in the Graeco-Arabic world has long had a presence on the South Asian subcontinent. The gnomonic projection is generally attributed to Thales of Miletus (sixth century BCE), but the practice of gnomonics, used to determine obliquity, hour, and latitude of celestial objects, was also described in the *Sūrya-Siddhānta*. The astrolabe and other Ptolemaic brass instruments were in common use in West and South Asia after the eleventh century. Much more recently, Babur, the first Mughal emperor of India (r. 1526-1530 CE), described the observatory of Ulugh Beg (b. 1394-c. 1449 CE) of Samarkand in his memoirs and compared it with the observatory Raja Vikramaditya had built in 57 BCE.⁷⁵ Babur's son, the emperor Humayun (r. 1530-1556 CE, including his fifteen year exile in Persia), is well known for his fall to the death on the stairs of the astronomical observatory that he had established in the renovated Sher Mandel (in present-day Purana Qila, Delhi).⁷⁶ Allegedly, Shah Jahan exhibited an interest in observational astronomy and intended to build an observatory at Jaunpur in Oudh.⁷⁷ And even when not involved in instrumental astronomy, the dynastic rulers of India were deeply invested in the

⁷⁴ Ghori, 23. The first Arabic *zīj* known to be produced in India dates to the mid-thirteenth century CE. See also Kim Plofker, *Mathematics in India* (Princeton: Princeton University Press, 2009), 274.

⁷⁵ Dilip Hiro, ed. *Babur Nama Journal of Emperor Babur*, trans. Annette Susannah Beveridge, (London: Penguin Books, 2006), 32. Babur added a note to his original description of Samarkand, indicating that "only seven or eight observatories existed in the world then. Caliph Mamoun one with which the Mamouni tables were written. Ptolemy constructed another. The oldest one was built in Hindustan during the reign of Raja Vikramaditya in 57 BC. Hindus used the tables of this observatory." Hiro, ed., 347-48, n. 11.

⁷⁶ Glenn D. Lowry, "Humayun's Tomb: Form, Function, and Meaning in Early Mughal Architecture," *Muqarnas* 4 (1987): 133.

⁷⁷ Blanpied, "The Astronomical Program of Raja Sawai Jai Singh II and its Historical Context," 114.

tradition of the *Zīj-i Ḥiṣabī*.⁷⁸ In the Sultanate era, Maḥmūd bin ‘Umar produced the *Zīj-i Nāṣirī* for the Sultan of Delhi, Iltutmish (r. 1246-1265 CE/644-664 AH).⁷⁹ The *Zīj-i Jāmi‘ Maḥmūd Shāh Khiljī*, seemingly inspired by Naṣīruddīn Ṭūsī’s *Zīj-i Īlkhānī* (an observational *zīj* based on work at the Maragha observatory c. 1258 CE), was written at court in the last years of the Sayyid Dynasty (1414-1451 CE).⁸⁰ In the Mughal era, Humayun experimented with visual astronomy, but died before any of his results could be developed into a working treatise. His son, Akbar, inspired by his new worldview and religious philosophy, “Dīn-i Ilāhī,” called for a new calendar to be created under the guidance of Amīr Faṭḥullah of Shīrāz to mark the beginning of the Ilāhī era. Akbar also charged Amīr Faṭḥullah, Abul Fazl, and a group of Sanskrit scholars to translate the *Zīj-i Ulugh Begī* into Sanskrit.⁸¹ In addition, he commissioned a recension of the *Zīj-i Ulugh Begī* from the court astronomer, Mullā Chānd.⁸² By command of Shah Jahan, Farīd Uddīn produced many examples of *zīj* literature, the most important and extensive of which was the *Zīj-i Shāhjahānī*, a full set of ephemerides based on the *Zīj-i Ulugh Begī*.⁸³

The method of construction of *azyāj* underwent several changes before formally arriving in India, with a number of new issues and developments occurring in the tenth and eleventh centuries CE.⁸⁴ For Sawai Jai Singh’s work, however, the most crucial moments in the development of Graeco-Arabian *azyāj* occurred in the second half of the fourteenth century in Central Asia under the patronage of Timur’s grandson, Ulugh Beg. Ulugh Beg, formally Mirza Muḥammad Tāragha bin Shāhrokh, assumed the governorship of the city of Samarkand in 1409

⁷⁸ Two main categories of *azyāj* existed: the *Zīj-i Raṣadī*, which were observational tables based on observations; and the *Zīj-i Ḥiṣabī*, which were computational tables. The major portion of Arabic and Persian *azyāj* are in the *Zīj-i Ḥiṣabī* class. Ghori, 23.

⁷⁹ Ibid., 30.

⁸⁰ Ibid., 26, 30-33.

⁸¹ See also Ghori’s list of the eighty-six *azyāj* known in the India during the reign of Akbar as mentioned by Abul Fazl in the *Ain I Akbari*. Ibid., 29, 45-47.

⁸² Ibid., 33.

⁸³ Farīd Uddīn mentioned twenty-six other known *azyāj* in the *Zīj-i Shāhjahānī* Ibid., 33-34, 48.

⁸⁴ Ibid., 23-27.

CE. Less than a decade later, he founded a madrasa to which he invited a number of Islamic mathematicians and astronomers. In 1428 CE, drawing on the expertise he had already gathered close, he founded an observatory, the main instrument of which was stone sextant with a radius of sixty meters. The observatory initially operated under the supervision of his mathematics teacher, Qāḍī Zādeh Rūmī and Maulāna Ghiyāth-uddīn al-Kāshī, but after their deaths, Maulāna ‘Alāuddīn al-Qaushjī assumed supervision of the observational work. Under al-Qaushjī, the observatory’s efforts were directed toward the production of what is now known as the *Zīj-i Jadid-i Sulṭānī*, or more familiarly, the *Zīj-i Ulugh Begī* or the *Zīj-i Gurgānī*. Dated to approximately 1438 CE, this set of tables saw wide circulation in Asia in the pre-Mughal era, and as the preceding paragraphs show, was well known in India during the Mughal era as well.

Even if we could not cite evidence of such direct and obvious contact with Ulugh Beg’s astronomy in India, we could suppose that some general knowledge of the work at Samarkand circulated within the intellectual circles of the Mughal ministry during the years Sawai Jai Singh served at the pleasure of the emperor. In the seventeenth and early eighteenth century, Afghanistan, the Turkic states, and even parts of Persia were part of the South Asian cultural sphere.⁸⁵ Mughal ministers, including the representatives of Rajput states, intermarried and circulated through central Asia and back to the subcontinent. For instance, Sawai Jai Singh’s father, Bishan (Vishnu) Singh, spent part of his reign representing Mughal interests in Peshawar and Kabul. His predecessor, Sawai Jai Singh’s great grandfather, Ram Singh, had been stationed at Jamrud (present-day north Pakistan) and in Pashtun territory on the Afghan frontier. Ram Singh’s father, Mirza Raja Jai Singh I traveled to Kandahar to formally accept the transfer of the city from Persian control to Mughal; he served in Balkh (north Afghanistan) and Badakhshan (near present-day Turkmenistan) as well.

⁸⁵ See the discussion of India as a “world region” in Asher and Talbot, 5-9.

We cannot posit a first-hand, physical connection between Sawai Jai Singh's work in Shahjahanabad and Ulugh Beg's observatory in Samarkand. Sawai Jai Singh never traveled to central Asia, and even if he had, by the eighteenth century CE, Ulugh Beg's observatory would have been completely dismantled and buried.⁸⁶ However, it is clear the Mughal political structure encouraged the trans-regional movement of cultural knowledge, a factor that eventually put the written version of Ulugh Beg's astronomy into Sawai Jai Singh's hands. Sawai Jai Singh was explicit about this intellectual debt in the description of his astronomical endeavors. In the preface to the *Zīj-i Muḥammad Shāhī*, a set of astronomical tables written at Jaipur and dedicated to the seated Mughal emperor, Sawai Jai Singh noted that his work dedicated to correcting the apparent errors discovered in the "new tables of *Sa'īd Gurgānī* [the *Zīj-i Ulugh Begī*] and *Khāqānī* [*Zīj-i Khāqānī*, c. 1420 CE], and the *Tashīl-Chānd-Akbar-Shāhī* [the *Tashīl Zīj-i Ulugh Begī*], and the Hindu books, and the European tables."⁸⁷ Moreover, he named the work of "Mirza Ulugh Beg" as his direct precedent, arguing that little of note had happened in the field of astronomy since the era of the Timurid prince's rule.⁸⁸ If we consider Sawai Jai Singh as a Rajput first, or as a Hindu king second, it is difficult to reconcile his intellectual pursuits with a worldview limited by the bounds of his clan heritage and religion. But if we consider him the heir to a hybridized culture founded on centuries of intellectual cross-fertilization and an active participant in a political institution that put Mughal and Rajput ministers in motion across a broad geography, his familiarity with Ulugh Beg's astronomy can almost be taken as a given.

⁸⁶ The observatory was dismantled after the death of Ulugh Beg. The remnants of the stone instruments and buildings remained buried until 1908 CE. Clive Ruggles and Michel Cotte, *Heritage Sites of Astronomy and Archaeoastronomy in the Context of the UNESCO World Heritage Convention: A Thematic Study* (Paris: ICOMOS and the International Astronomical Union, 2010), 166.

⁸⁷ *Zīj-i Muḥammad Shāhī*, Add. 14373, fol. 3r, Asia, Pacific and Africa Collections, British Library, London.

⁸⁸ *Ibid.*, fol. 3v.

To be sure, the accounting records associated with the Jaipur observatory do suggest that cultural categories of difference existed within the population laboring at the observatories, in that Muslim, Hindu, and European astronomers were categorized and recompensed for their work in ways that highlighted the differences in their religions or country of origin; however, the astronomical tasks performed by these supposedly distinct groups were indistinguishable on the ground. Jagannātha Samrāt, one of the high-ranking literate astronomers at Sawai Jai Singh's court, may have been marked individually and bureaucratically as a Hindu *paṇḍit*, but he participated in a practice of science that was directed toward the production of a supposedly Islamic *zīj*, among other tasks. Jagannātha Samrāt's writings, particularly the *Samrāt Siddhānta*, his Sanskrit translation of and commentary on the Arabic version of Ptolemy's *Almagest*, stands as an important reminder that neither religion nor language was co-terminus with supposed scientific tradition; so, too, does the work of the Royal Astronomer, Kevelrāma, who is credited as the author of the Sanskrit *Tārāsāranī*, a table of fixed stars also based on the *Zīj-i Ulugh Begī*.⁸⁹ Whenever Sawai Jai Singh imported astronomical tables, such as the *Tabulae Astronomicae* written in France by Philippe de la Hire, he immediately arranged for Persian, Sanskrit, and vernacular (*bhāṣa*) translations for use by his court astronomers.⁹⁰ The literary output alone demonstrates the hybrid nature of Sawai Jai Singh's scientific practices and the multicultural nature of his court ministry.

Sawai Jai Singh's place in the history should reflect this complicated heritage. As an astronomer, he was working within a fully hybridized scientific culture, and though he is

⁸⁹ According to Pingree, Kevelrāma also composed a Sanskrit version of de la Hire's tables called the *Dr̥kpaṣasāraṇi*. Pingree, *A Descriptive Catalogue of the Sanskrit Astronomical Manuscripts Preserved at the Maharaja Man Singh II Museum in Jaipur, India*, vii-xvii; ———, "Indian and Islamic Astronomy at Jayasimha's Court," 320.

⁹⁰ Philippe de la Hire, *Tabulae Astronomicae*, 2nd ed. (Paris: n.p., 1727); Mercier, "Account by Joseph Dubois of Astronomical Work under Jai Singh Sawai," 157-66.

frequently styled as a Hindu king, it is clear that his science drew on more than the established tenets of Hindu/Vedic philosophies. His behavior as an observer was congruent with that exhibited by Flamsteed in London and Cassini in Paris, and he was working with a set of manuscripts and astronomical treatises with which his European counterparts were also familiar. And yet, perhaps because he rejected the use of the telescope, or perhaps because of the aesthetics and size of his instruments, Sawai Jai Singh never seems to be as fully integrated into historical discussions of astronomy as he surely was in the scientific activities of his time. My analysis of the observatories seeks to re-position Sawai Jai Singh in the timeline of the history of science as much as it seeks to reposition him in the historical landscape of South Asia. Viewed through the analytics of space, motion, and scale, Sawai Jai Singh's astronomical observatories and their associated institutions offer a fresh opportunity for an examination of the ways in which Sawai Jai Singh operated within a vibrant scientific culture as much as it shows how carriers of knowledge in the form of manual laborers, Jesuit priests, and scientific experts moved through and inhabited the landscapes northern India in the second quarter of the eighteenth century.

1.4 Sources and Plan of the Dissertation

While the focus of this dissertation is on the materiality and experience of the built environment and landscape, much of the interpretive work in this project relies on written material collected from archives in India, France, and the United Kingdom. My research in India was conducted in three major government archives: the National Archives of India (NAI), in New Delhi, the Rajasthan State Archives (RSA), in Bikaner, Rajasthan, and the Directorate of Archaeology, Archives, and Museums (DAAM), in Bhopal, Madhya Pradesh. The documents unearthed at the NAI and DAAM proved essential for solidifying the argument outlined in

Chapter Two regarding the detrimental effects of colonialism on recent interpretations of the observatories' history, and also helped me sort through contradictory reports on nineteenth- and twentieth-century restorations and renovations of the instruments at the observatories in Ujjain, Delhi, and Jaipur. At the RSA, I was able to access accounting, construction, and library records produced in the royal *karkhānas* during the fifteen years following the founding of Jaipur. These seldom-used records, written in the Jaipuri dialect of Rajasthani, proved an invaluable source of information on issues related to budget, construction materials, and laborers working at the Jaipur observatory. The bulk of the argument made in Chapter Three relies on these records.

During a three-month sojourn in the United Kingdom, I conducted research in the relevant reading rooms at the British Library, the Royal Society, the Royal Asiatic Society, the Royal Institute of British Architects, and the Science & Society Picture Library. These five centers proved particularly strong sources for images, maps, travel journals, seventeenth- and eighteenth-century Rajasthani and Sanskrit manuscripts exported from India to the United Kingdom, and foreign-language secondary sources not available in the United States. I spent a fortnight conducting research at the Jesuit Archives in Vanves, France, where I translated a collection of letters and journals penned by French Jesuit-Astronomers in conversation with the Maharaja Dhiraja Sawai Jai Singh II. This research inspired Chapter Four, and marked the beginning of my foray into the history of Jesuit missions in India and the ways in which the Jesuit presence affected the work conducted at the observatories during the eighteenth century. In addition to research conducted overseas, I explored the collections of several libraries in the United States, including the Special Collection Research Center at the University of Chicago (for the journals of the Austrian Jesuit, Joseph Tieffenthaler), the Lilly Library at Indiana University (for nineteenth-century editions of published collections of Jesuit correspondence), and the Rare

Book and Manuscript Library at University of Illinois (for German-language Jesuit publications).

A note on language: In her study on native Hawaiian resistance to American imperialism, Noenoe K. Silva chose to abandon the practice of italicizing Hawaiian words, and forgo the use of diacritics in her transcriptions, “in order to resist making a native tongue foreign in writing produced in and about a native land and people.”⁹¹ In contrast, I have deliberately italicized Hindi, Urdu, and Sanskrit vocabulary in order to highlight words with specific linguistic and cultural connotations for Hindi- and Urdu-speaking scholars. This can also be read as an attempt to recover and make visible a language that has been marginalized in a profession that privileges English-language scholarship. The inclusion of diacritics conforming to the International Alphabet of Sanskrit Transliteration serves to emphasize this point, making the distinctions between long and short vowels immediately apparent to Hindi-speaking scholars, even as it slows the forward progress of the English-speaking reader. When referring to people and places commonly known in the world, such as the city of Jaipur, or Sawai Jai Singh, I have chosen to write the words as we would normally encounter them in Indian and American English, without diacritics. When referring to cities in eighteenth-century India, however, I have used the names reflected in the non-colonial primary sources. For example, I move between ‘Shahjahanabad,’ ‘Indraprastha,’ and ‘Delhi (Dilli),’ depending on whether the primary source was written in Persian/Urdu, Sanskrit, or Hindi, respectively. Similarly, I have chosen to use almost exclusively ‘Varanasi’ in place of the colonial appellation of ‘Benares,’ except when citing verbatim a primary source, or when the use of ‘Benares’ is demanded for clarity. For the most part, I have left the variants of Rajasthani spellings intact. The notable exceptions are the

⁹¹ Noenoe K. Silva, *Aloha Betrayed: Native Resistance to American Colonialism* (Durham: Duke University Press, 2004), 13.

construction materials mentioned in Chapter Three, and the calendar dates, which I have regularized throughout the dissertation. In the bibliography, I have retained the transliteration styles used by the relevant archives and library systems.

Following this introduction, this dissertation has four chapters, organized thematically. Chapter Two opens with an expanded analysis of early English-language descriptions of the observatory in Varanasi and the effect these descriptions had on colonial depictions of the spatial and design relationships among the five observatories. This chapter demonstrates that our current understanding of the literal and imaginary spatialization of the observatories in the north Indian landscape is deeply indebted to the histories written and circulated within the dominant institutions of science during the late eighteenth century, and argues that our unquestioned acceptance of this legacy has narrowed the scope of our interpretive imagination. This narrowing has resulted in the complete erasure of agency on the part of the patron of the observatories, despite the fact that Sawai Jai Singh II, as the Maharaja Dhiraja of Amer and Jaipur, was one of the most powerful rulers of the hereditary states during the late Mughal era. In this chapter, I propose a reconceptualization of the spatialization of the observatory network, and argue that we should approach the network from the west, at the locus of Sawai Jai Singh's political power, instead of positing the colonial core in eastern India as the starting point in our studies. In doing so, I demonstrate that the instruments outside the walls of Shahjahanabad, not those standing on the roof of the Mān Mahal in Varanasi, functioned as the primary center for scientific experimentation and production in Sawai Jai Singh's astronomical program. My analysis of the design and construction of the observatory at Shahjahanabad shows that, contrary to colonial representations of these spaces as perpetually empty and inert, the observatories began their lives as active and productive sites of empirical inquiry.

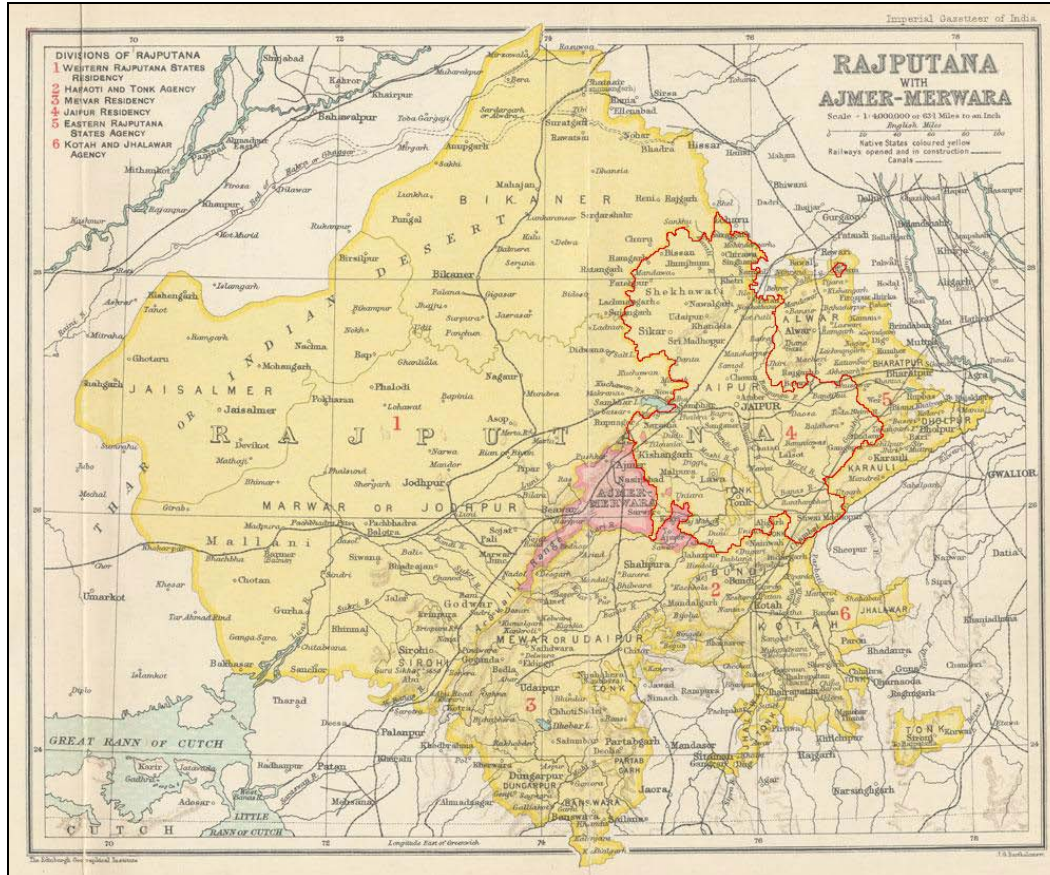
Chapter Three uses a close reading of the intramural landscape of the fiat city of Jaipur to reveal the multiple types of knowledge emplaced in the local landscape as a result of the construction and function of the observatory in that city. By tracing the routes through which people and knowledge circulated through the town, palace, and observatory complexes, I prove that while the ostensible goal of the observatory was the production of astronomical knowledge, in fact, ancillary knowledge—accounting, building, political—was privileged in the communicatory landscapes of the city. An analysis of this secondary knowledge and its motion suggests that the astronomical work completed at the observatory formed only a small piece of a larger process of intellection production that split its focus between the institutions of the privileged body of the Maharaja Dhiraja Sawai Jai Singh, the royal *karkhānas* at the City Palace, and the astronomical observatory. In my discussion of the relationship between these institutions and the greater urban fabric, I disentangle the complexity of labor divisions at the observatory, and reveal the mechanism of erasure that wiped the names and lives of the illiterate classes from the historical record.

Chapter Four takes us beyond the city walls of Jaipur and Shahjahanabad to the regional landscape of northern India. This chapter considers the stretch and limitations of Sawai Jai Singh's political power and reputation, and the ways in which certain elements of the natural and designed landscape contributed to his successes and failures as an astronomer. This chapter, which opens with a description of the Maharaja Dhiraja's endeavors to consolidate his intellectual wealth into a single locale—the scholar's village of Bhramapurī in the north sector of Jaipur—analyzes three specific attempts made by the king to bring European experts close to his most active observatory for ease of access and consultation. Without ever leaving his seat of power in Jaipur, Sawai Jai Singh appropriated the infrastructure of the Jesuit mission and used it

to circumvent the hardships impressed upon travelers by the South Asian landscape in order to bring representatives of European science back to his capital city. This chapter demonstrates that, in spite of the strength of Sawai Jai Singh's political and economic position in northern India, the natural landscape served as a powerful deterrent to scientific success.

By way of conclusion, Chapter Five introduces us to the Austrian Jesuit geographer, Father Joseph Tieffenthaler, and his mid-eighteenth-century visits to the observatories. This chapter has two goals. First, in order to draw attention to the irascible nature of Orientalist/colonial discourse, I introduce Tieffenthaler's opinions and descriptions of the observatories and explain why his descriptions of the sites were ignored by later historians when writing about the observatories, despite the wide circulation of his work in the eighteenth century. Second, I turn to the present and introduce the dominant themes in contemporary heritage discourse as they relate to the observatories. How does the historiography discussed in Chapter Two, and challenged in Chapters Three and Four, shape current interpretations of the observatory in Delhi as a symbol of Mughal splendor, the observatory in Jaipur as celebration of Rajput honor, and the observatories in Ujjain and Varanasi as exemplars of an ancient Hindu science? How do we interpret recreations of the observatories as they are presented on a global scale to an international audience? The chapter concludes with a discussion of these symbolic representations of the observatories, and a summary of the arguments made in this dissertation.

1.5 Maps

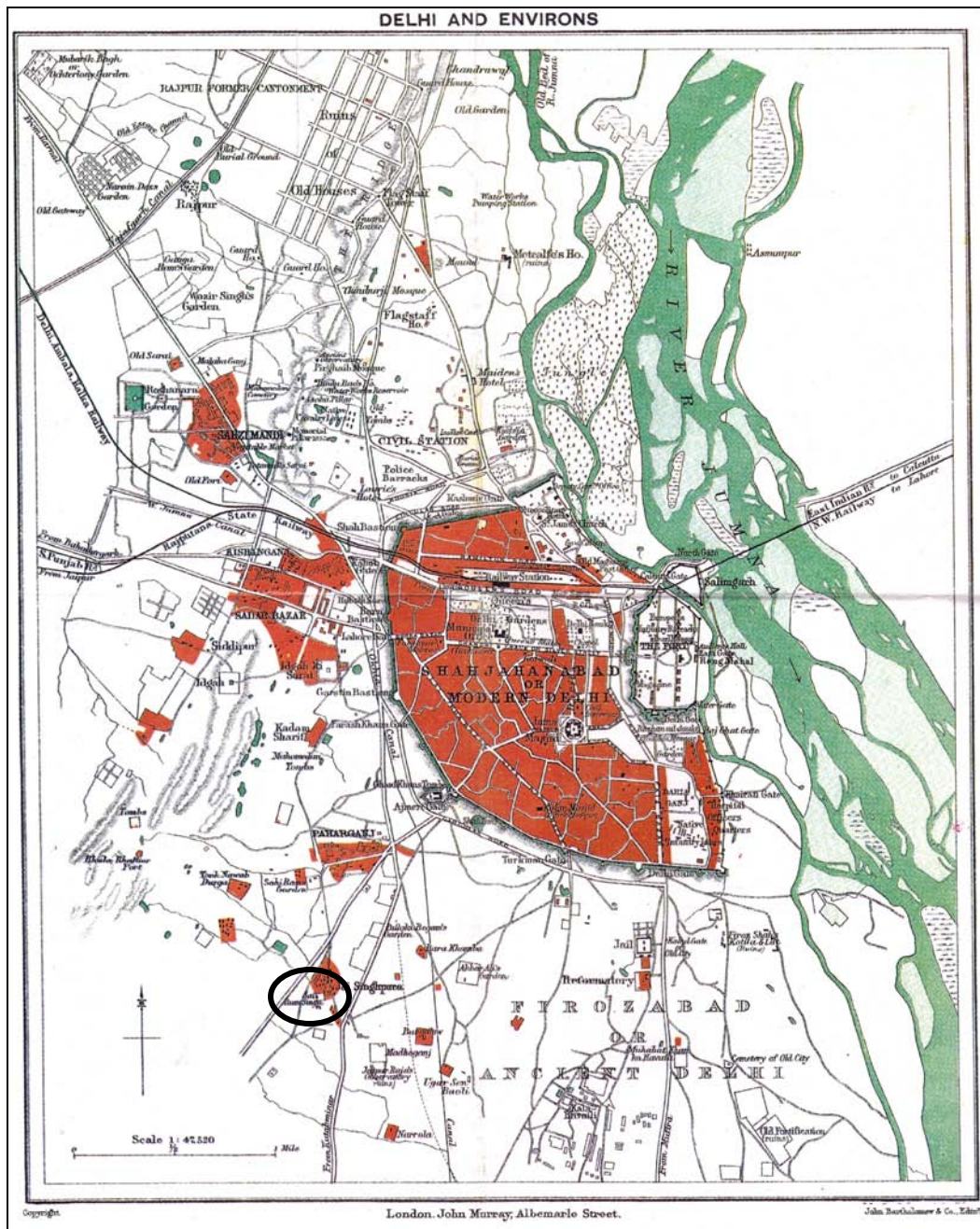


Map 1.1. Outline denotes early eighteenth-century boundaries of the State of Amer and Jaipur. Adapted from *Imperial Gazetteer of India*, opp. 154.

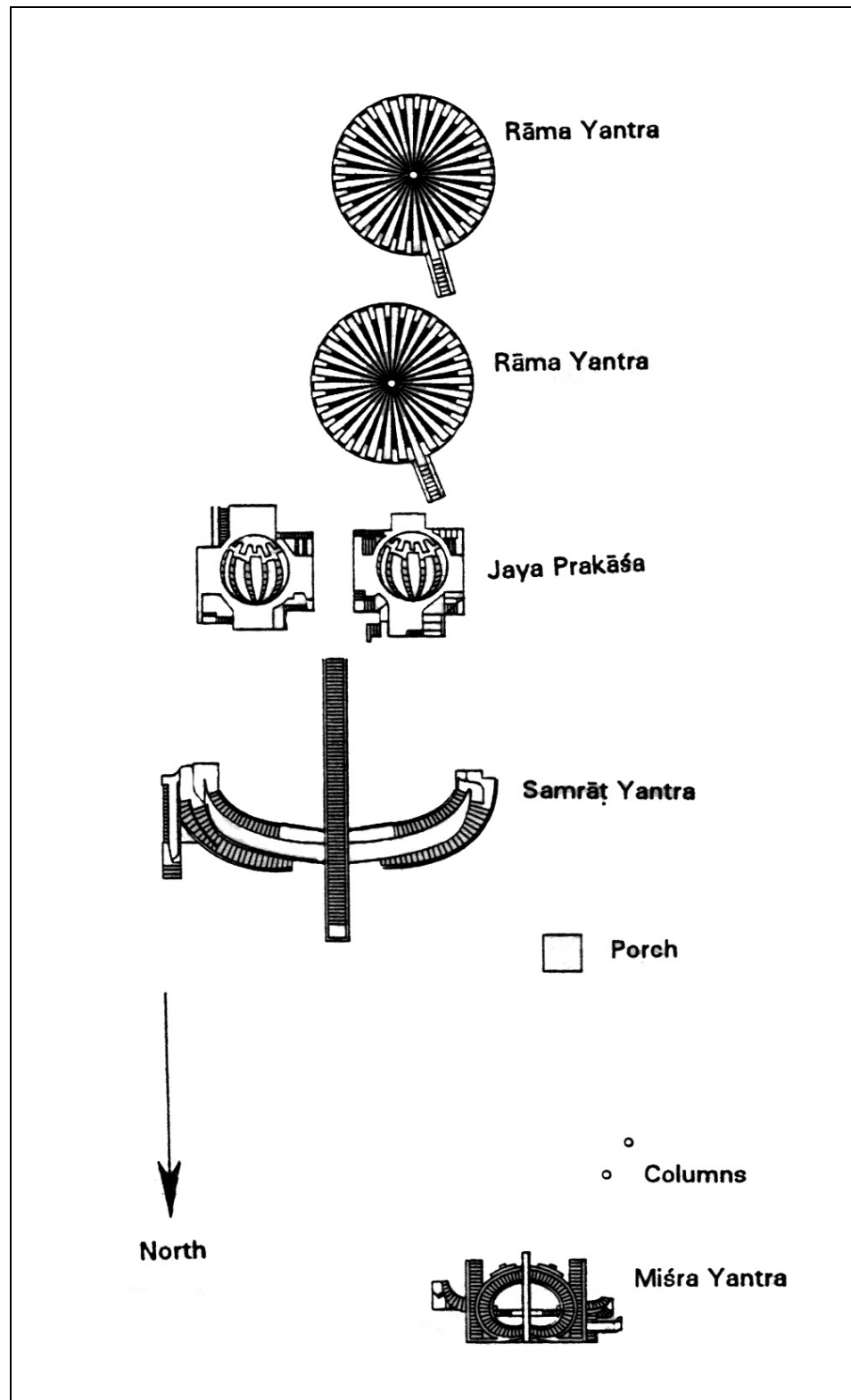


Map 1.2. Locations of Maharaja Dhiraja Sawai Jai Singh II's Observatories.⁹²

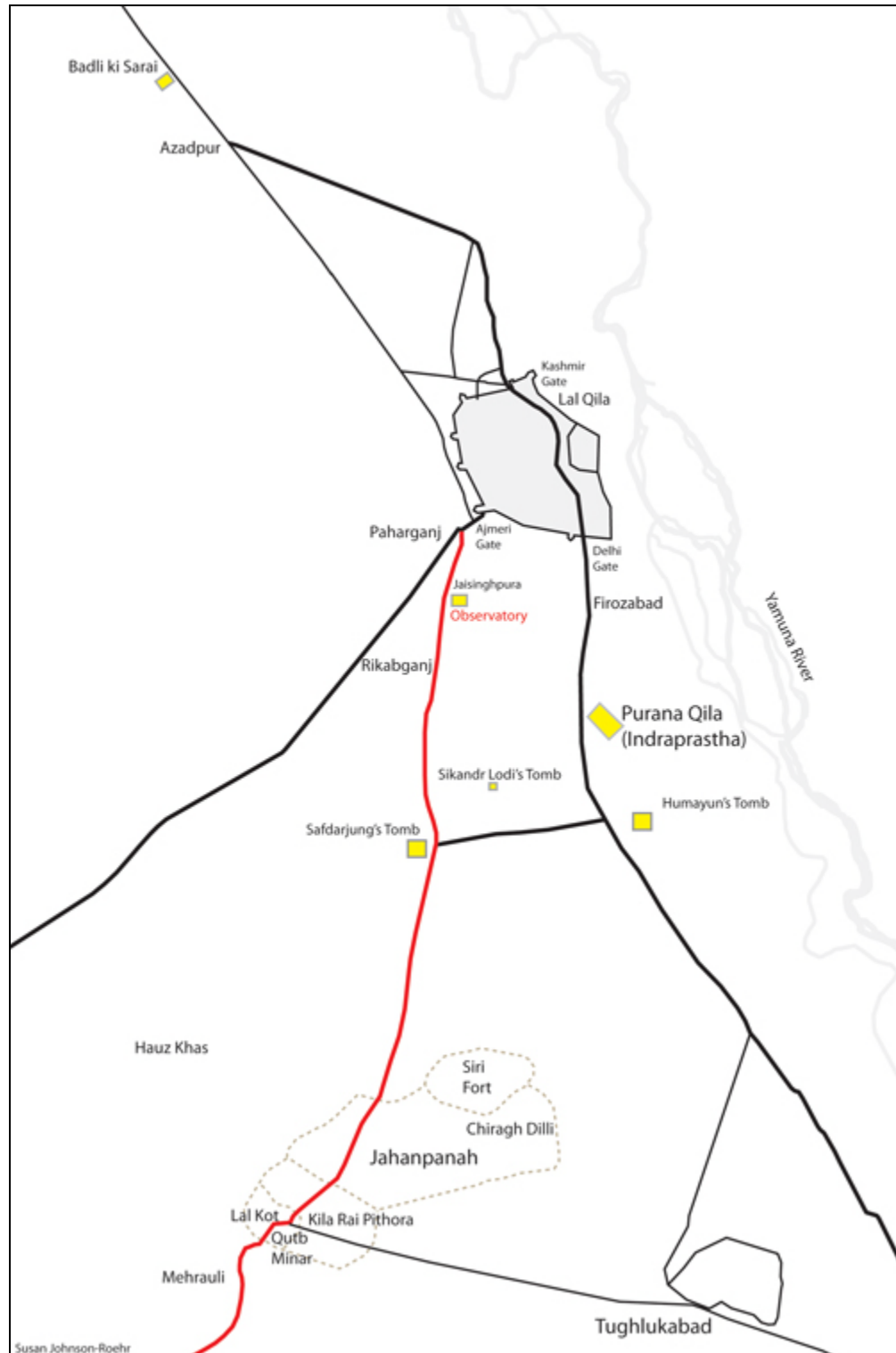
⁹² Unless noted otherwise, all maps were created by the author.

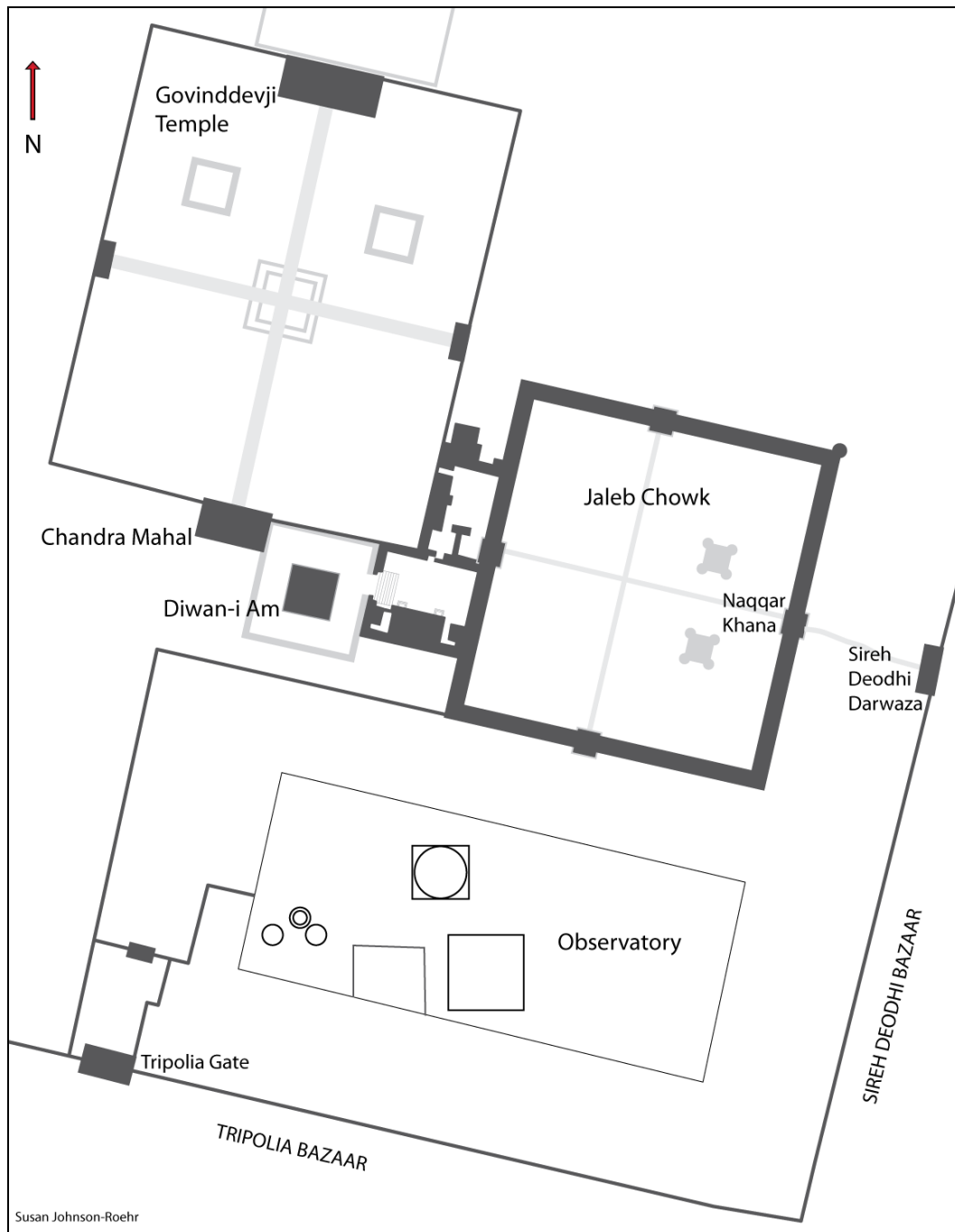


Map 1.3. Location of Observatory (in black circle) in relation to the walls of Shahjahanabad. From Fanshawe, end pocket.

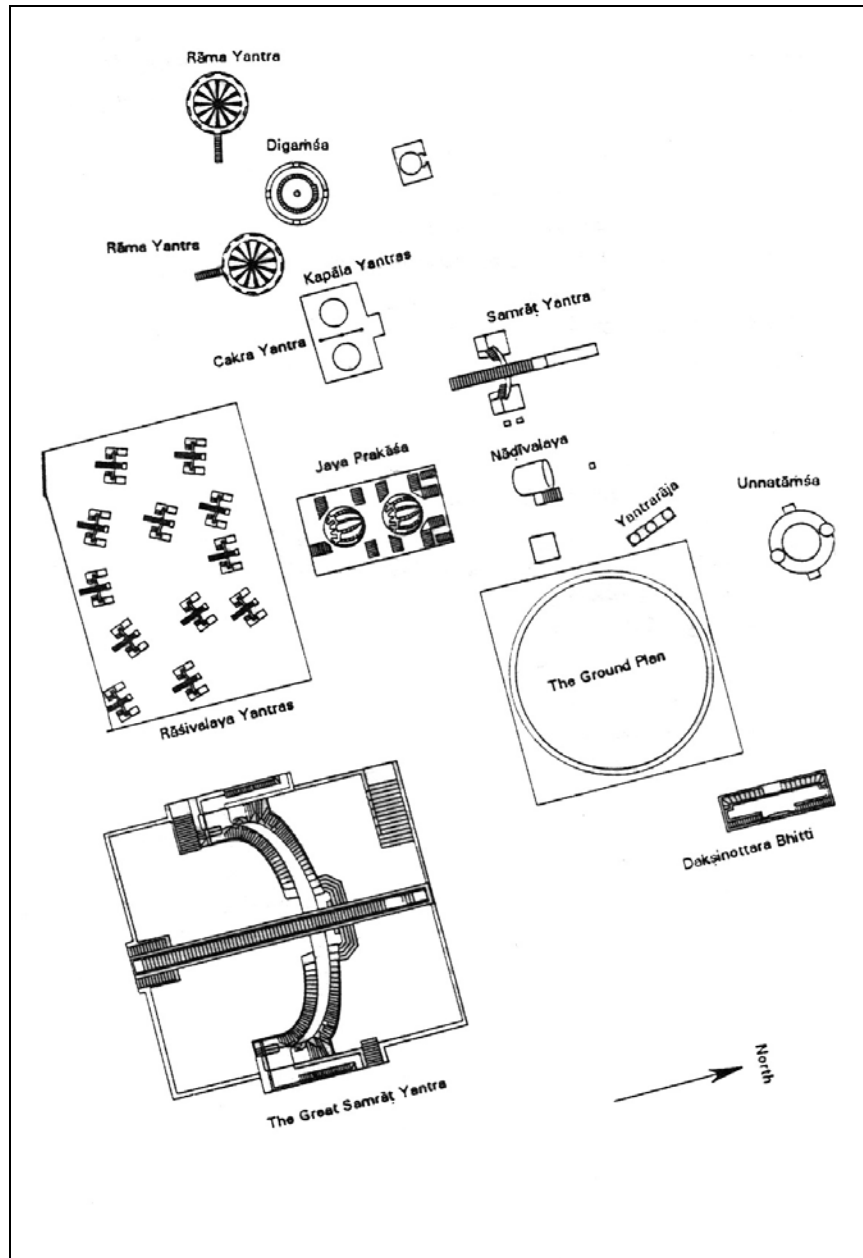


Map 1.4. Site Plan for observatory, Shahjahanabad. From Sharma, *Sawai Jai Singh and His Astronomy*, 97.

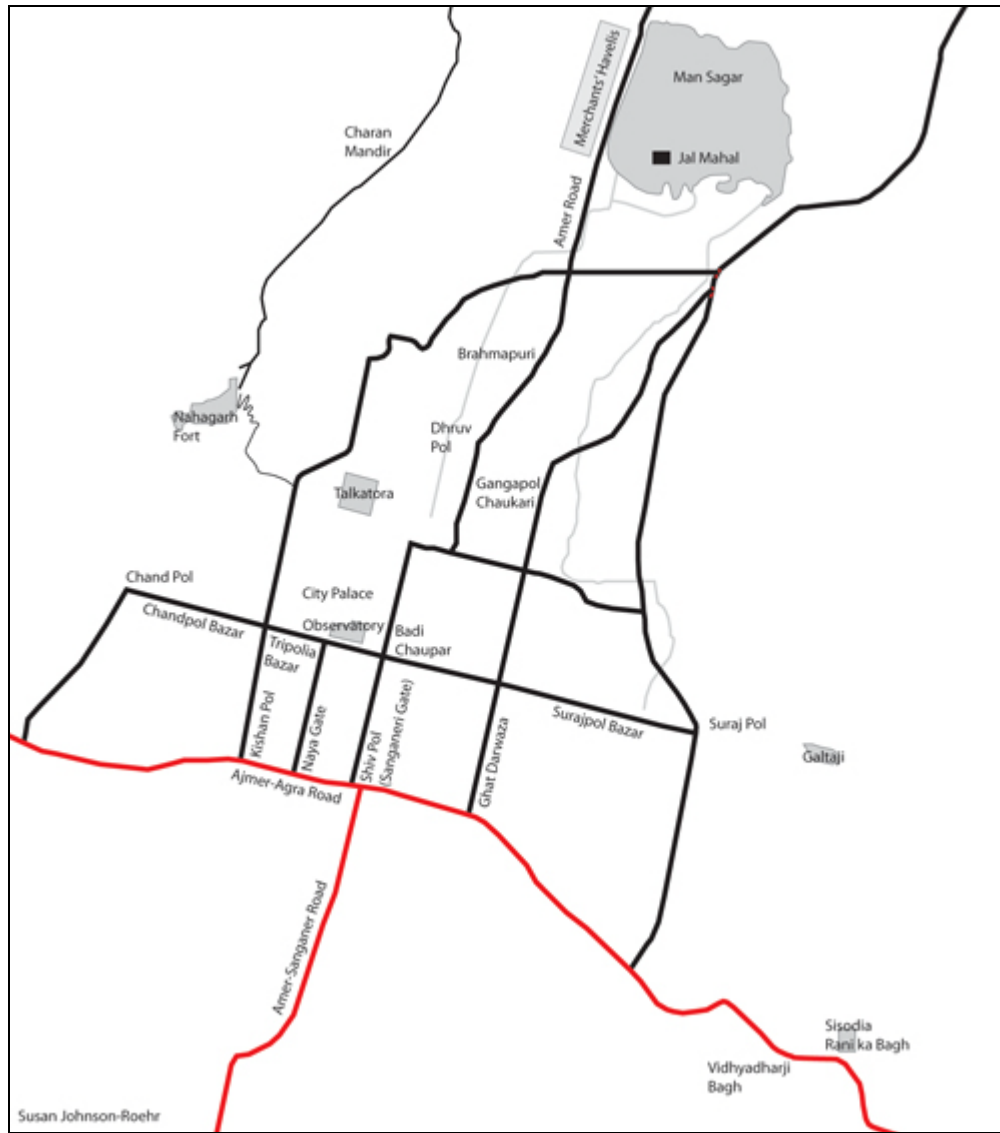




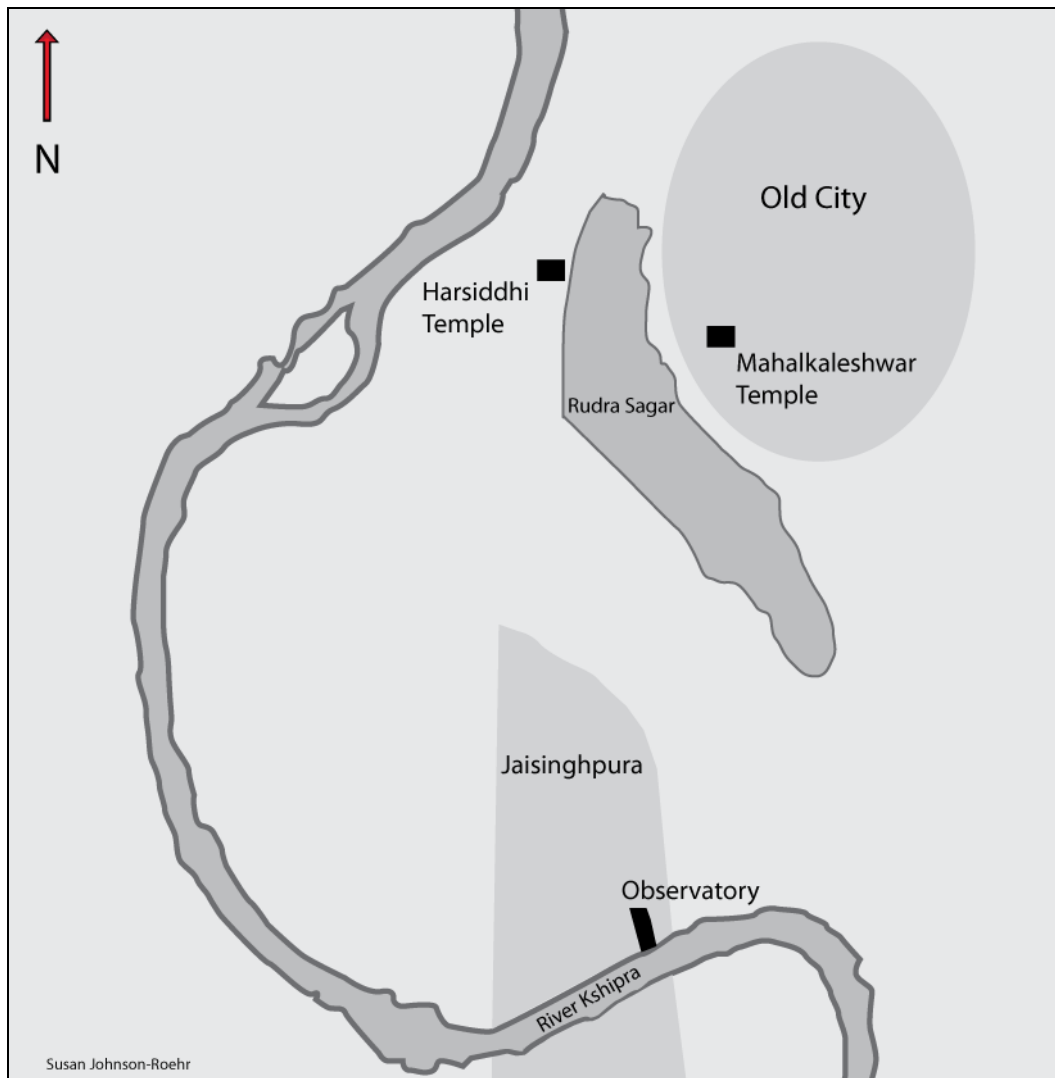
Map 1.6. City Palace, showing location of observatory relative to public gate (Sireh Deodhi Darwaza) and ceremonial gate (Tripolia).



Map 1.7. Site plan of observatory, Jaipur. From Sharma, *Sawai Jai Singh and His Astronomy*, 132.



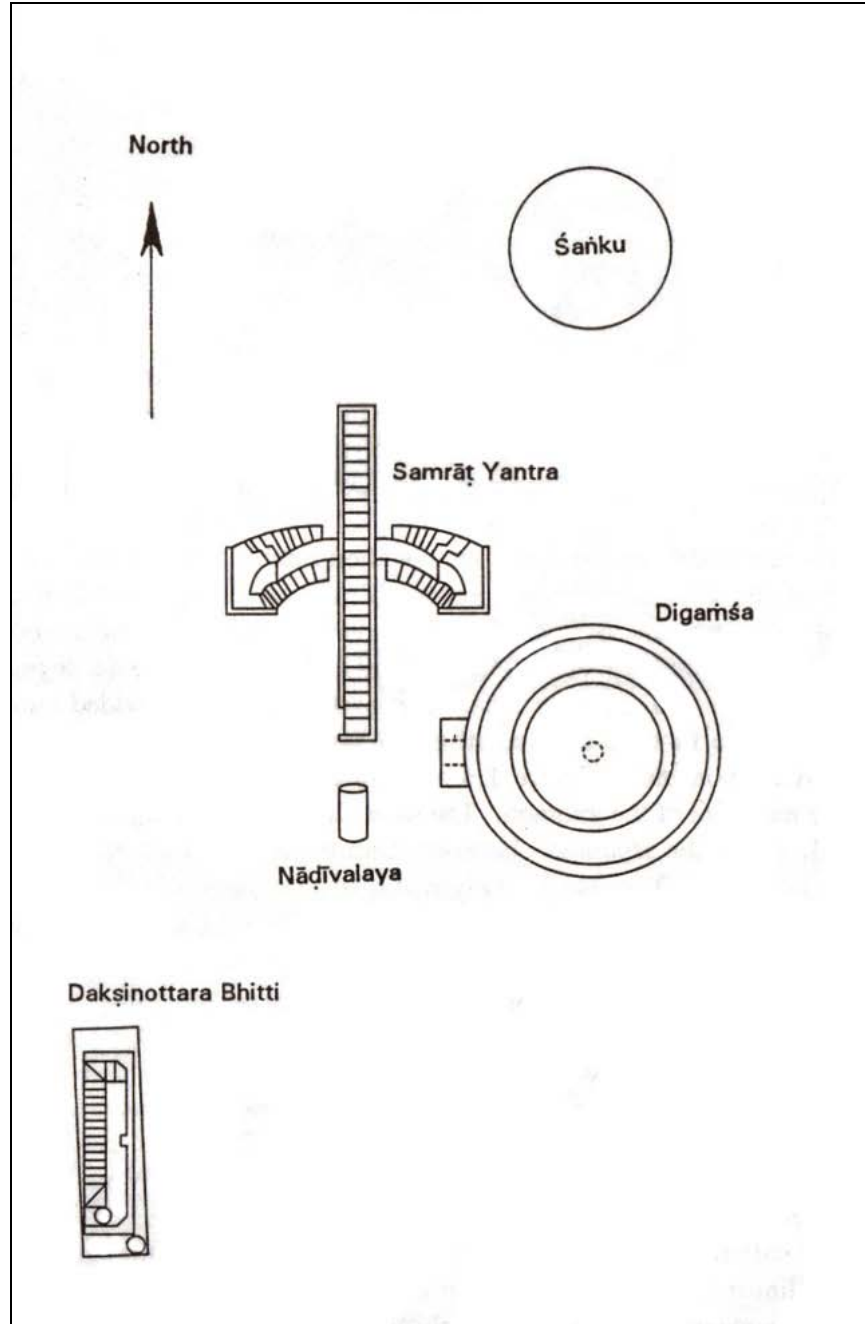
Map 1.8. Jaipur City Plan, showing Amer-Sanganer and Ajmer-Agra Roads.



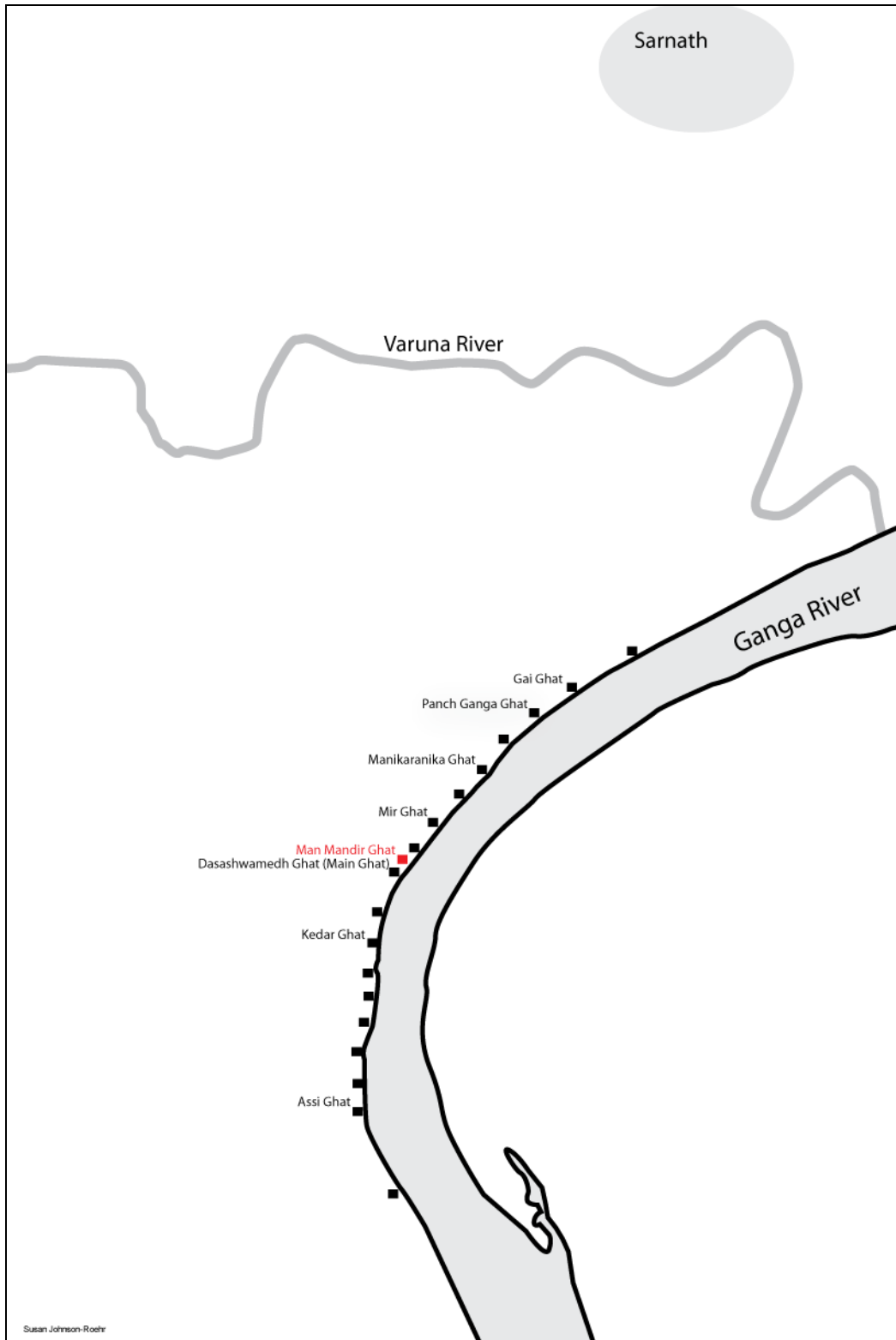
Map 1.9. Ujjain city plan, showing location observatory relative to old city.



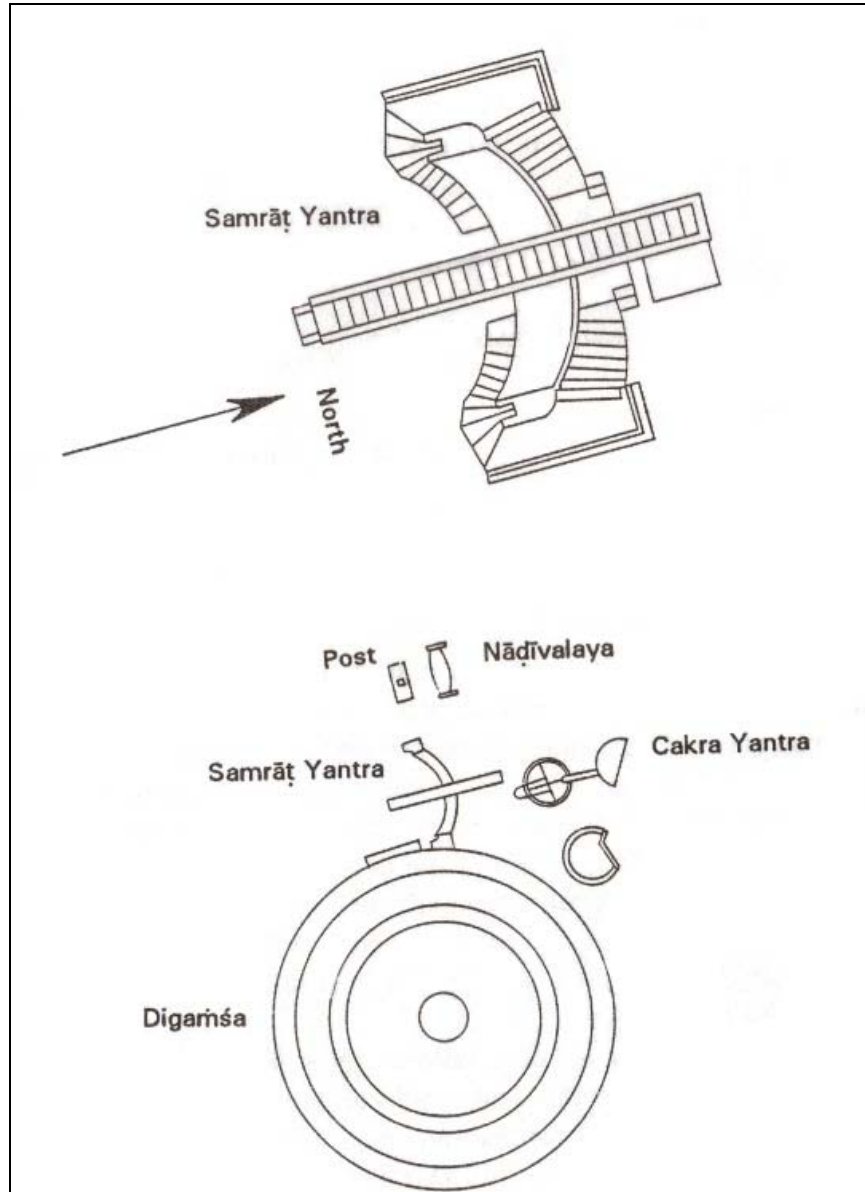
Map 1.10. Jaisinghpura, Ujjain, with Shipra River running from upper right to lower left, showing bridge, c. 1713-14 CE. From Bahura, fig. 62.



Map 1.11. Site plan of observatory, Ujjain. From Sharma, *Sawai Jai Singh and His Astronomy*, 219.



Map 1.12. Riverside ghats, Ganges River, Varanasi, showing relative location of Man Mandir Ghat and observatory.



Map 1.13. Site plan of observatory, Varanasi. From Sharma, *Sawai Jai Singh and His Astronomy*, 201.

1.6 Figures

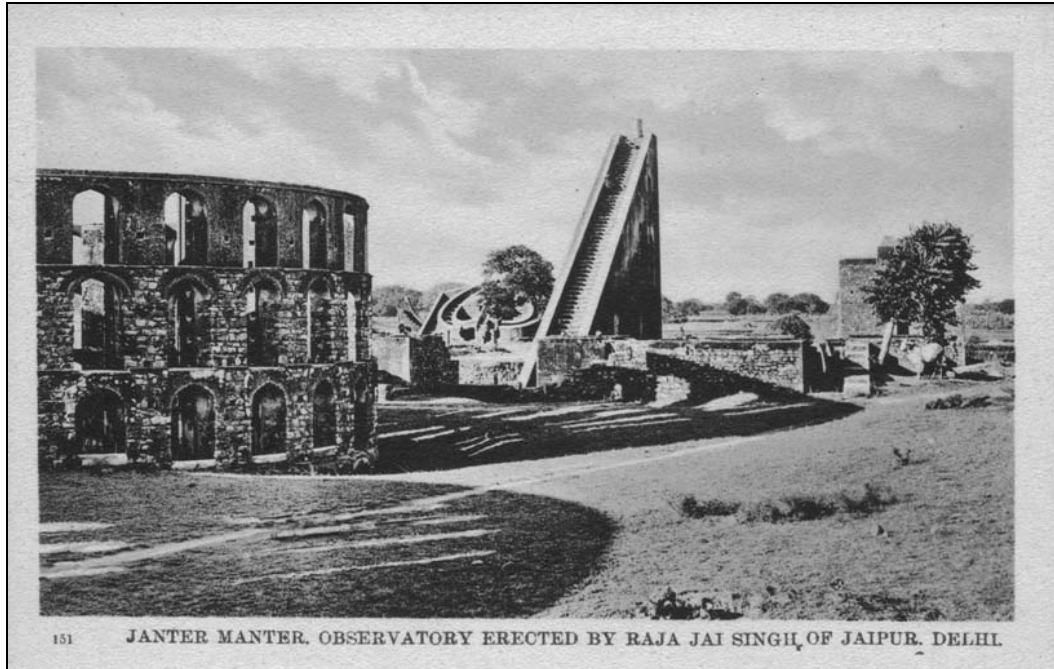


Figure 1.1. View toward northwest on tourist postcard, based on photograph taken by Lala Deen Dayal, Shahjahanabad (Delhi), c. 1880 CE.⁹³

⁹³ Unless otherwise noted, all images and photographs were provided by/taken by the author.



Figure 1.2. Gnomon of Samrāt Yantra, Delhi, June 2007 CE.



Figure 1.3. Samrāt Yantra gnomon and quadrants, Delhi, August 2007 CE.



Figure 1.4. Āgra Yantra at top of gnomon of Samrāt Yantra (Miśra Yantra in background), Delhi, 1982 CE. Courtesy of George G. Hawxhurst © California Academy of Science.



Figure 1.5. Exterior walls and superstructure of Jaya Prakāśa Yantra (Rāma Yantra behind), Delhi, June 2007 CE.



Figure 1.6. Walkways between scaled surfaces of Jaya Prakāśa Yantra, Delhi, 2009 CE.



Figure 1.7. Exterior walls of Rāma Yantra, Delhi, August 2007 CE.



Figure 1.8. Chandra Mahal as viewed from the quadrant of the Samrāt Yantra, 2006 CE.



Figure 1.9. Large Samrāt Yantra, Jaipur, c. 1928 CE.



Figure 1.10. Rāma Yantra, Jaipur, 2006 CE.



Figure 1.11. Rāma Yantra, Jaipur, 2006 CE.



Figure 1.12. Jaya Prakāśa Yantra, Jaipur, March 2009 CE.

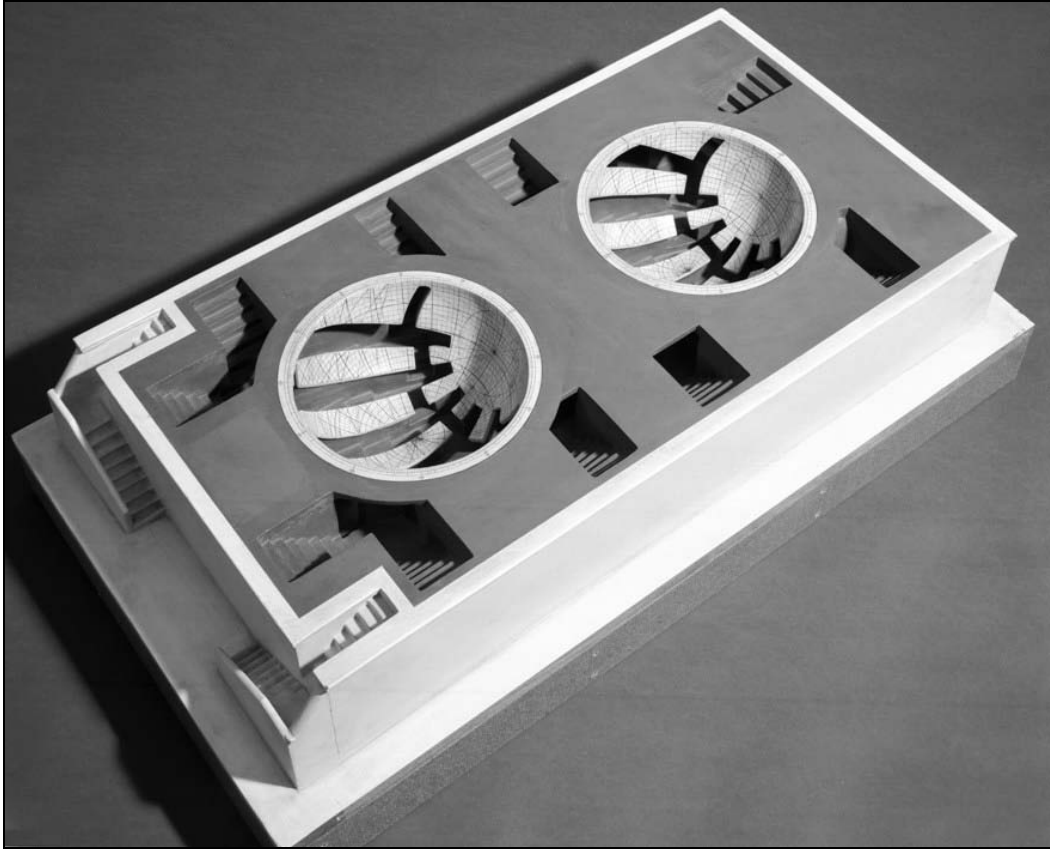


Figure 1.13. Model of Jaya Prakāśa Yantra, Jaipur. Courtesy of Science & Society Picture Library, London.



Figure 1.14. Kapāla Yantra, Jaipur, 2006 CE. Courtesy of Volwahren, 52.



Figure 1.15. Digamśa Yantra, Jaipur, March 2009 CE.



Figure 1.16. Rāśivalayas before 1901 CE restoration. From Shepp, 411.



Figure 1.17. Rāśivalya after restoration, c. 1928 CE.



Figure 1.18. View from Nahagarh (Sudarshangarh), Jaipur, Large Samrāt Yantra at center, August 2007 CE.



Figure 1.19. Samrāt Yantra, Ujjain, with human for scale, July 2007 CE.



Figure 1.20. Samrāt Yantra (left), Nāḍivalaya (center), and Digamśa Yantra (right), Ujjain, August 2009 CE.



Figure 1.21. Dakṣinottara Bhatti Yantra, as seen from quadrant of Samrāt Yantra, Ujjain, August 2009 CE.



Figure 1.22. Digaṃśa Yantra as viewed from Samrāt Yantra, Ujjain, July 2007 CE. Courtesy of Crystal Watson.



Figure 1.23. Samrāt Yantra with monkeys for scale, Varanasi, August 2009 CE.



Figure 1.24. View of Cākra, Digamśa, and Small Samrāt Yantras from gnomon of Large Samrāt Yantra, Varanasi, August 2007 CE.



Figure 1.25. Cākra Yantra at Varanasi, Digamśa Yantra at back, small Samrāt at right, Varanasi, August 2009 CE.



Figure 1.26. Small Samrāt Yantra, center, Varanasi, August 2007 CE.



Figure 1.27. Digaṃśa Yantra, Varanasi, August 2007 CE.



Figure 1.28. Nāḍīvalaya Yantra, Varanasi, August 2007 CE.



Figure 1.29. Dakṣiṇottara Bhitti Yantra on second roof, Varanasi, August 2007 CE.



Figure 1.30. Mānmandir Ghat from Ganges River, Digamśa Yantra visible top center, on roof of Mān Mahal, Varanasi, August 2009 CE.



Figure 1.31. View of Man Mahal from south, Varanasi. Photograph by Brajo Gopal Bromochary, 1869 CE. Courtesy of British Library.



Figure 1.32. Former site of observatory and Mathura fort, March 2009 CE.



Figure 1.33. Robert Montgomery Martin, "An Old Fort at Muttra," Engraved by R. Sands, c. 1860 CE. From *The Indian Empire, Illustrated*, Vol. 3, following p. 56.

CHAPTER TWO

SPATIALIZATION OF KNOWLEDGE

The possibilities available for writing the histories of the five observatories built under the patronage of Sawai Jai Singh II are limited by the way in which we conceptualize the distribution of these sites across the landscape of northern India. It matters a great deal if we approach this network of scientific and cultural communication as if it ranges from east to west (that is, from Varanasi to Jaipur) or from west to east (from Jaipur to Varanasi). In the first instance, the standard for instrumentation and observational practices is the observatory of Varanasi, the city that served as the foundational site of histories that assumed the observatory's instruments to be decaying exemplars of an ancient past. This approach, which has become the conventional method for visualizing the astronomical network, follows the trajectory of British colonialism from its eastern stronghold into the more contested regions of northwestern India. In the second instance, the pivot point of Sawai Jai Singh's astronomical program is the observatory of the new capital city of Jaipur and, as this chapter will demonstrate, the geographically proximate observatory at Shahjahanabad. This reversal of direction opens to a reconceptualization of the communicatory landscape, so that Sawai Jai Singh can be posited at the center of this moment of astronomical history in India. The re-visioning permits a more historicized focus on the institutions in Shahjahanabad and Jaipur, and serves as a corrective to specific long-standing misconceptions about the observatories and their potential for producing useful astronomical knowledge. This chapter re-positions the observatories at Jaipur and Shahjahanabad as the crucial loci in the regional network and demonstrates that they together functioned as the prototypes upon which were based the instrumentation at the observatories in Mathura, Ujjain, and Varanasi.

2.1 Changing Directions

One of the problematic legacies of the colonial historiography is the persistent conflation of one observatory space with the next, with Varanasi designated as the paragon, and the remaining sites at Ujjain, Mathura, Jaipur, and Shahjahanabad defined as derivatives. Although many elements of the observatories differ demonstrably in terms of form, scale, and distribution across the sites, because of a rhetorical device and narrative technique employed in the writing of the first known English-language descriptions of the observatory in Varanasi, all of the observatories were, and typically still are, styled as identical to the one built above the Mān Mandir Ghat. These early documentary articles, written in 1777, 1793 and 1799 CE, conspired to position this single observatory, located in a city under Company control, as the primary model for Sawai Jai Singh's scientific program. The early focus on the Varanasi observatory can be viewed as partly circumstantial, in that the articles written by colonial administrators required a certain level of access to both the instruments in the city as well as to an interested audience. Had Sawai Jai Singh sponsored an observatory in any of the Presidency towns (Calcutta, Madras, or Bombay), it is possible that it would have been "discovered" even earlier, and thus served as the starting point for British inquiries into the history of the remaining instruments. However, the observatory most distant from the state of Amer was built only as far away as Varanasi, a city in which the European population rose steeply at the end of the eighteenth century as the East India Company spread westward from Bengal.¹ Simultaneous to this population increase was the creation of the Asiatick Society of Bengal, an organization whose *Asiatick Researches* circulated not only in Calcutta, where the original editions were published, but in London, where

¹ Bernard Cohn's classic analyses of Benares describe well the political and social changes the city underwent with the arrival of the British/East India Company at the end of the eighteenth century. See Bernard S. Cohn, "The British in Benares: A Nineteenth Century Colonial Society," *Comparative Studies in Society and History* 4, no. 2 (1962): 169-99; ———, "Political Systems in Eighteenth-century India: The Banaras Region," *Journal of the American Oriental Society* LXXXII (July-Sept 1962): 312-14.

special issues were printed “verbatim from the Calcutta Edition.”² The London edition of *Asiatick Researches* joined the *Philosophical Transactions* of the Royal Society as the dominant publications involved in the process of producing and constructing knowledge about South Asian science and religion for consumption by an English-speaking audience. An active communications system that functioned in dialogic mode developed between these particular institutions in metropolitan London and those located in metropolitan India (Calcutta, the Presidency towns, Varanasi, Surat). Interested parties in both regions posed questions and intellectual problems, which were then given over to discussion by members of their respective institutions, often in quasi-public fora such as Society meetings, but also within the pages of institutional publications such as the *Philosophical Transactions* and *Asiatick Researches*.³

² The eighteenth-century *Asiatick Researches* comprised six volumes, the first of which was printed in Calcutta in 1788 CE. Pirated editions were printed in London in 1796, 1798, 1799, 1801, and 1806 CE. German translations were issued in 1796-1797 CE, with French editions following in 1801 and 1806 CE. The existence of competing editions has resulted in a convoluted trail of citations. The articles cited in this dissertation have been standardized to match the twelve-volume compendium of *Asiatick Researches* held in the Herman B Wells Library at Indiana University. See also J. M. Steadman, “The Asiatick Society of Bengal,” *Eighteenth-Century Studies*: 477; Thomas R. Trautmann, *Aryans and British India* (New Delhi: Yoda Press, 2004), 29.

³ For example, John Playfair, Professor of Mathematics at Edinburgh, posed his “Questions and Remarks on the Astronomy of the Hindus” in response to Samuel Davis’ recension of the *Surya Siddhānta*, excerpts of and expansions on which were published in *Asiatick Researches*. Similarly, the essays of Reuben Burrow (b. 1747-d. 1792 CE) on Hindu astronomy and mathematics crossed back and forth between the formal institutional publications and his private correspondence with Warren Hastings. Burrow, a mathematician who was appointed assistant to Astronomer Royal Nevil Maskelyne at the Greenwich Observatory, London, in 1771 CE, showed an almost obsessive concern with the Benares observatory in his private correspondence, but his thoughts on that topic seem not to have made it into print in either the *Philosophical Transactions* or *Asiatick Researches*. See John Playfair, “Questions and Remarks on the Astronomy of the Hindus,” *Asiatick Researches* 4 (1798): 159-63; Samuel Davis, “On the Early Astronomical Computation of the Hindus,” *Asiatick Researches* 2 (1799): 225-87; ———, “On the Indian Cycle of Sixty Years,” *Philosophical Transactions of the Royal Society of London* 3 (1791): 209-27; Reuben Burrow, “Demonstration of a Theorem Concerning the Intersections of Curves,” *Asiatick Researches* 1 (1798): 330-31; ———, “A Proof that Hindoos had the Binomial Theorem,” *Asiatick Researches* 2 (1799): 487-97; ———, “A Demonstration of one of the Hindoo Rules of Arithmetick,” *Asiatick Researches* 3 (1799): 145-48; ———, “Remarks on the Artificial Horizon, &c.,” *Asiatick Researches* 1 (1798): 327-29; Reuben Burrow, Reuben Burrow to Warren Hastings, n.d., Add. 29233, Department of Manuscripts, British Library, London; ———, Reuben Burrow to Warren Hastings, June 12 1783, Add. 29233, Department of Manuscripts, British Library, London; Reuben Burrow, Reuben Burrow to Warren Hastings, April 12 1784, Add. 29233, Department of Manuscripts, British Library, London; Burrow, Reuben Burrow to Warren Hastings. For biographical details, see Leslie Stephen and Ruth Wallis, “Burrow, Reuben (1747–1792),” in *Oxford Dictionary of National Biography*, ed. H. C. G. Matthew and Brian Harrison (Oxford: Oxford University Press, 2004); Jack Morrell and Ruth Wallis, “Playfair, John (1748–1819),” in *Oxford Dictionary of National Biography*, ed. H. C. G. Matthew and Brian Harrison (Oxford: Oxford University Press, 2004).

The first public mention of the astronomical observatories in British histories of India can be found in a letter read before the Royal Society of London in 1777 CE and published in the Society's *Philosophical Transactions* later that same year. Authored by Robert Barker, F. R. S., and addressed to John Pringle, F. R. S., the missive described Barker's quest to verify his conviction that the "ancient Bramins" had a working knowledge of astronomy.⁴ Hypothesizing that the ability of contemporary Brahmins to predict eclipses of sun and moon was due to the transmission of ancient knowledge practices across generations, Barker inquired "among the principal Bramins" in Varanasi as to the means by which successful predictions were made by *pandits* in the city. Although Barker did not name any individual with whom he spoke about these matters (indeed, this entire section of his letter is constructed in passive voice, allowing him to elide the speech of the local residents completely), we may surmise that his informants had some experience, either first hand or through second-hand observation, with astronomical texts. Barker emphasized that these works, some "containing the mysteries of their religion, and others the tables of astronomical observations, written in the Sanskirrit [sic] language," were unintelligible to all but the few initiated in the texts.⁵ He, too, could gain no intellectual purchase on the tomes stacked in front of him and had to be satisfied with a study of the remnants of the allegedly ancient astronomical instruments used to compile the Sanskrit tables based on naked-eye observations. His guides conducted him to "an ancient building of stone"

⁴ The original letter was read before the Society on May 29, 1777 CE (see Robert Barker, Letter, May 29 1777, VI.248, L & P, Royal Society, London.), and published later the same year as ———, "An Account of the Bramin's Observatory at Benares," *Philosophical Transactions of the Royal Society of London* 67 (1777): 598. John Pringle, the "Physician to His Majesty's Army in Flanders" and a "Gentleman well versed in Mathematical, Philosophical and other Learning" was elected to the Royal Society of London in 1745. Sir Robert Barker, "late Commander in Chief in Bengall [sic]" was elected a Fellow thirty years after Pringle, in 1775. See Pringle, Sir John, 1745, EC/1745/13, GB 117, Certificates of Election and Candidature, Royal Society, London; Barker, Sir Robert, 1774, EC/1745/13, GB 117, Certificates of Election and Candidature, Royal Society, London.

⁵ Barker, "An Account of the Bramin's Observatory at Benares," 598-99.

that he understood to be a former public building, on top of which spread an open terrace.⁶ As he described it, the terrace contained

a number of instruments, yet remaining, in the greatest preservation, stupendously large, immoveable from the spot, and built of stone, some of them being upwards of twenty feet in height; and, although they are said to have been erected two hundred years ago, the graduations and divisions on the several arcs appeared as well cut, and as accurately divided, as if they had been the performance of a modern artist.⁷

Barker's letter plainly recorded his amazement at the precise construction of the instruments, noting that they "exhibited a mathematical exactness, bearing, and fitting of the several parts," quite beyond what he had expected to find in an "ancient" observatory.⁸ He could only explain the quality of the stonework on display before him by attributing the observatory to the patronage of the Mughal emperor, Akbar, a "wise prince" who wished to "recover the sciences of Hindostan."⁹

Barker's letter stands as a magnificent feast of Orientalist stereotypes and assumptions: the instruments exhibited a "firmness and art" completely lacking in contemporary Indian architecture; the instruments were "the more wonderful and extraordinary when compared with the works of the artificers of Hindostan at this day...[as]...arts appear to have declined equally with the science in the East"; the observatory was necessarily ancient because "the manners and customs of the Gentoo religion are such as to preclude them from admitting the smallest innovation in their institutions."¹⁰ Yet, for our purposes, Barker's assumptions about the lack of creativity and mechanical capabilities of the local population are not the most important part of

⁶ Ibid., 599.

⁷ Ibid.

⁸ Ibid., 599-600.

⁹ Ibid., 604. Barker's assumption about the observatory's patron misled him into believing that the observatory was built in conjunction with two others allegedly built during the reign of Akbar, the first in Delhi, and the second in Agra.

¹⁰ Ibid., 600-01, 605-06.

his letter. Instead, it was the establishment, through his reliance on a rhetoric of precision and transparency, of a baseline model against which the other observatories would be measured for the next two hundred years.

A significant component of Barker's original letter to John Pringle was an enclosure of three images that were reproduced as engravings in the *Philosophical Transactions* along with the edited version of Barker's missive. The first image was a watercolor-on-paper perspectival view of five of the instruments, completed by the East India Company's Chief Engineer in Bengal, Archibald Campbell (figure 2.1); the second and third were ink-on-paper measured drawings of a single equinoctial dial (the large Samrāt Yantra) with its quadrants and gnomons carefully marked with lowercase letters (figures 2.2-2.3). The perspectival portrayal "of the whole apparatus that could be brought within his eye at one view" would have been particularly compelling to the Fellows of the Royal Society. By the time these drawings reached their audience in London, Campbell's reputation as a talented engineer, based in large part on his economical designs for Fort William in Calcutta, had been established.¹¹ The easy assumption of Campbell's engineering skill, combined with the illusion of transparency in the drawings, must have combined to create a robust discourse of exactness, instilling in its audience a sense of immediacy that was further enhanced by Barker's own narrative, with its emphasis on the eye-witness experience.¹² And indeed, the drawings adhered closely to Barker's description,

¹¹ Archibald Campbell served with the 29th Regiment of Foot and the 42nd Highlanders (the Black Watch) before the East India Company appointed him Chief Engineer of Bengal. He successfully re-designed the defenses of Fort William in 1769 CE; however, he resigned his office in December of 1772 due to failing health. He returned as Great Britain in October 1773 CE, presumably permanently, but he found himself again in India in 1787 CE to commander of the 74th Highlanders. He remained in India until 1789 CE. J. L. Campbell, "Campbell, Sir Archibald (1739–1791)," in *Oxford Dictionary of National Biography*, ed. H. C. G. Matthew and Brian Harrison (Oxford: Oxford University Press, 2004).

¹² A few of the instruments could not be included in Campbell's depiction—or, at least, to include them would distort the single-point perspective employed by the engineer—and even Barker found this troublesome. Campbell was forced to leave "some very large quadrants" out of his drawings, and Barker was grateful that he could at least diminish this loss through the provision of exact measurements of the equinoctial sundial that he felt representative

including even the three small brass rings attached to the edge of the gnomon and used by the author to verify the accuracy of the line created by cut stone.¹³ The combination of Campbell's reputation, the use of one-point perspective, and the first person singular employed by Barker, gave the reader little room or reason to doubt the accuracy of his assessment of the instruments.¹⁴ Barker himself was uncertain as to the purpose of some of the instruments, yet still he described them at length, perhaps hoping the construction and aesthetic details would suffice as a substitute for an actual understanding of the observatory's functionality. For instance, he concluded a paragraph description of the "brass circle" that he labeled 'C' (today known as the Cakra Yantra [Wheel Instrument]) with the speculation that "this instrument appear[ed] to be made for taking the angle of a star at setting or rising, or for taking the azimuth or amplitude of the Sun at rising or setting."¹⁵ In reference to the instrument he labeled 'D' (what we now refer to as the Digamśa Yantra [Azimuth Instrument]), he openly admitted he was "at a loss to account for [it]."¹⁶ In place of a deep knowledge, however, he provided a lengthy characterization of the concentric masonry walls and their graduated markings, suggesting that they would "bear a nice examination with a pair of compasses," even if he could not decipher what that would ultimately reveal about them.¹⁷

The work of John Lloyd Williams, a member of the Medical Service of the East India Company, was an amplification of Barker's claims rather than a new assay of the history of the

of the functions of most of Varanasi instruments. The instruments omitted from the drawing were probably the Dakṣiṇottara Bhitti Yantra I and II (Transit Instruments), which stood on an adjacent terrace.

¹³ Barker, "An Account of the Bramin's Observatory at Benares," 600.

¹⁴ As Thomas points out, the use of one-point perspective not only "organised represented objects in relation to each other" but also established a "fixed relationship between object and subject, locating the viewer outside the picture, and outside the relationships being depicted. The viewer is therefore rendered transcendental, outside of history." N. Thomas, *Colonialism's Culture* (Cambridge: Polity, 1994), 21-2.

¹⁵ Barker, "An Account of the Bramin's Observatory at Benares," 603. Like the Cakra Yantra at the Jaipur observatory, this instrument was designed to measure the hour angle and declination of celestial objects.

¹⁶ Ibid.

¹⁷ Ibid.

observatories.¹⁸ Williams re-measured the instruments surveyed by Barker, relying on Campbell's illustrations for clarification. He also performed a bit of fact-checking by calling on the chief magistrate of Benares, Ali Ibrahim Khan, through whom he learned that the building upon which the instruments stood was the Mān Mandir, constructed under the patronage of Raja Mān Singh, for use by pilgrims seeking access to the Ganges to perform religious ablutions.¹⁹ He also identified the correct patron, "Rajah Jeysing," and claimed the instruments were constructed only six years before Sawai Jai Singh's death in 1743 CE.²⁰ His informants averred that the observatory had never been used, "nor did they think it was capable of being used, for any nice observations; and believe that it was built more for ostentation, than the promotion of useful knowledge."²¹ He did not provide further commentary on the purposes of the instruments, but he carefully confirmed or corrected the measurements sent back to London by Barker by supplementing or replacing the original numbers with measurements taken by himself with a two-foot ruler and a rod of ten feet "very exactly divided."²² Thus, where Barker described the

¹⁸ Williams, John Lloyd, 1801, EC/1801/09, GB 117, Certificates of Election and Candidature, Royal Society, London.

¹⁹ Warren Hastings appointed Ali Ibrahim Khan Chief Magistrate and Chief Judge of Benares. Shayesta Khan, *A Biography of Ali Ibrahim Khan (circa 1740-1793): a Mughal Noble in the Administrative Service of the British East India Company* (Patna: Khuda Bakhsh Oriental Public Library, 1992), 88. For an example of Khan's interpretation of Hindu law, see Ali Ibrahim Khan, "On the Trial By Ordeal, Among the Hindus," *Asiatick Researches* 1 (1798): 389-401.

²⁰ John Lloyd Williams, "Further Particulars Respecting the Observatory at Benares, of Which Account, with Plates, is Given by Sir Robert Barker, in the LXVIIIth Vol. of the Philosophical Transactions. In a Letter to William Marsden, Esq. F.R.S. from John Lloyd Williams, Esq. of Benares," *Philosophical Transactions of the Royal Society of London* 83 (1793): 49. In fact, since there are no extant construction records for the observatory, it might be possible that the observatory was built late in the life of Sawai Jai Singh. Shastri dates the observatory to 1737 CE; however, it was mentioned in the preface to the *Zīj-i Muḥammad Shāhī*, which Kennedy dates to c. 1730 CE and Pingree dates to after 1734 CE (and possibly as late as 1736 CE), as well as in Jagannātha's *Samrāt Siddhānta*, which Pingree dates to c. 1732 CE. Using these dates as estimates, the observatory could have been constructed any time after 1730 CE. E.S. Kennedy, "A Survey of Islamic Astronomical Tables," *Transactions of the American Philosophical Society* New Series, 46, no. 2 (May 1956): 137; David Pingree, "An Astronomer's Progress," *Proceedings of the American Philosophical Society* 143, no. 1 (1999): 85, n. 51; ———, "Indian and Islamic Astronomy at Jayasimha's Court," in *From Deferent to Equant*, ed. David A. King and George Saliba (New York: New York Academy of Sciences, 1987), 315; Bapudeva Shastri, *Mānamandira Observatory of Kāśī*, trans. Shakti Dhara Sharma, 1982 ed. (Dt. Ropar: Martand Bhawan, 1866), xiv.

²¹ Williams, "Further Particulars Respecting the Observatory at Benares," 45.

²² Ibid.

Digamśa Yantra as consisting of “two circular walls, the outer of which is about forty feet in diameter, and eight feet high,” Williams offered that “the floor [of the Digamśa Yantra] being broken, and uneven, renders the height of the outer wall irregular, but it measured from 8 feet 1 inch, to 8 feet 3 inches; diameter inside, 27 feet 6½ inches; thickness of the wall, 2 feet.”²³

Barker described the largest instrument, the Large Samrāt Yantra, as “upwards of twenty feet in height”; Williams measured the same instrument to be “5 feet 4¼ inches” at the south end, and “22 feet 3 inches” at the north.²⁴ Williams’ contribution to the intellectual conversation surrounding the observatory served to concretize the monument through precise metrics, particularly when read in conjunction with Archibald Campbell’s illusionistic drawing.

Together, Barker and Williams set up the format for inquiry into “Hindu” astronomy through a narrative that emphasized their own accuracy and precision. However, the single-most influential article about the observatories was published by William Hunter (b. 1755-d. 1812 CE) in *Asiatick Researches* in 1799 CE.²⁵ Hunter was inspired in his study of the observatories by “the pen of the illustrious Sir William Jones,” the man whom he credited with bringing the work of Sawai Jai Singh II to the attention of Europe.²⁶ In 1799 CE, Hunter contributed two essays to *Asiatick Researches*. The first documented his 1791 CE overland journey from Agra to Ujjain in

²³ Barker, “An Account of the Bramin’s Observatory at Benares,” 603; Williams, “Further Particulars Respecting the Observatory at Benares,” 48.

²⁴ Barker, “An Account of the Bramin’s Observatory at Benares,” 599; Williams, “Further Particulars Respecting the Observatory at Benares,” 46.

²⁵ William Hunter arrived in India in 1781 CE off an East Indiaman. He transferred to the East India Company, where he served as a surgeon in various locations, including the British residency at Agra. He also served as secretary to the Asiatic Society of Bengal from May 1798 to March 1802 CE, and April 1804 to April 1811 CE. E. J. Rapson and Michael Fry, “Hunter, William (1755–1812),” in *Oxford Dictionary of National Biography*, ed. H. C. G. Matthew and Brian Harrison (Oxford: Oxford University Press, 2004).

²⁶ William Hunter, “Some Account of the Astronomical Labours of Jayasinha, Rajah of Ambhere, or Jayanagar,” *Asiatick Researches* 5 (1799): 177. I have been unable to locate any public statement made by Jones about Sawai Jai Singh’s observatories. Jones does mention the Maharaja in private correspondence exchanged with Samuel Davis in 1793 and 1794 CE, but it was unlikely that Hunter was referring to these letters. See William Jones, “Letter to Samuel Davis,” in *The Letters of William Jones*, ed. Garland Cannon (Oxford: Oxford University Press, 1970), 920, 930, 932.

the form of tables recording observations of latitude made along the way.²⁷ The second article aimed to fully describe four of the five extant observatories based on notes he had taken during his 1796 CE visits to the sites.²⁸ Although he credited Jones with sparking his interest in the observatories, Hunter was quite familiar with Barker's work at Varanasi, and indeed, he not only elaborated on that earlier description but relied on the plates published with Barker's letter to supplement his own account. It is Hunter's characterizations that thread through the travel literature of the nineteenth century (via Hooker, Prinsep, Parks, etc.), and it is Hunter's opinions of Sawai Jai Singh's work that resonate even during the twentieth century. Even today, the only published English translation of the preface to the *Zīj-i Muḥammad Shāhī* is the one completed by Hunter for inclusion in his 1799 CE article.²⁹ Hunter's essay should be read as a response to Barker's, in that he returned to that earlier scholarship as his lodestone during his examinations of the observatories at Mathura, Ujjain, Delhi and Varanasi. He compared everything he described to the observatory at Varanasi, and when necessary for clarification, he referred not to drawings sketched during his own journey from Agra to Ujjain, but to the three illustrations produced by Archibald Campbell for publication in the *Philosophical Transactions*. Thus, the large Samrāt Yantra at Delhi, a massive instrument looming some eighty feet above grade, was "of the form represented at the letter A in Sir Robert Barker's description of the Benares observatory," despite the fact that the Samrāt Yantra in Varanasi was composed of different materials (most notably, it was the only equinoctial sundial built with sandstone scales), was considerably smaller (the gnomon height at Varanasi is 6.80 meters), and was aligned according

²⁷ William Hunter, "Astronomical Observations Made in the Upper Parts of Hindostan, and on a Journey Thence to Oujein," *Asiatick Researches* 4 (1798): 141-64.

²⁸ Significantly, Hunter did not visit the observatory at Jaipur. Hunter published a third article in 1801, a detailed journal of his journey from Agra to Ujjain. See ———, "Narrative of a Journey from Agra to Oujein," *Asiatick Researches* 6 (1801): 7-76.

²⁹ The *editio princeps* of the *Zīj-i Muḥammad Shāhī* is being prepared by S. M. R. Ansari, retired Professor of Aligarh Muslim University.

to a different latitude (the latitude at Varanasi is 25° 18N; at Ujjain, 23° 10 N; at Mathura, 27° 30N; at Shahjahanabad, 28° 37N).³⁰ This act began an extended process of substitution and omission by the author. Hunter considered the Samrāt Yantra at Shahjahanabad comparable to those in Varanasi, Ujjain, and Mathura, but when faced with the particularities of the Rāma Yantra and the Jaya Prakāśa Yantra in Shahjahanabad, he was unable to provide any external references, because their development was continued only at Jaipur, a city to which he had never traveled. When he turned to back to the Samrāt Yantra at Varanasi near the conclusion of his article, he entered a tight, self-referential loop, circling back to define the instrument on the roof of the Mān Mandir as identical to those in Ujjain and Mathura. This practice is notable because it almost completely elided the existence of the observatory at Jaipur, even though it was well known by the publication date of Hunter's notes that Sawai Jai Singh was the patron of five, not four, observatories. Hunter mentioned Jaipur only as the residence of the son of Don Pedro de Silva, a Portuguese astronomer who traveled to Jaipur at the Maharaja Dhiraja's request, and as the site of death for the grandson of Sawai Jai Singh's *jyotiṣa rai* (royal astronomer), Kevelrāma, the individual who represented Hunter's last great hope for forcing upon "the Eastern nations...a taste for European science."³¹ With the death of the grandson, "the genius of Jayasinha became extinct," and the city of Jaipur was no longer of any concern to Hunter's version of the observatories' past.³²

It is important to recognize the implications of accepting unquestioned the centrality of the Varanasi observatory in the early story of the observatories. With Varanasi as the hinge on which all else rotated, the rest of the network was imagined as if it spread out from seat of

³⁰ Hunter, "Some Account of the Astronomical Labours of Jayasinha, Rajah of Ambhere, or Jayanagar," 190; Virendra Nath Sharma, *Sawai Jai Singh and his Astronomy* (Delhi: Motilal Banarsidass Publishers, 1995), 202.

³¹ Hunter, "Some Account of the Astronomical Labours of Jayasinha, Rajah of Ambhere, or Jayanagar," 210.

³² Ibid.

colonial power in the east, toward the west, skipping those regions into which the East India Company and the British Central Government had not yet penetrated (ie., the kingdom of Amer and Jaipur). This practice had two immediate consequences: first, because Barker couched his description of the observatory in the language of unchanging antiquity, drawing on the reputation of Benares as the “ancient city of Kāśī,” the observatories were dead on their arrival into the *Philosophical Transactions* and *Asiatick Researches*.³³ Once deciphered, “Hindu science” was unlikely to change in character or application, so there was little need to explore further these supposedly unproductive and static spaces. Second, the twin motives of transparency and precision, introduced by Barker, embellished by Williams, and relied upon by Hunter, ensured that their early characterizations of the observatories would not be questioned, as they were clearly accurate, scientific and rational. These two effects teamed up to contribute to the total erasure of agency by Sawai Jai Singh as patron or astronomer. As a result, entire branches of the observatories’ histories have been amputated and discarded. Labor, in both manual and intellectual terms, has been obliterated, and any signs of the production, or even the comprehension, of astronomical knowledge has been wiped away. Most importantly, the dynamism and power embedded in the landscape of the newly established fiat city of Jaipur has been stilled by the lethargy and decay assumed to characterize the ancient city of Kāśī. The potential for creativity and productivity has been rejected simply by the failure to recognize the existence of the observatory of Jaipur and its patron.

³³ For discussions of Varanasi as the timeless Hindu city of Kāśī, see Hans Bakker, “Construction and Reconstruction of Sacred Space in Varanasi,” *Numen* 43, no. 1 (1996): 32-55; Diana Eck, *Banaras: City of Light* (New York: Knopf, 1982), passim; Rana P. B. Singh, “Vārāṇasī: The Pilgrimage Mandala, Geomantic Map and Cosmic Numbers,” in *Banāras (Vārāṇasī): Cosmic Order, Sacred City, Hindu Traditions*, ed. Rana P. B. Singh (Varanasi: Tara Book Agency, 1993), 37-64; ———, “Time and Hindu Rituals in Vārāṇasī: A Study of Sacrality and Cycles,” in *Banāras (Vārāṇasī): Cosmic Order, Sacred City, Hindu Traditions*, ed. Rana P. B. Singh (Varanasi: Tara Book Agency, 1993), 215-24.

Quite obviously, Williams, Barker, and Hunter, could not write a comprehensive history of the observatories for inclusion in the pages of the *Philosophical Transactions* or *Asiatick Researches*, and they are not personally accountable for the rhetoric and style of what would come to be considered “colonial” history writing. However, we should consider seriously the implications of reading a history of the observatories that approached the work completed at these sites from the east, rather than from the west. What is at stake if we ground our discussion within the walls of Amer and Jaipur, a city founded by fiat? What is automatically elided with a point of origin located above a ghat in Varanasi, a city that the East India Company had separated only recently from the kingdom of Awadh? I argue that our point of departure makes a great difference. If we choose to posit one (or even better, two) observatories as exemplars of astronomical science in India in the first half of the eighteenth century, we should not start with the outlier. If this dissertation is a recuperative effort, if it is an attempt to locate the dynamo that fueled the system, it needs to draw back from a colonial historiography that posits an ancient center of Hindu science at its core, and instead examine the interconnectivity of the observatories. In particular, it needs to interrogate the relationship of the Jaipur observatory to the one at Shahjahanabad, and beyond that, to evaluate the possibility or the necessity of recovering the outlying observatories into a network of production and exchange. A careful comparison of the construction methods deployed at Shahjahanabad and Jaipur suggests the instrumentation followed a three-stage process of experimentation and refinement. Sawai Jai Singh [1] used the suburban plains outside the walls of the capital city of Shahjahanabad (and possibly the future site of Jaipur) as an open-air laboratory to create a critical mass of construction knowledge [2] that he deployed first at Jaipur, and [3] again in the cities of Mathura, Ujjain, and Varanasi.

2.2 Extramural Shahjahanabad

Although ultimately the Jaipur observatory functioned as the brain in the observatories' central nervous system, in point of fact, evidence suggests that the observatory built outside the walls of Shahjahanabad was the first of the five to be constructed under the patronage of the Maharaja Dhiraja of Amer, Sawai Jai Singh.³⁴ According to the prefatory pages of the *Zīj-i Muḥammad Shāhī*, Sawai Jai Singh petitioned the newly seated emperor, Muhammad Shah (r. 1719-1748 CE), for the opportunity to correct the errors perceived in the ephemerides produced by the astronomers of Samarkand working under the Timurid prince, Ulugh Beg: the *Khāqānī Zīj*, the *Zīj Gurgānī*, and a revised version of the *Zīj-i Jadīd*.³⁵ These *azyāj* consisted of numerical tables accompanied by the necessary exegesis to allow an astronomer/astrologer to calculate the time, locate the relative positions of celestial objects, predict lunar and solar eclipses, and complete other important calendrical tasks.³⁶ The promulgation of a new calendar, much like the issue of new coins and the assumption of the royal insignia, was understood as “an imperial right and a mark of sovereignty,” and as the author of the preface of the *Zīj-i Muḥammad Shāhī* explained,

since very important affairs both regarding religion and matters of state rely upon [the places of the stars], and on the time of the rising and setting of planets, as well as the seasons of the eclipses of the sun and the moon, and many considerable disagreements, of

³⁴ See footnote 1, Chapter One.

³⁵ The *Zīj-i Khāqānī* was written c. 1420 CE by Jamshīd al Kāshī, and dedicated to Ulugh Beg Khaqani (“Ulugh Beg the Supreme Ruler”). The *Zīj-i Gurgānī*, also referred to as the *Zīj-i Ulugh Begī*, the *Zīj-i Jadīd-i Sulṭānī*, the *az-Zīj al-Kurkānī*, and the *Zīj-i Mīrzā Ulugh Bīk*, was a collaborative effort of multiple astronomers working under Ulugh Beg in Samarkand. As noted in Chapter One, it was the most widely circulated *zīj* even as late as the eighteenth century. The *Zīj-i Jadīd* referred to in the preface of the *Zīj-i Muḥammad Shāhī* was the *Tashīl-i-Zīj Ulugh Begī* of Mullā Chānd ibn Bahā’ al Dīn, and had been commissioned by Akbar c. 1556 CE. Kennedy, 166-67; Pingree, “An Astronomer's Progress,” 76-77; ———, “Indian and Islamic Astronomy at Jayasimha's Court,” 313; *Zīj-i Muḥammad Shāhī*, Add. 14373, fol. 3, Asia, Pacific and Africa Collections, British Library, London.

³⁶ Kennedy, 123.

a similar nature, were found [in the existing tables], he [Sawai Jai Singh] represented [his astronomical plan] to his majesty of dignity and power...Muhammad Shah.³⁷

Muhammad Shah, allegedly pleased with the request from an allied ruler who had already “gathered geometricians and astronomers of the faith of Islam, and Brahmins, and Pandits, and European astronomers, and...prepared all the instruments of an observatory,” awarded to Sawai Jai Singh the task of rectifying any mistakes found in the ephemerides on which the calendars of the Mughal court were based at that time.³⁸ According to the narrative provided in the *Zīj-i Muḥammad Shāhī*, the king of Amer approached the emperor only after preliminary observations had been completed, presumably with a collection of modest brass instruments. This implies that Sawai Jai Singh’s astronomers began testing instruments and making trial observations at Shahjahanabad at some date before November 1720 CE, the month of Sawai Jai Singh’s first audience with Muhammad Shah.³⁹ More precisely, this means that we can locate the originary moment of Sawai Jai Singh’s scientific explorations not inside the walls of Jaipur, the capital city he founded in 1728 CE, but outside the walls of Shahjahanabad, itself a fiat city constructed wholesale by order of the emperor Shah Jahan between 1639 and 1648 CE.

Although nineteenth- and early twentieth-century photographers repeatedly framed their depictions of the observatory to lend an air of emptiness and antiquity to the site outside Shahjahanabad, excluding all signs of nearby buildings and village populations, in fact the instruments were not built in a remote location but in the capital’s well-peopled suburbs (figure 2.4). By 1739 CE, or four years before the death of Sawai Jai Singh, the suburban areas of

³⁷ Derek J. de Solla Price, “Astronomy’s Past Preserved at Jaipur,” *Natural History* 73, no. 6 (June-July 1964): 51; Andrea Hintze, *The Mughal Empire and Its Decline: an Interpretation of the Sources of Social Power* (Aldershot: Ashgate, 1997), 51; *Zīj-i Muḥammad Shāhī*, fol. 3.

³⁸ *Zīj-i Muḥammad Shāhī*, fol. 3v. At the time of Muhammad Shah’s governance, at least three formal calendars were in common use in northern India: the Hindu Vikram Samvat (VS), the application of which varied from city to city; the Islamic Hijri (AH) calendar; and the Muhammad Shahi era, which began on Monday of the fourth month of the Hijri calendar in the year 1131 AH (February 20, 1719 CE). See footnote 2, Chapter One.

³⁹ V. S. Bhatnagar, *Life and Times of Sawai Jai Singh, 1688-1743* (Delhi: Impex India, 1974), 159.

Shahjahanabad covered about 1800 acres (compared to 1500 acres within the walls of the city) and contained about 25% of the local population.⁴⁰ Because representatives of the hereditary states could expect to spend a decent amount of time in the capital city conducting imperial business, the emperor typically designated specific areas of the town for use by these individuals and their entourages. Occasionally, the assigned residential districts consisted of havelis located within the city walls, but just as frequently, they encompassed the territory of a specified *purā* outside the walls. The *purā* functioned as *zamīndārī* land, in that the ruler of the princely state to whom the land had been awarded held *zamīndārī* rights, or the privilege to make fiscal claims on the resident population.⁴¹ In some cases, it also operated as *watan jāgīr*, or part of the hereditary land system, and instead of reverting to the emperor as *khālīsā* upon the death of a ruler, it was inherited by the next Raja in line for the territorial throne. The *purā* conventionally associated with the Kacchawāhā clan, the Jaisinghpura (“Jai Singh Village”), stood on a slightly raised plain to the southwest of the city, just south of one of the most important suburbs of the city, Paharganj, the location of the city’s grain market, and immediately north of Rikabganj, the suburb in which most of the imperial grain dealers dwelled (map 2.1).⁴² Mirza Raja Jai Singh I, the great-great

⁴⁰ Stephen Blake, *Shahjahanabad: The Sovereign City in Mughal India, 1639-1739* (Cambridge: Cambridge University Press, 1991), 58.

⁴¹ Many rulers of hereditary states recognized the imperial sovereignty of the Mughal court. Some were brought into the Mughal administrative system by force, while others willingly cooperated with the currently-seated emperor in hopes of improving their financial, political, or military position. These individuals were typically referred to as *zamīndārs*, or “hereditary possessors of a right to a share of the peasants produce.” *Zamīndārī* rights were usually temporary, and on the death or disgrace of a hereditary ruler, the land would revert to *khālīsā* (lands whose revenues were directed to the imperial treasury), or would be transferred to a different chieftain. See Irfan Habib, *Essays in Indian History: Towards a Marxist Perspective* (New Delhi: Tulika, 1995), 94-95, 101-08, 186; Hintze, 72-73.

⁴² Although the name of “Jai Singh” remains attached to several of these *purās* around India, even today, often they were renamed or even expanded when a new Raja ascended to the *gaddi*. For instance, the Jaisinghpura of Delhi was extended to the east by Madho Singh I (r. 1750-1767 CE), under the name Madhoganj (Madho Village). Most of the area originally encompassed by Jaisinghpura and Madho Ganj was subsumed by the development of Connaught Place between 1929 and 1933 CE. Joseph Tieffenthaler, Anquetil du Perron, and James Rennell, *Description Historique et Géographique de l'Inde*, trans. Jean Bernoulli, 1 ed., 3 vols., vol. 1 (Berlin: Chrétien Sigismond Spencer, 1786), 125-27; Blake, 58-59, 117; H. C. Fanshawe, *Delhi Past and Present* (London: John Murray, 1902), 247-48; “Heritage Status for Connaught Place Likely,” *The Hindu*, March 14, 2005, <http://www.hinduonnet.com/2005/03/14/stories/2005031410020400.htm>, (accessed March 2, 2010); Sandeep Joshi, “CP Redevelopment Plan Yet to Begin,” *The Hindu*, July 25, 2005

grandfather of Sawai Jai Singh and a significant member of Shah Jahan's political family, probably established the Jaisinghpura during the reign of that emperor, and by custom, the court of Amer pitched its tents here when it came to Shahjahanabad on official business.⁴³ A century later, whenever Sawai Jai Singh arrived at the gates of the city, his court was free to encamp in the Jaisinghpura and exploit the local resources for the benefit of his camp.⁴⁴ It was here, in the Jaisinghpura alongside the road connecting the Ajmeri Gate and the Qutb Minar in Mehrauli, that laborers and *najūmī* (Islamic astronomers) worked together to build the first observatory associated with the patronage of Sawai Jai Singh.

The observatory outside Shahjahanabad would eventually become one in a series of similar sites and would later be displaced from its status as innovator by the Jaipur observatory.

⁴³ The Mughal emperors believed mobility and political strength were inseparable, and as such, spent much their reigns on the move, traveling across the entirety of the South Asian subcontinent. According to Jos Gommans and Stephen Blake, Emperors Akbar, Jahangir, Shah Jahan, and Aurangzeb spent approximately 35-40% of their reigns in camp. In order to participate fully in the imperial political system, rulers of hereditary states were required to mimic this behavior. See Blake, 97; Jos J. L. Gommans, *Mughal Warfare: Indian Frontiers and Highroads to Empire, 1500-1700*, Warfare and History (London: Routledge, 2002), 101.

⁴⁴ In fact, the permanent tenants of the *purā* owed their rents to the State of Amer and Jaipur, regardless of the Maharaja Dhiraja's presence. Jaisinghpuras were located not just in Delhi, but in Allahabad, Oudh, Agra, Ujjain, Aoshnugabad (Hosangabad), Hyderabad, and other cities as well. A century after Sawai Jai Singh's death, the Central Government still recognized the Jaipur Maharaja's right to govern the Jaisinghpuras in Allahabad, Oudh, Ujjain, Hosangabad, and Hyderabad. In 1832 CE, the Jaipur Darbar petitioned the British Governor General through its *vakīl* (agent or attorney) for assistance in obtaining back rents from Mewatis (Meos) inhabiting the Jaisinghpura of Delhi, as "they paid no regard to the Maharaja," despite the demands of custom. In that same year, Maharaja Sawai Jai Singh III demanded that the Central Government recognize his claim to the Jaisinghpuras of Mathura and Agra, in addition to those in the above-named cities. The legal discussion regarding these properties extended into 1833 CE, as the Magistrate at Agra saw no evidence that the Government should release its own claim on the Mathura Jaisinghpura as *khālisā* lands. As far as the Agra Jaisinghpura was concerned, the Government considered it a private property dispute, as the haveli was claimed not by the State, but by an individual, and Sawai Jai Singh III was advised to pursue his claim in Civil Court (no evidence exists to suggest that he followed this advice). In 1838 CE, Jaipur again appealed to the British Government to clarify the Maharaja's ancestral claim to the Man Mahal, the site of the observatory in Benares (Varanasi), alleging that "the buildings were erected and established by [his] predecessors and have been in [his family's] possession for hundreds of years, both in the time of the Kings and since the Company's rule." In the case of the Benares property, it would appear that the British Government had previously sorted out Jaipur's claim to the buildings rising above the Mān Mandir Ghat in 1802 CE as part of a tax collection inquiry. See Government of India, June 18, 1832, *Jeypore Vakeel's Complaint Against Mewatees Occupying Jeysingpoorah*, Foreign Department, Political Consultation, Nos. 73-4, 497-99; Government of India, July 9, 1832, *Jeypore Durbar Claims Jeysingpoora*, Foreign Department, Political Consultation, Nos. 3-14, 1-18; Government of India, February 12, 1833, *Jaipur Claims Jeysingpoorah*, Foreign Department, Political Consultation, Nos. 43-46, 1-12; Government of India, October 10, 1833, *Jeypore Durbar claims Jeysingpoorah*, Foreign Department, Political Consultation, Nos. 52-57, 319-26; Government of India, July 11, 1838, *Jeypore Durbar Claims Jeysingpoorah*, Foreign Department, Political Consultation, No. 102 A, 1; ———, September 5, 1838, *Jeypore Durbar Claims Jeysingpoorah*, Foreign Department, Political Consultation, No. 16, 1-2.

At the time of its initial construction, however, the masonry instruments at Shahjahanabad were largely without precedent on the South Asian subcontinent. This does not mean that the Maharaja Dhiraja of Amer fabricated his observational program and masonry instruments out of imagination and daydreams, however. Although we should be careful not to fall into the colonial trap of trying to distinguish “Hindu” from “Islamic” elements of Sawai Jai Singh’s observational program, the instruments at Shahjahanabad conformed to the skill set typically considered Islamic today.⁴⁵ We can follow Sawai Jai Singh’s use and adaption of these familiar instruments through descriptions included in three manuscripts produced in the *karkhāna* of Jaipur: the *Samrāt Siddhānta*, Jagannātha Samrāt’s translation of Naṣīr al Dīn’s recension of Ptolemy’s *Almagest*; the *Yantraprakāra*, a supplement to the *Samrāt Siddhānta* that included instructions for instrument making; and the *Zīj-i Muḥammad Shāhī*, the preface of which outlined the motivations for and development of the five observatories constructed in Shahjahanabad, Jaipur, Mathura, Ujjain, and Varanasi.⁴⁶ From these manuscripts, we know that there already existed at Amer the Ptolemaic instrument *Dhāt al-Shu‘batayn* (triquetrum, or parallactic ruler) for measuring the altitude and azimuth of a celestial object (so, based on a horizontal system), and the instrument *Dhāt al-Ḥalaqa* (armillary sphere) that modeled a geocentric celestial sphere illustrating the predicted movement of the stars and planets.⁴⁷ According to the *Zīj-i Muḥammad*

⁴⁵ David Pingree defines “Islamic astronomy” as any Muslim interpretation of Ptolemaic principles. This definition covers recensions written in a variety of languages and a variety of locations throughout West and South Asia. See David Pingree, “Indian Reception of Muslim Versions of Ptolemaic Astronomy,” in *Tradition, Transmission Transformation*, ed. F. Jamil Ragep and Sally P. Ragep (Leiden: E. J. Brill, 1996), 471; Pingree, “Indian and Islamic Astronomy at Jayasimha’s Court,” 320, 22.

⁴⁶ Kennedy dates the *Zīj-i Muḥammad Shāhī* to c. 1730 CE, while Pingree dates it to after 1734 CE (and possibly as late as 1736 CE). Pingree dates Jagannātha’s *Samrāt Siddhānta* as a whole to c. 1732 CE but suggests the supplementary *Yantraprakāra* was penned c. 1730 CE. Kennedy: 137; Pingree, “Indian and Islamic Astronomy at Jayasimha’s Court,” 315.

⁴⁷ A description of the Ptolemaic armillary sphere and triquetrum can be read in David H. Kelley and Eugene F. Milone, *Exploring Ancient Skies: An Encyclopedic Survey of Archaeoastronomy* (New York: Springer, 2005), 77-79.

Shāhī, Sawai Jai Singh and his astronomers had at their disposal these and multiple types of other well-known instruments of measure

like those that had been erected in Samarkand, according to the Islamic book, such as the brass *Dhāt al-Halaq* [armillary sphere], with a diameter of three *gaz*...and the *Dhāt al-Shu'batayn* [triquetrum] and *Dhāt al-Thuqbatayn* [dioptra], and *Suds-i Fakhri* [60-degree meridian dial/sextant], and *Shāmlāh*.⁴⁸

Since all of these instruments were common in West and South Asia during the early eighteenth century, we can assume Sawai Jai Singh and his astronomers were knowledgeable in their use and function, even though we have few observational records incontrovertibly dated to this period of his reign. However, even though he knew well the technology employed for naked-eye astronomy, and that others were using the same instruments for the same purposes, the Maharaja Dhiraja found that when he employed them to make astronomical observations,

the brass instruments did not measure up to the ideas that he had formed about accuracy, because of the smallness of their size, the want of division into minutes, the shaking and the wearing of their axes, the displacement of the centers of the circles, and the shifting of the planes of the instruments.⁴⁹

Noting these flaws, Sawai Jai Singh concluded that the errors he found in the works of Hipparchus and Ptolemy, as well as in his own star tables, were probably produced by a similar reliance on metal instruments, and so “constructed in the Abode of the Caliphate Shahjahanabad, the seat of empire and prosperity, instruments of his own invention” intending to correct the perceived inaccuracies.⁵⁰ It would appear from a close inspection of the *Zīj-i Muḥammad Shāhī*,

⁴⁸ *Zīj-i Muḥammad Shāhī*, fol. 4r. For a detailed analysis of the dioptra see Michael Jonathon Taunton Lewis, *Surveying Instruments of Greece and Rome* (Cambridge: Cambridge University Press, 2001), 51-108. The *Suds-i Fakhri*, or Fakhri's Sextant, was invented by Abū Mahmūd Hāmid al-Khujandi c. 1000 CE. See C. E. Bosworth and M. S. Asimov, *History of Civilizations of Central Asia*, vol. 4 (Delhi: Motilal Banarsidass, 2002), 202. The *Shāmlāh* was a revolving parallactic ruler, or a hemisphere with a revolving disk. See Sharma, 24, 36.

⁴⁹ *Zīj-i Muḥammad Shāhī*, fol. 4r.

⁵⁰ *Ibid.*, fol. 3v-4r.

the *Samrāt Siddhānta*, and the *Yantraprakāra*, along with the instruments themselves, that the goal was not to create instruments with new functions, but rather, to build sturdier and larger models that mimicked the modes of observation already in common use in north India. The turn to masonry as a building material solved the two major problems Sawai Jai Singh associated with brass: the persistent material instability of metal instruments; and the restrictions imposed by the instruments on the subdivision of scales by their small size. The *Zīj-i Muḥammad Shāhī* leaves no doubt that the instruments “of his own invention,” which he named as the *Jaya Prakāśa*, the *Rāma Yantra*, and the *Samrāt Yantra*, were constructed of stone because it was a substance the Maharaja Dhiraja equated with firmness, but also because it allowed him to design his instruments at a larger scale.

The assertion that Sawai Jai Singh was pursuing stability and size as correctives is borne out when we read Jagannātha Samrāt’s design instructions against one of the instruments completed outside Shahjahanabad, such as the *Samrāt Yantra*. As would be true later at Jaipur, the massive *Samrāt Yantra*, an equinoctial sundial consisting of an eighty-foot gnomon flanked by two curvilinear quadrants, dominated the observatory space in the Jaisinghpura (figure 2.5).⁵¹ In terms of functionality, the *Samrāt Yantra* was meant to supplant the easily available astrolabe that allegedly produced faulty measurements. As Jagannātha described in the *Samrāt Siddhānta*,

one knows time and the correction for the difference between ecliptic and polar longitudes from the *yantrarāja* [astrolabe]. The *yantrarāja* ought not to be made large because, even if a large staff is constructed to support the circle, that [staff] bends; the circle becomes imperfect and [the position of] a fixed star ceases to be correct. So again, an instrument like a half-moon, called the *yantrasamrāt*, was constructed, whose radius is

⁵¹ The *Ṣaṣṭhamśa Yantra*, a sixty-degree arc aligned with the meridian and enclosed within a light-proof masonry chamber, stands immediately adjacent to the terminus of the eastern quadrant of the *Samrāt Yantra*, undetectable by most visitors. Since the terminus chamber is an integral part of the quadrant construction, it was probably constructed simultaneous to the larger instrument. The termini of the quadrants of the Jaipur *Samrāt Yantra* contain four separate *Ṣaṣṭhamśa Yantras*, with the underside of the quadrant arcs serving as the ceilings. This, too, suggests that the chambers were added during the original construction phase of the instrument.

eighteen blacksmith's cubits...By means of it one knows the declination and the [time in] *ghaṭikas* from noon; by means of the declination and the *ghaṭikas* from noon one knows [the position of] a fixed star.⁵²

The Samrāt Yantra, which did not distort under its own weight, was viewed as at least a partial solution to the problems introduced into Sawai Jai Singh's observation program by the construction flaws in available astrolabes. Moreover, because of the large size of this instrument, the quadrants could be inscribed with "fifteen *ghaṭikas* each and as many small divisions of *palas* as possible."⁵³ The gnomon of the instrument was scaled to measure the angle of declination of any celestial object visible above the southern horizon, and it was inscribed with "sixty divisions in accordance with the tangent of the declination angles."⁵⁴

To the immediate south of—and on-axis with—the Samrāt Yantra at Shahjahanabad stood the two complementary bowls of the Jaya Prakāśa, elevated above grade on stone platforms that covered a warren of storage and habitable spaces (figures 2.6-2.7). As he did with the Samrāt Yantra, Sawai Jai Singh invented the Jaya Prakāśa in order to replace a common instrument that was believed to be a root cause of the faulty numbers that continued to appear in his astronomical tables. Although the problem that the Jaya Prakāśa was supposed to solve was referred to in the preface to the *Zīj-i Muḥammad Shāhī*, it was described even more precisely in the body of the *Samrāt Siddhānta*. According to that text,

⁵² Ramasvarupa Sharma, ed. *Samrāt-Siddhāntah Avāntara Paṭhabhedasamanvitah Siddhāntasārakaustubhah*, 3 vols., vol. 2 (New Delhi: Indian Institute of Astronomical and Sanskrit Research, 1967), 1163; Pingree, "Indian and Islamic Astronomy at Jayasimha's Court," 316.

⁵³ Sharma, ed. *Samrāt-Siddhāntah Avāntara Paṭhabhedasamanvitah Siddhāntasārakaustubhah*, 1039. In north India during the time of Sawai Jai Singh, time was measured according to *ghaṭikas* and *palas*. Our twenty-four day would have been divided into sixty *ghaṭikas*, which were then subdivided into sixty *palas*. The scales for measuring time extant today on the instruments at Shahjahanabad (or any of the observatories), whether marking *ghaṭikas*, *palas*, hours, minutes or seconds, are the result of later restoration projects and should not be considered original.

⁵⁴ Ibid. For angular measurements, a 360° circle was divided into four equal parts, which were then subdivided into fifteen equal parts. These fifteen subdivisions were further subdivided into six parts, each on one of which represented an *amśa*, or one degree. If the measuring scale was large enough, the *amśas* could be further divided into sixty *kalās*, or minutes.

previously observations were carried out by the Muslims (*Yavana*) with a metal instrument called *Dhāt al-Ḥalaq*, its other name being *Golayantra*. There is a flaw: owing to the excessive weight of the metal, the ecliptic ring shifts from its pole. Because of its shifting, there was an error of 30 minutes in the readings of observations. When this was noticed, the Maharaja Dhiraja Jayasimha devised the *Jayaprakāśa* with a new design. The method of its construction can be seen in the *Yantrādhyāya*. Whatever task is achieved with the armillary sphere, the same can be obtained with this also. This instrument is firm.⁵⁵

Unfortunately, the precise thought process that took Sawai Jai Singh and his astronomers from the *Dhāt al-Ḥalaq* to the concave bowls of the *Jaya Prakāśa* was not recorded by Jagannātha; he did, however, provide instructions on how to build the new instrument. We can cross-reference the *Jaya Prakāśa* in the *Yantraprakāra* (*Yantrarādhyāya*) to understand in more detail Sawai Jai Singh's approach to the conversion of brass to stone:

On a ground made level with water describe first a circle of any radius (*karkaṭa*). After determining the cardinal points (*diksādhana*) there, draw east-west and south-north lines. Dig out [the earth] within the circle to form a concave hemisphere (*kapāla*). Prepare in metal or wood a semi-circular ring (*valayārdha*), i.e., a half of the circle [first drawn], and rotate this ring all around in the excavated pit. If it moves smoothly, then the instrument is correctly made.⁵⁶

Alternatively, if Sawai Jai Singh wished to build an instrument that was not embedded in the ground, the craftsman could use a semi-circular ring to

prepare in metal or wood a circular instrument resembling a hemisphere...Fill the instrument with water up to the top of the gnomon (*śaṅku*) of any height. Cut the bowl at

⁵⁵ Ibid., 1162-63. For competing translations of this passage, see Pingree, "Indian and Islamic Astronomy at Jayasimha's Court," 315; Jagannātha Samrāt, "Yantraprakara of Sawai Jai Singh," in *Supplement to Studies in History of Medicine and Science*, ed. Sreeramula Rajeswara Sarma (New Delhi: Department of History of Medicine and Science, Jamia Hamdard, 1987), 49. Sarma also provides an extensive glossary of Sanskrit astronomical terms with their English-language equivalents. Sharma, ed. *Samrāt-Siddhāntah Avāntara Paṭhabhedasamanvitah Siddhāntasārakaustubhaḥ*, 135-37.

⁵⁶ Samrāt, 13-14, 46. There is some dispute as to the relationship of the *Yantraprakāra* to the *Yantrādhyāna*, but according to S. R. Sarma, the majority of the passages contained in the two are identical, while a few sections in the *Yantrādhyāna* appear to be revisions of the *Yantraprakāra*. This dissertation draws on Sarma's translation and commentary on both texts, which he has collated into a full version of the *Yantraprakāra*. See ———, 2.

the line where the water [level] touches it all around and set it up [firmly at the desired place]. This, then, is the instrument of the desired size.⁵⁷

The passage further describes the method for scribing the bowl such that both horizontal (azimuth-altitude) and equatorial (right ascension-declination) measurements could be taken with a single instrument. Once a set of cross-wires was stretched across the concavity, the shadow projected onto the bowl by the intersection of the wires indicated the current coordinates of the sun according to either system. The instrument was also marked in such a manner that it could be used to determine when a particular sign would approach the prime meridian during daylight hours by watching for the same thrown shadow to cross the arc associated with a given constellation.⁵⁸

As the *Samrāt Siddhānta* indicates, the purpose of the *Dhāt al-Halaq* was clear and well-understood, and the *Jaya Prakāśa* was not intended to do anything more. The translation of its functionality into stone was something altogether new, however. While perhaps Sawai Jai Singh knew of the existence of hemispheric sundials, and the notion of projecting the celestial equator onto a concave surface was not particularly innovative, the *Jaya Prakāśa Yantra* combined those familiar forms into a tool that he hoped would work more reliably than the ones he had on hand. So, what is intriguing about the instruments at Shahjahanabad is not necessarily their use in the collection or production of new types of knowledge, but rather the co-option of a known building technology by Sawai Jai Singh as a solution to long-standing problems in a completely different discipline, astronomy. The development of the stone instruments suggests that there was an

⁵⁷ *Samrāt*, 14, 46.

⁵⁸ Although the *Yantraprakāra* provides instructions for a single bowl, at Shahjahanabad, the instrument has been broken into two complementary hemispheres in order to allow an observer to position his eye at the edge of a circle in order to determine the coordinates of a celestial object at night. A lucid explanation of the function and construction of the *Jaya Prakāśa Yantra* can be read in Sharma, *Sawai Jai Singh and his Astronomy*, 67-72, 106-07, 156-61.

active process of problem-solving in play at Shahjahanabad based on both experiment and empiricism. The problem-solving exceeded any known approaches to instrument making, and we can see the results of that exploratory instinct in instruments such as the Samrāt Yantra and Jaya Prakāśa Yantra.

This story of adaptation and experimentation ran much the same in the case of the Rāma Yantra, the fourth of the five original instruments constructed as part of the Shahjahanabad observatory.⁵⁹ The arcuated chambers of the Rāma Yantra were raised to the southwest of the Jaya Prakāśa, slightly off-axis from the other instruments (figure 2.8). According to the *Samrāt Siddhānta*, this instrument, too, was a response to the instability of the brass instruments. There already existed

an instrument for the purpose of knowing the azimuth and the altitude, called a *Dhāt al-Shuʿbatayn* [triquetrum], is described by the Muslims (*Yavana*). Its observational plate is too large and it bends because of its size. Therefore, an observation does not come out correctly, and there is a difference in the degrees of coalitude. Recognizing this fault, we imagined the fixed *Rāmayantra* for the purpose of knowing the azimuth and altitude.⁶⁰

Again, despite the unique aesthetics of the Rāma Yantra, its functionality fell in line with an already-existing instrument. It was designed as a replacement machine for the *Dhāt al-*

⁵⁹ The fifth instrument, an Agrā Yantra (horizontal sundial), was perched at the top of the gnomon of the Samrāt Yantra, visible from the ground, but seeming to be a part of the larger instrument. It seems likely that one or more Dakṣinottara Bhitti Yantras (transit instrument/meridian dials) were built at Shahjahanabad during the reign of Sawai Jai Singh as well. Jagannātha indicates the latitude of Indraprastha (Delhi) was determined to be 28° 39', and the obliquity 23° 28', measurements obtained with the help of a Dakṣinottara Bhitti Yantra. Joseph Tieffenthaler did not mention this instrument in the record of his 1743 CE visit to the observatory, but Hunter described it or something similar after his visit to the site in 1796 CE. See Hunter, "Some Account of the Astronomical Labours of Jayasinha, Rajah of Ambhere, or Jayanagar," 191. The Miśra Yantra, a conglomeration of five instruments in one structure, probably dates to some period after 1750 CE, well beyond the death date of Sawai Jai Singh. Jagannātha does not describe the instrument in the *Samrāt Siddhānta*, nor does Tieffenthaler include it in his description of the Delhi observatory. Sharma speculates that it was built under the patronage of Sawai Jai Singh's second son, Madho Singh, as a token of support for the emperor, Ahmad Shah. See Virendra Nath Sharma, "Miśra Yantra of the Delhi Observatory," *Indian Journal of History of Science* 29, no. 3 (1994): 477; Andreas Volwahren, *Cosmic Architecture in India: the Astronomical Monuments of Maharaja Jai Singh II* (New York: Prestel, 2001), 82-83.

⁶⁰ Sharma, ed. *Samrāt-Siddhāntah Avāntara Paṭhabhedasamanvitah Siddhāntasārakaustubhah*, 1163.; See also Pingree, "Indian and Islamic Astronomy at Jayasimha's Court," 316.

Shu'batayn and was meant to produce equivalent measurements, the azimuth and altitude of a celestial object, with a minimum amount of error due to material flaws or instabilities.

All of these instruments were probably designed in consultation with a group of *najūmī* (astronomers) usually designated “Islamic” in the histories of the observatories, but who probably represented a variety of viewpoints within that general category, in that some were undoubtedly of direct Persian descent—the author/scribe of the *Zīj-i Muḥammad Shāhī*, Abu'l-Khayr Khayr Allāh Khān, for instance—while others, such as Dayānat Khān, probably hailed from closer locales. A host of *najūmī* worked for Sawai Jai Singh, and judging from archival sources, it seems that the majority (and perhaps all) were employed with observation or design tasks at Shahjahanabad. That is, almost all of Sawai Jai Singh’s Muslim *najūmī* worked with him well before the possible dates of construction of the observatory at Jaipur, and in some cases, even before work realistically could have started in Shahjahanabad. According to the *Dastūr Kaumwār*, which listed the gifts of protocol awarded by the court of Amer, Sawai Jai Singh paid out most of the rewards to his *najūmī* in the form of gifts and cash in two clusters, the first between the years 1718 and 1721 CE, and the second in the years 1725 and 1726 CE, a coincidence that suggests these dates might function as bookends for the project in Shahjahanabad.⁶¹ On December 3, 1718 CE (Mangsira Sūdi 11 VS 1775), almost a year before Muhammad Shah’s victory over the Sayyid brothers, and thus the date of his unimpeded ascension to the imperial throne, a remarkably lavish gift was awarded to Sheik Asadulā Najūmī

⁶¹ The *Dastūr Kaumwār* (DK) documents awards of money and gifts-in-kind given to a variety of individuals—from servants to heads of state—by the Court of Amer and Jaipur. With over 90,000 entries, this is an invaluable resource for historians of the Rajput state. Originally a collection of loose sheets of paper (*arsattas*), the pages were copied and sorted into a 32-volume collection at the end of the nineteenth century. The volumes are alphabetized according to caste names; individual names are alphabetized in each caste section. Thus, the first volume, ka (क), includes entries for the Kacchawāhās, Kumbhanis, Kayanot, Kavishwar, Kayasthas, etc. The *Musalamān* caste, i.e., Muslim section, is in Vols. 18 and 19. Occasional transcription mistakes were made during the copying process, so some individuals are listed twice under slightly different spellings, or included in the wrong caste section. For instance, while we would expect gifts given to Europeans to be included in the Foreign (*firengī*) section, in fact, many of the Jesuit priests appear under the *Musalamān* heading.

by the Amer court, in the form of a *sirapāo*.⁶² The extravagance of the *sirapāo*, while not quite matching the high standards for textiles awarded to Rajput royalty, nonetheless confirms both that Sheik Asadulā Najūmī's work was greatly valued, and that astronomical inquiry, probably with assistance of brass instruments, was well underway before Sawai Jai Singh approached the new emperor about the revision of the imperial calendar.⁶³ The Maharaja Dhiraja made many similar grants, both large and small, over the next three years. He awarded Asatulā Najūmī a small prize of 1r-0a-0p⁶⁴ on September 20, 1719 CE (Pratham Asoj Sūdi 7 VS 1776).⁶⁵ Six weeks later, on November 3, 1719 CE (Kāti Vadi 6 VS 1776), he gave ceremonial armor from the *Sileh Khāna* to this same astronomer.⁶⁶ On February 8, 1721 CE (Magh Sūdi 11 VS 1777) Mirza Abdul Rahamān Najūmī accepted a horse, a woven braid (rope), and a bridle in lieu of a cash wage.⁶⁷ Implicit in the value of these gifts, particularly the horse awarded to Abdul Rahamān Najūmī, is the supposition that work at Shahjahanabad must have progressed enough

⁶² The *sirapāo*, the Mughal equivalent of the Arabic *khila't*, was meant to cover the recipient from head to foot, cloaking him entirely in the royal presence. The *sirapāo* given to Sheik Asadulā Najūmī consisted of four parts: a *cirā-mukešī* (high-walled, threaded style of turban) (36r-7a-0p); a *phenṭā-gujarātī* (Gujarati-style garment) (22r-12a-0p); a *masrū-būṭādār* (high-quality cloth) (31r-6a-0p); and a *sarpec* (gold-threaded covering for a turban) (5r-4a-0p). Sheik Asadulā Najūmī, VS 1775, 540, Vol. 18, DK, RSA, Bikaner. For a discussion of the symbolic properties of the *sirapāo*, see Harbans Mukhia, *The Mughals of India* (Oxford: Blackwell, 2004), 104.

⁶³ The costume and jewels awarded Ishwari Singh on his appointment to the position of crown prince far exceeded in value any gift given to court *najūmī*. Sawai Jai Singh gave to Ishwari Singh a *sarpec* with diamonds (valued at 1300r-0a-0p), a *kanthi* (pearl necklace, valued at 3795r-0a-0p), and an outfit consisting of a *denawati* (37r-2a-0p), two *jamahs* (109r-0a-0p, 1r-4a-0p), a Gujarati *phenta* (52r-0a-0p), an *izar* (20r-12a-0p), a *turra* (turban ornament) (10r-8a-0p), an *alam* (9r-14a-0p), and a *taihpēc* (0r-15a-0p). Ishwari Singh, VS 1790, 57-59, Vol. 24, DK, RSA, Bikaner.

⁶⁴ The primary coin in circulation in eighteenth-century South Asia was the silver *rupee*, which subdivided into sixteen *anna*. The *anna* then subdivided into four *paise*. The secondary form of currency was the *ṭaka*. The value of the *ṭaka* varied across South Asia, but in north India, it was generally accepted as the equivalent to two *paise*, or 1/8 of a *rupee*. The *ṭaka* subdivided into 100 *poiše*.

⁶⁵ It is possible that Asadulā and Asatulā are the same person, and the alternate spelling is simply a transcription error. Sheik Asatulā Najūmī, VS 1776, 554, Vol. 18, DK, RSA, Bikaner.

⁶⁶ The armor was valued at 20r-0a-0p. Ibid.

⁶⁷ Mirza Abdul Rahamān Najūmī, VS 1777, 557, Vol. 18, DK, RSA, Bikaner.

that Sawai Jai Singh felt inclined to distribute treasures that incontrovertibly marked an individual as “in favor” with the Rajput ruler.⁶⁸

In a similar fashion, recompense distributed to *najūmī* in 1725 and 1726 CE leads us to the conclusion that the majority of the work at Shahjahanabad wrapped up during those two years. This is indicated especially by the prizes given to Dayānat Khān, arguably the most rewarded *najūmī* working for Sawai Jai Singh at any time during the course of the king’s life. On March 8, 1725 CE (Prathan Asāḍh Vadi 6 VS 1781) an order was issued to give Khān the relatively large cash sum of 100r-0a-0p.⁶⁹ A year later, on October 10, 1725 CE (Asoj Vadi 14 VS 1782), while at Jaisinghpura outside Shahjahanabad, Sawai Jai Singh rewarded him again with a customary gift valued at 135r-2a-9p.⁷⁰ Approximately one month later, Nizām Khān delivered to Dayānat Khān the tremendous sum of 400r-0a-0p with the indication that 200r-0a-0p would soon follow.⁷¹ On December 8, 1725 CE (Mangsira Sudi 4 VS 1782), Nizām Khān Najūmī himself was granted a royal *sirapāo* at the Jaisinghpura of Shahjahanabad.⁷² The frequency with which the *najūmī* were rewarded only grew over the next year: in 1725/26 (VS 1782), at least five different astronomers were rewarded multiple times with cash gifts ranging in

⁶⁸ While the Mughal court considered the horse a mark of nobility, or a sign of royal authority, the Rajputs took the symbolism of the horse even further. For instance, Sawai Jai Singh is credited with renewing the *Aśvamedha Yajna*, or “horse sacrifice” in 1734 CE. In this rite, a stallion was sprinkled with water and set free to roan unimpeded through the kingdom. The fact that the horse was able to travel unharmed across large expanses of territory symbolized the king’s power. At the end of the year, the horse was recaptured and sacrificed with the consorts of the ruler close at hand. For a commentary on the sacrifice by a visiting Jesuit, see Claude Boudier, Letter to Étienne Souciet, 18 January 1736, fol. 143v, GBro 088, Fonds Brotier, Les Archives des Jésuites de Paris, Vanves. Other descriptions can be read in Gopal Narayan Bahura, *Literary Heritage of the Rulers of Amber and Jaipur: with an Index to the Register of Manuscripts in the Pothikhana of Jaipur (I. Khasmohor Collection)* (Jaipur: Maharaja Sawai Man Singh II Museum, 1976), 60; Mirja Juntunen, “The Town Plan of Jaipur: Its Sources and Narrations” (Stockholm University 2004), 105-06; Ashim K. Roy, *History of the Jaipur City* (New Delhi: Manohar Publishers & Distributors, 1978), 19, 22-23; Kala Nath Shastri, “The Religious Heritage of Jaipur: Vedic, Vaishnava and Shaiva,” in *Cultural Heritage of Jaipur*, ed. Jai Narayan Asopa (Jaipur: Oriental Printers and Publishers, 1979), 89.

⁶⁹ Dayānat Khān Najūmī, VS 1782, 564, Vol. 19, DK, RSA, Bikaner.

⁷⁰ Ibid.

⁷¹ Ibid.

⁷² The *sirapāo* had the customary value of 39r-7a-0p. Nizām Khān Najūmī, VS 1782, 674-75, Vol. 20, DK, RSA, Bikaner.

value from 1r-0a-0p to 200r-0a-0p.⁷³ It is easy to conclude that the group of rewards in the early years represented the planning and early stages of construction of the Shahjahanabad site, while those distributed in the 1725-1726 CE range of years represented the successful completion of the observatory's instruments. This assertion seems even more credible since the notations in the *Dastūr Kaumwār* frequently included a mention of the Jaisinghpura in Shahjahanabad as the site of the gifting ceremony. Interestingly, few of the names of these *najūmī* appear in the *Dastūr Kaumwār* after 1726/27 CE (VS 1783), further indicating that their design or construction was completed, and their expertise was no longer needed, not even during the building of the observatory at Jaipur.

The fact that few of the Islamic astronomers moved to Jaipur deserves special scrutiny, since many of the instruments at Jaipur were derivative of those at Shahjahanabad. This observation prompts many questions as to the nature of technology and knowledge transfer between the two sites, particularly in terms of construction techniques and instrument design and, in fact, a comparison between the observatory at Shahjahanabad and the observatory at Jaipur highlights an ambiguous and tense relationship between the two sites. Although archival records do not prove that the workforces at the two cities were in dialogue with each other, the similarity of the instruments in both locations indicates that the laborers at Jaipur were responding to the structures built outside Shahjahanabad. When the instruments from the two observatories are compared, it is clear that Jaipur as a scientific space is derivative of the space at Shahjahanabad. Many of the instruments at Jaipur were merely smaller scale versions of the originals in Shahjahanabad, refined in such a way as to require less material and less land. A few

⁷³ Sheik Ahamad Najūmī, VS 1782, 502, Vol. 18, DK, RSA, Bikaner; Muhammad Āvad Najūmī Mulla, VS 1782, 590-91, Vol. 18, DK, RSA, Bikaner; Imāmū'dīn Najūmī, VS 1782, 745, Vol. 18, DK, RSA, Bikaner; Imāmū'dīn Najūmī, VS 1783, 745, Vol. 18, DK, RSA, Bikaner; Sayed Muhammad Najūmī, VS 1782, 193-94, Vol. 20, DK, RSA, Bikaner; Muhammad Syaha Najūmī, VS 1783, 194, Vol. 20, DK, RSA, Bikaner.

instruments did appear first at Jaipur (the Digamśa Yantra, for instance) before being exported to the outlying observatories in Mathura, Ujjain, and Varanasi; but, in terms of general functionality, the instruments in the palace complex of Jaipur echoed those already at Shahjahanabad. Even the Rāśivālayas, which mark the ascendant star and are unique to the observatory Jaipur, operated according to the same basic construction and observation principles as the Samrāt Yantra at Shahjahanabad (figure 2.9).⁷⁴ Thus, the primary difference between the two sites is one of scale and method. Almost without exception, the instruments at Shahjahanabad dwarf those in Jaipur. While the height and breadth of the two Samrāt Yantras are similar (the gnomon at Shahjahanabad is 21.3 meters tall, the quadrants have a radius of 15.09 meters; the gnomon at Jaipur is 22.62 meters tall, the quadrants have a radius of 15.15 meters),⁷⁵ the Rāma Yantra and the Jaya Prakāśa Yantra of Shahjahanabad were noticeably larger than their Jaipur counterparts. The circumference walls of the Rāma Yantra at Shahjahanabad, composed of four tiers of load-bearing arches (three arcades above grade, one blind arcade below), ranged in thickness from 1.45 meters to 1.68 meters (figure 2.10).⁷⁶ Scaled pillars, standing 7.52 meters tall, were attached to the interior surface of the circular enclosure created by the superimposed arcades (figure 2.11). These pillars served no structural function, and in fact were thoroughly perforated by square openings designed to receive the ends of planks on which the astronomers needed to perch in order to read the scales situated above their heads

⁷⁴ The Rāśivālayas were designed to measure the latitude and longitude of a celestial object, and can be considered a masonry translation of the functions of the torquetum. Each of the twelve Rāśivālayas were aligned such that the latitude and longitude of an object could be measured at the precise moment the leading star of a given constellation arrived at the prime meridian. Supposedly, each Rāśivālaya was aligned to measure the approach of a specific zodiac constellation (Gemini, Leo, etc.). However, the Rāśivālayas have been subjected to several restorations throughout the years, and during at least one of those restorations, the instruments were re-aligned according to the “best guess” as to which constellations they were intended to track through the night sky. This basic truth throws some doubt on the interpretation of the instruments based on their current location as proposed by Volwahren. See Arthur ff. Garrett and Chandradhar Guleri, *The Jaipur Observatory and Its Builder* (Allahabad: Pioneer Press, 1902), 71-73; Sharma, *Sawai Jai Singh and his Astronomy*, 145-51; Volwahren, 127-29.

⁷⁵ Sharma, *Sawai Jai Singh and his Astronomy*, 99, 133-35.

⁷⁶ *Ibid.*, 107. In the southern component of the Rāma Yantra, the top two tiers of arches stretch only half-way around the structure. The other half consists of a solid masonry wall.

(figure 2.12). The inside diameter of the instrument was 16.65 meters.⁷⁷ In comparison, the inside diameter of the Jaipur Rāma Yantra is 6.95 meters, and the height from finish floor to the top of the anchor ring is 4.58 meters.⁷⁸ In terms of materials consumed, then, the structure at Jaipur, which performed observational tasks (measuring altitude, zenith distance, and azimuth) identical to those made at Shahjahanabad, was noticeably more efficient and streamlined.

That the construction techniques applied in Jaipur for the erection of these instruments bear some relation to, but were not blind duplicates of those implemented at Shahjahanabad, was a further indication that Shahjahanabad was posited as a solution and became a problem in and of itself, which then had to be resolved in Jaipur. The massive Rāma Yantra was the result of a redesign and replacement for the *Dhāt al-Shu^cbatayn*, a smaller brass triquetrum. Between the modest metal fabrication of the *Dhāt al-Shu^cbatayn* and the bloated excess of the stone arcades in Shahjahanabad hovered the utilitarian post-and-lintel system (or pier and anchor-ring) of the Jaipur instrument (figure 2.13). In addition, the Rāma Yantra at Jaipur was built entirely above grade, on a sandstone plinth, meaning that considerably less effort was required for excavation and construction. While all of the stone instruments at every observatory were over-engineered, the Rāma Yantra outside Shahjahanabad was dramatically so, and was apparently recognized as such by the patron, as the Jaipur equivalent was notably scaled down. The development of the instrument, from brass triquetrum to above-grade post and lintel system, followed an arc shaped by experimental design and subsequent improvement.

⁷⁷ George Rusby Kaye, *A Guide to the Old Observatories at Delhi; Jaipur; Ujjain; Benares* (Calcutta: Superintendent Government Printing, 1920), 38; Sharma, *Sawai Jai Singh and his Astronomy*, 107.

⁷⁸ George Rusby Kaye, *The Astronomical Observatories of Jai Singh* (Calcutta: Superintendent Government Printing, 1918), 167. Kaye asserts that the Rāma Yantra of Jaipur was a late addition to the collection, built in 1891 CE. However, this instrument, or one very much like it, appears in an eighteenth-century map of the observatory. While the dating of the map is not precise, it does include a few structures, such as the *Jalayantra* (Persian wheel), that were removed before the era of photography. This might be the same Persian wheel included in the palace expense records for 1729/30 CE (VS 1786). See Bhādvā Sūdi 3 VS 1786 to Bhādvā Sūdi 2 VS 1787, fol. 35, Bundle No. 2, AI, RSA, Bikaner; Kaye, *The Astronomical Observatories of Jai Singh*, 38; Sharma, *Sawai Jai Singh and his Astronomy*, 128.

This pattern also holds true in a comparison between the Jaya Prakāśa Yantras at both sites.⁷⁹ The Jaya Prakāśa Yantra in Shahjahanabad, meant to replace the *Dhāt al-Ḥalaq*, was designed at a much larger scale than the instrument at Jaipur; its complementary bowls stretched to a diameter of 8.33 meters, while the diameters of the matching hemispheres in Jaipur cover only 5.44 meters.⁸⁰ Here again, the instruments at Shahjahanabad must have consumed more resources than those built at Jaipur simply based on depth and breadth. It would appear, then, that most of the intellectual work was accomplished by the astronomers working outside the walls of Shahjahanabad, rather than by the laborers who designed and built the instruments at Jaipur. This is not to say that because the instruments went under a second process of improvement in Jaipur, the observatory at Shahjahanabad was a failure, especially if we consider the ancillary functions of such a space. Shahjahanabad was only 171 miles (275 km) from Jaipur, and because of Sawai Jai Singh's continued proximity to this locale, the observatory in the Jaisinghpura of Shahjahanabad functioned in a manner symbolically similar to the one in Jaipur (see Chapter Three). The highly mobile court of Amer and Jaipur visited this space relatively frequently on imperial business, and after the victory at the second siege of Thūn (October 25 to November 20, 1722 CE), the Maharaja Dhiraja spent four years moving between Delhi, Amer, and Mathura, making multiple pilgrimages to significant *tīrthas* (river crossings) and completing the Brajmandala Parikrama.⁸¹ Moreover, the *Syāha Hazūr* (Court Accounts)

⁷⁹ The Jaya Prakāśa Yantra permitted astronomers to take celestial measurements according to two coordinate systems, the horizontal (alt-azimuth, with the horizon as the primary referent) and equatorial (declination-right ascension, with the celestial equator as the primary referent).

⁸⁰ Sharma, *Sawai Jai Singh and his Astronomy*, 106. The concave surfaces of the Jaya Prakāśa at Jaipur are faced today with marble, but the original scales were etched on to a surface finished with *chunā*. Garrett and Guleri noted during the restoration process of 1901 CE that the rims of the instrument were composed of marble, "but the hemispherical surfaces are finished off in white chuman, ruled with coloured lines to represent various circles." Garrett and Guleri, 49.

⁸¹ Jadunath Sarkar, *A History of Jaipur c. 1503-1938* (Jaipur: Maharaja Sawai Man Singh II Museum, 1984), 204. The Brajmandala, also known as the Ban-Yātrā, is an annual pilgrimage associated with the with the *līlā* (playful life or sport) of Krishna and his consort, Rādhā. During this twenty-four hour event, pilgrims follow a circular path

indicate that the Maharaja Dhiraja spent a fair amount of time in the Jaisinghpura of Shahjahanabad during the years most likely to encompass the completion of the building of the instruments, despite travels taken for purposes of pilgrimage or military campaigns.⁸² The extended presence of Sawai Jai Singh must have contributed much to the symbolic work of propping up both his own court and that of the Mughal throne through the observatory and its instruments. It is probably not a coincidence that Sawai Jai Singh's interest in astronomy, long-standing but somewhat erratic in application, coalesced into a building program just at the moment of Muhammad Shah's arrival at the throne in Shahjahanabad. Rather, this development can be understood as the logical outcome of the Mughal emperor's desire to legitimate his own rule, as well as a simultaneous attempt by the Rajput king to reclaim some of Amer's lost land and cultural authority.

While it is well-established that the "decline of the Mughal empire" is in large part an Orientalist invention that colored historians' readings of the short period of instability immediately preceding Muhammad Shah's reign, this particular emperor did inherit a somewhat unstable throne, weakened by a decade of wars of succession.⁸³ Muhammad Shah moved quickly to consolidate his power by drawing close to him Sawai Jai Singh and other leaders of

through Braj, the greater landscape encompassing Mathura and Vrindavan, visiting the forests connected with the Krishna *līlā*. When this pageant of Krishna's life began in the sixteenth century, 153 forests were marked on the prescribed route; by the end of the nineteenth century, that number had been reduced to twenty four, in addition to five hills, eleven rocks, four lakes, eighty-four ponds and twelve wells. Today, pilgrims visit only twelve forest sites, perhaps because of serious deforestation in the region. See also F. S. Growse, "Sketches of Mathurā: II. The Ban Yatra," *Indian Antiquary* 1 (May 3 1872): 133-37; ———, *Mathurā: A District Memoir*, 3d ed. (Ahmedabad: New Order Book Co., 1882; reprint, 1978), 80; David L. Haberman, *Journey Through the Twelve Forests: an Encounter with Krishna* (Oxford: Oxford University Press, 1994), xii; Charlotte Vaudeville, "Braj, Lost and Found," *Indo-Iranian Journal* 18 (1976): 197.

⁸² For example, in 1726/27 CE (VS 1783), the Maharaja Dhiraja's presence is recorded in the Jaisinghpura from December 15, 1726 CE to February 7, 1727 CE (Kāti Sudi 14 to Phālguna Vadi 1), a relatively long stretch of time immediately preceding the foundation of the city of Jaipur. See Kāti Sūdi 13-Phālguna Vadi 1 VS 1783, Bundle No. 23, SH, RSA, Bikaner.

⁸³ C. A. Bayly, *Imperial Meridian: the British Empire and the World, 1780-1830* (London: Longman, 1989), 3, 23-4; P. J. Marshall, *The Eighteenth Century in Indian History: Evolution or Revolution?* (New Delhi: Oxford University Press, 2003), 3.

hereditary states who might otherwise undermine his claim to authority. Sawai Jai Singh's knowledge of Islamic astronomy created an opportunity for the new ruler to exercise his imperial prerogative of calendrical reform through the construction projects paid for out of the coffers of Sawai Jai Singh's court. It also provided the possibility for validation through architectural patronage, and we might consider reading the observatory at Delhi as part of a tradition of reviving specific components of the built environment in order to establish a connection between the seated emperor and the legendary Timurid dynasty. The sustained and deliberate association of Mughal rulers with Timurid architecture as a means of establishing authority, as well as an ongoing visual and spatial revival of Timurid form in Mughal tomb building, is well documented in the history of the built environment of India. For example, both Jahangir and Shah Jahan contributed money toward the upkeep of the Samarkand mausoleum Gur-i Amir, built for Timur Amir in 1405 CE; between the date of Babur's death in 1530 CE and Aurangzeb's in 1707 CE, mausoleum designs in India repeatedly invoked formal characteristics associated with Timur's Persian dynasty.⁸⁴ It is possible that the observatory outside the walls of Shahjahanabad provided a similar connection with the Timurids through its invocation of science adapted from the observatory of Timur's grandson, Ulugh Beg, in Samarkand.⁸⁵ In fact, historians have frequently associated the large scale of the observatory outside Shahjahanabad with Ulugh Beg's in Samarkand, claiming the masonry instruments as a translation of the forms used by the

⁸⁴ Michael Brand, "Orthodoxy, Innovation and Revival: Considerations of the Past in Imperial Mughal Tomb Architecture," *Muqarnas* 10 (1993): 423-34.

⁸⁵ Ulugh Beg founded his observatory in Samarkand in 1424 CE, after three years of consultations with astronomers from around greater Asia. His workmen and astronomers apparently studied the observatories at Maragha and Rei, using them as models for a new observatory set into a hillside outside the city walls. For an archaeological description of the observatory at Maragha, see M. C. Bulatov, "Predshestvenitsa Observatorii Ulugbeka (Precedent of the Observatory of Ulugh Beg)," *Arkhitektura i Stroitel'stvo Uzbekistana* 11 (1986): 11-12; P. Vardjavand, "Un Observatoire Astronomique du XIIIe Siecle," *Archeologia* 151 (February 1981): 46-53. For the observatory at Samarkand, see M. C. Bulatov, "Observatoriya Ulugbeka (Observatory of Ulugh Beg)," *Arkhitektura SSSR* (January-February 1985): 91-93; Aydin Sayili, *The Observatory in Islam and Its Place in the General History of the Observatory*, 2nd ed. (Ankara: Türk Tarih Kurumu Basimevi, 1988), 260-89.

Timurid prince in his outsize 90-degree quadrant.⁸⁶ We should be cautious in accepting this theory, however. First, Sawai Jai Singh did not have first-hand experience of the space at Samarkand. He never traveled to present-day Uzbekistan to visit the site, and even if he had, it is probable that the ruins would have been abandoned and buried beneath sand. Second, the only instrument that unquestionably existed at both sites is the *Suds-i Fakhrī*, or Ṣaṣṭhāmśa Yantra, which was contained in the quadrant terminus of the Samrāt Yantra at Shahjahanabad, and therefore invisible to the outside viewer. To argue that a direct visual or aesthetic connection existed between the two sites is probably futile.⁸⁷ However, from Jagannātha's *Samrāt Siddhānta*, as well as through the existence of instruments such as the Ṣaṣṭhāmśa Yantra, we do know Sawai Jai Singh was conversant with Ptolemaic astronomy as applied by Ulugh Beg. Quite obviously, he knew of Ulugh Beg's *Zīj-i Jadīd*, having acquired a copy in 1725/26 CE (VS 1782), and thereafter referring to them frequently in the preface to the *Zīj-i Muḥammad Shāhī* and the *Samrāt Siddhānta*.⁸⁸ Even more obviously, he was thoroughly familiar with Ptolemaic

⁸⁶ For typical formulations of this idea, see B. Mayer, "Touring the Jai Singh Observatories," *Sky and Telescope* 58 (July 1979): 6; Dilip Salwi, "The Wondrous Observatories of Jai Singh," *New Science* 92 (December 10 1981): 730; Stella Snead, "Observatories Reveal the Imagination of India and the Mind of a Maharaja," *Industrial Design* 7 (January-June 1960): 58.

⁸⁷ On the other hand, it is possible that the stone masons and other laborers working on Sawai Jai Singh's instruments inherited knowledge of some of the technical or aesthetic approaches applied at Samarkand from their predecessors in the trade. The transmission of building knowledge did not necessarily occur at the patron level, but rather was passed at the levels of designer and labor. That this is true is evidenced by the Mughal tomb and garden works designed under the supervision of Mirak-i Sayyid Ghiyas, an Iranian horticulturalist and garden designer who relocated from Iran to India, where he worked for the emperor Babur. From India, he moved to Bukhara, where he applied his aesthetic and horticultural principles to the gardens he designed for the Uzbek khan. See Ebba Koch, *The Complete Taj Mahal and the Riverfront Gardens of Agra* (London: Thames and Hudson, 2006), 27; ———, *Mughal Architecture: An Outline of Its History and Development (1526-1858)* (Munich: Prestel, 1991), 44; D. Fairchild Ruggles, *Islamic Gardens and Landscapes* (Philadelphia: University of Pennsylvania Press, 2008), 38.

⁸⁸ In addition to the ephemerides themselves, that same year Sawai Jai Singh acquired al-Birjandī's commentary on the *Zīj-i Jadīd*. A second version of al-Birjandī's commentary was acquired in 1728/29 CE (VS 1785). Akbar commissioned Mullā Chānd to revise Ulugh Beg's tables so that its epoch date coincided with the beginning of his reign. Shah Jahan requested that Farīd al-Dīn Mas'ūd ibn Ibrāhīm al-Dihlawī perform the same service for him in 1629 CE. In addition, Munīsvara Visarūpa and Kamalākara of Benares (Varanasi) seem to have had access to a Sanskrit translation of the *Zīj-i Jadīd* in the seventeenth century. So, Sawai Jai Singh may have encountered Ulugh Beg's work through multiple works besides the actual *Zīj-i Jadīd*. See Pingree, "An Astronomer's Progress," 76-77; ———, "Islamic Astronomy in Sanskrit," *Journal for the History of Arabic Science* 2, no. 2 (November 1978): 320, 22-23; ———, "Indian and Islamic Astronomy at Jayasimha's Court," 313.

instrumentation as filtered through these same manuscripts. It is conceivable that Sawai Jai Singh and Muhammad Shah were pursuing a cultural or scientific association with the Timurid dynasty through the construction of a new observatory, even if that connection relied not at all on the visual characteristics of the monument, and even if it was intelligible only to a certain learned audience.

The motivations for Sawai Jai Singh's participation in this venture remain unclear, particularly as the money for the observatories came from his own coffers. Rather than reforming the calendar out of a blind allegiance to imperial authority, or even as an act of financial generosity, he was more likely attempting to establish his own claims as the ruler of the hereditary state of Amer. He was on the cusp of founding a new capital city, and the observatory could have been a preliminary experiment in patronage before he moved onto a larger project. Outside the walls of Shahjahanabad, he was testing the waters, so to speak, of his capabilities of ensuring a lengthy reign through architectural imagery while simultaneously establishing his own authority as patron, scientist, and landowner. In this way, we can read the observatory as something more than a space of astronomical research; it was imbued with political symbolism meant to underscore the legitimacy of Sawai Jai Singh's claim to power.

At the same time, the symbolic strength of the site should not be overstated, particularly in comparison to future work at Jaipur. First, the observatory was established in a quarter already associated with the Kacchawāhā clan, so although Sawai Jai Singh may have been attempting to assert the strength his political position, or the position of the newly-seated Mughal emperor, he did not develop completely new lands to do so as he did later on the southern plains of Amer. Second, the observatory at Shahjahanabad was comprised originally of only five instruments: the Samrāt Yantra, the Rāma Yantra, the Jāya Prakāśa Yantra, the Agrā Yantra, and

the invisible Śaṣṭhāṁśa Yantra, while the Jaipur observatory continued to expand throughout Sawai Jai Singh's reign. Though the Shahjahanabad observatory was notable simply because it was a new feature of the suburban landscape, and it probably did do important political work for the both Mughal and Rajput rulers, it operated more as a flourish than as a declarative statement of authority. The observatory was plainly visible to the local populace, as it occupied land next to a well-traveled roadway, but it predated the obvious claim to power issued by Sawai Jai Singh through the founding by fiat of the city of Jaipur. So, while it is indeed tempting to read the spaces of the Shahjahanabad observatory as unambiguous statements of control, at the time of its founding it was not clear that Sawai Jai Singh was going to emerge unscathed from the interregnum political intrigues, much less found a significant commercial and capital city. Shahjahanabad represented a preliminary foray into real estate development, in much the same way that the additions of gates and courtyards to the palace at Amer (discussed in Chapter Three) did—these were embellishments to royal holdings, limited in scope, and unlikely to generate much cultural or political capital outside the immediate vicinity of the site.

2.3 Realignments

This preliminary examination of the research agenda at Shahjahanabad and comparison of the instruments constructed at the city with those in Jaipur differs greatly from the treatments handed down by Barker, Williams, and Hunter. Thinking from west to east allows us to reconsider the point of origin of Sawai Jai Singh's astronomy, and further forces us to question the necessity of a central point in a scientific network. Although Jaipur obviously became the administrative and economic hub of the state of Amer, and the collection of instruments at Jaipur continued to grow throughout Sawai Jai Singh's life, the observatory at Shahjahanabad played a crucial role in the early development of the observatories. In this model, Varanasi becomes

almost a footnote, and in fact, in comparison to the observatories in Shahjahanabad and Jaipur, the three outliers, in Mathura, Ujjain, and Varanasi make only minor appearances in the historical archives. In truth, despite two hundred and fifty years of colonial history writing positioning Varanasi as the premier space of Sawai Jai Singh's scientific agenda, it is quite difficult to consider it, or the observatories at Mathura or Ujjain, as significant elements even in the local landscape. Sawai Jai Singh intended for these subsidiary sites to function in a manner similar to those in Shahjahanabad and Jaipur, at least in terms of collection of astronomical data. The Maharaja Dhiraja believed he had developed "an accurate means of constructing an observatory" such that any observational errors due to the use of brass instruments were corrected by his redesign. Thanks to the masonry instruments, "the difference which had existed between the computed and observed places of the fixed stars and planets, by means of firsthand observation of their mean motions and aberrations with such instruments, was removed."⁸⁹ Having vanquished the twin enemies of instability and mutability from Shahjahanabad, Sawai Jai Singh proceeded to construct instruments "of the same kind in Sawai Jaipur and Mathura and Benares and Ujjain."⁹⁰ The motivation for the construction of the observatories in these four cities seems to have been one of practicality. In addition to cross-checking his local observations for accuracy, the Maharaja Dhiraja allegedly desired the ability to record observations regardless of the weather in his current location. As Jagannātha noted

on whatever day it was cloudy in Indraprastha (Delhi), on that day the observation was made in Sawai Jaipur; whenever it was cloudy at Sawai Jaipur, on that day the observation was made at Indraprastha. So it was confirmed everywhere—at Avantī (Ujjain), at Mathura, and at Kāśī (Varanasi). There is no necessity for clouds to be

⁸⁹ *Zīj-i Muḥammad Shāhī*, fol. 4r.

⁹⁰ *Ibid.*, fol. 4v.

everywhere. It is not cloudy in Kabul in the rainy season; it is not cloudy in the months beginning with Pauṣa. Therefore, there is no necessity.⁹¹

This quite mundane concern was reconfirmed in the preface to the *Zīj-i Muḥammad Shāhī*, but with a slight twist: in addition to ensuring the ability to obtain the desired data regardless of the weather, the decision to erect observatories in these (and other) large cities was also made “so that every person who is devoted to these [astronomical] studies, whenever he desires to ascertain the location of a star, or the relative location of a star to another, might use these instruments to observe the phenomena.”⁹² At the same time he was offering this opportunity to his subjects, Sawai Jai Singh recognized that “the observation, or the power and opportunity of access to an observatory may be wanting,” and he saw the proposed compilation and circulation of the *Zīj-i Muḥammad Shāhī* as a way around these potential obstacles.⁹³ If he could gather together his own observations in a single manuscript, an authoritative set of ephemerides “by means of which the daily places of the stars being calculated ever year, and gathered in a calendar, may always be readily available,” regardless of one’s right of access to the observatories.⁹⁴

It would be easy to conclude that Sawai Jai Singh believed early on that he had solved his problems with masonry instruments, and that he made the decision to export the instrumentation to Mathura, Ujjain, and Varanasi as part of three-pronged agenda: for the confirmation of the accuracy of his observations; to make up for a lack of data due to weather conditions; and for the use of the inhabitants of other cities. If only the textual sources are consulted, especially the *Zīj-i Muḥammad Shāhī* and the *Samrāt Siddhānta*, then it would certainly appear as if the king of

⁹¹ Pingree, “Indian and Islamic Astronomy at Jayasimha’s Court,” 317; Sharma, ed. *Samrāt-Siddhāntah Avāntara Paṭhabhedasamanvitah Siddhāntasārakaustubhah*, 1134.

⁹² *Zīj-i Muḥammad Shāhī*, fol. 4v.

⁹³ Ibid.

⁹⁴ Ibid.

Amer had no intention of deliberately imprinting his name on the landscape as he possibly did in Shahjahanabad, and definitely did in Jaipur. And, in fact, although the Maharaja Dhiraja did compile a new set of astronomical tables, issued as the *Zīj-i Muḥammad Shāhī*, there is little evidence to support the assertion that he successfully transferred astronomical data from Mathura, Ujjain, and Varanasi to Jaipur and/or Delhi, even though the outlying observatories were successfully constructed and capable of serving as daily observation sites.⁹⁵

To date, little evidence exists to support Sawai Jai Singh's claim that the outlying observatories functioned as data collection points. But if they did not function as active sites of scientific inquiry, were they capable of doing any cultural or political symbolic work? This question becomes particularly pressing in the case of Mathura, a city with which Sawai Jai Singh and his Kacchawāhā ancestors were closely connected in both governmental and religious terms. Possibly because it was demolished in the first half of the nineteenth century, we know very little about the observatory in this temple town, despite its proximity to Shahjahanabad, Jaipur, and the imperial city of Agra. Although Mathura had its own Jaisinghpura associated with Sawai Jai Singh's Kacchawāhā clan, located three miles north of the town proper, the observatory was built on top of the Mathura Fort, Kans ka Kilā, rather in the *purā* as might be expected.⁹⁶ Kans ka Kilā, too, was connected with the Kacchawāhā clan, as it had been constructed by Raja Mān Singh I of Amer, and when Sawai Jai Singh was appointed the military governor of Mathura in 1723 CE, only two years after the founding of the observatory at Delhi, he undoubtedly used the

⁹⁵ To date, no one has been able to definitely mark the founding dates of the outlying observatories on the calendar. Because the Varanasi and Ujjain observatories both house Digamśa Yantras, I propose that they post-date the founding of the Jaipur observatory (c. 1728 CE) where the instrument was designed and built for the first time. It is possible that a Digamśa Yantra was built first in Shahjahanabad and then exported to Jaipur, Ujjain, and Varanasi, but no archaeological, visual, or written evidence exists to prove this point.

⁹⁶ J. Ph Vogel, "Archaeological Exploration in India, 1910-11," *Journal of the Royal Asiatic Society of Great Britain and Ireland* (1912): 123.

fort as his residence.⁹⁷ By all accounts, it enjoyed a prominent place above the banks of the Yamunā River, where it was quite visible to the local populace and visiting pilgrims. But the level of visibility enjoyed by the observatory itself is unknown, particularly given that it was contained within a royal residence, and access to this private space was limited to a privileged few. In extant images of the Kans ka Kilā drawn before the observatory's dismantling, it seems that the instruments were completely obscured from the public gaze, visible only to those actually standing on the roof of the fortress (figures 2.14-2.16).⁹⁸

The earliest known description of the observatory at the fort was penned by Joseph Tieffenthaler, an Austrian Jesuit who visited the Mathura observatory in May 1744 CE, a year after the death of Sawai Jai Singh.⁹⁹ His two-paragraph sketch of the rooftop observatory gave the overall dimensions of a few of the instruments, but indicated their functions only in the most general manner, and his travelogue suggests that even if the instruments had been visible to outsiders, they may not have been particularly striking objects. After he noted that “one sees on top of the fortress the astronomical instruments erected by the famous Raja, Jai Singh, an admirer of astronomy,” he pointed out that the collection was nothing but a weak imitation of the observatory in Jaipur.¹⁰⁰ And if his measurements were even close to accurate, the instruments reached nowhere near the height achieved by stonemasons in Shahjahanabad or Jaipur, as the Samrāt Yantra at Mathura reached a height of only twelve Parisian feet (approximately 12.79

⁹⁷ Vakil Report 1482, cited in Harish Chandra Tikkiwal, *Jaipur and the Later Mughals (1707-1803 A.D.): A Study in Political Relations* (Jaipur: Hema Printers, 1974), 32. See also Sharma, *Sawai Jai Singh and his Astronomy*, 229.

⁹⁸ William Orme's view of the Mathura Fort, based on painting by Francis Swain Ward, depicted the fort as a rather quiet and empty space, suffering from erosion at the riverside, and capped with an apparently temporary thatch roof (figure 2.14). The hazy, distant view of the fort, published in the third volume of Thomas and William Daniell's *Oriental Scenery* just after the turn into the nineteenth century, allowed the viewer to see little beyond the ramparts of the fortified palace (figure 2.15). Similarly, R. Sands engraving of the “Old Fort at Muttra,” completed at some date previous to 1861, provides a dramatic interpretation of the fort, but does little in the way of clarifying the scope or extent of the observatory (figure 2.16).

⁹⁹ Severin Noti, “Joseph Tieffenthaler, S.J., A Forgotten Geographer of India,” *East & West* 5 (1906): 150.

¹⁰⁰ Tieffenthaler, du Perron, and Rennell, 201.

feet).¹⁰¹ Tieffenthaler's lack of enthusiasm paralleled the sentiments expressed by other European visitors. William Hunter visited the Mathura observatory in 1796 CE and described the instruments as "imperfect, and in general of small dimensions."¹⁰² He noted the presence of a Samrāt Yantra, two small Agrā Yantras (horizontal sundials), one of which he would not attribute to Sawai Jai Singh and his astronomers since it appeared to serve no purpose, a small instrument for measuring amplitude, and what might have been the remnants of a Dakṣinottara Bhatti Yantra.¹⁰³ The third commonly invoked description of the observatory was written in 1883 CE by F. S. Growse, Magistrate and Collector of Bulandshahr. By the time Growse penned his notes on the observatory, however, the instruments, as well as Mathura fort, had long since been demolished. As Growse described it, the buildings of the fort were pulled down shortly before the 1857 CE uprising by "the great Government contractor, Joti Prasād," in order that the materials encumbered in the fort could be reused in new construction.¹⁰⁴ It is uncertain as to whether Growse himself had seen the instruments before the demolition of the fort; even if he had, he provided no written description of them in his memoir cum gazetteer of Mathura.

This is the extent of our knowledge of the Mathura observatory and its several instruments. If the intent behind its construction was to make a statement of political or cultural authority, even in the realm of abstract symbolism, the modesty of the declaration did Sawai Jai Singh no favors. No one seems to have made much note of the instruments during or after his lifetime. It would be easy to explain away the lack of archival evidence for this observatory by its relatively early date of demolition; however, the instruments existed *in situ* for at least seventy-five, and possibly as many as one hundred, years before they were demolished by Joti

¹⁰¹ A Parisian foot is roughly 12.79 inches, or 1.066 feet.

¹⁰² Hunter, "Some Account of the Astronomical Labours of Jayasinha, Rajah of Ambhere, or Jayanagar," 200.

¹⁰³ Ibid., 200-01.

¹⁰⁴ Growse, *Mathurā: A District Memoir*, 141.

Prasād. No construction or accounting records exist for the site, no images of the rooftop exist, and even the fort exists only in the trace of its stone foundations buried in the dust of the banks of the Yamuna River. The minimization of the observatory at Mathura in the archival record seems all the more puzzling when we recognize that more than any other cultural landscape available to the Maharaja Dhiraja, the region of Braj was one that he could easily and efficiently exploit in his favor. The Kacchawāhā clan, and particularly Sawai Jai Singh and his father, Bishan (Vishnu) Singh, as devotees of the cult of Krishna, were well acquainted with the landscape surrounding the cities of Mathura and Vrindavan. Bishan Singh (r. 1688-1699), although formal ruler of the state of Amer, spent most of his reign in Braj, leading military campaigns against the Jats in the name of Emperor Aurangzeb. While in Agra and Mathura, he apparently became interested in Krishna *līlā* (“frolics and playful life of Krishna”) and commissioned two poems centering on Krishna *līlā* themes, the *Govardhanalīlā* (written by Dūnarāi) and the *Govardhanoddharanalila vyāyoga* (written by Dhurandhara Kavi).¹⁰⁵ In addition, he is credited with the founding of the city Vishnupura near the capital city of Mathura, as well as “rehabilitating” twelve forests along the Ban-Yātrā route that was followed later by Sawai Jai Singh during his Brajmandala pilgrimage.¹⁰⁶ Bishan Singh’s interest in the religious landscape of Braj was inherited by Sawai Jai Singh, and when the Maharaja Dhiraja later returned to Mathura and Agra as *fauzdāra* (military governor), he actively sought out the priests of the local Gaudiya sect of the Krishnaite cult.¹⁰⁷ More important than any one individual act of

¹⁰⁵ Khasmohor MS. Nos. 958 and 1876, Potikhana of the Maharaja Sawai Man Singh II Museum. See Bahura for a catalogue of and commentary on the Sanskrit and Brajbhasha manuscripts held in the Khasmohor collection. Bahura, 49; G. P. Pilia, *Enlightened Government in Modern India: Heritage of Sawai Jai Singh* (Jaipur: Aalekh Publishers, 2002), 117.

¹⁰⁶ Kṛṣṇa Bhaṭṭ, *Īśvaravilāsa Mahākāvya*, trans. Madhuranatha Shastri (Jaipur: Oriental Research Institute, 1958), 36-42. See also Bahura, 49; Pilia, 117.

¹⁰⁷ This particular form of Krishna worship was developed by Chaitanya, born 1486 CE in Navadvīpa (Bengal). According to Vaishnava tradition, Chaitanya sent two brothers, Rūpa and Sanātana Goswāmi, to the Braj city of Vrindavan in order to seek out sites that had once been associated with the pageant of Krishna, but had since been

religious devotion on the part of Bishan Singh or Sawai Jai Singh, however, was the fact that the Kacchawāhā clan, and Sawai Jai Singh in specific, was known by the resident and visiting populace as a devotee of Krishna and the formal custodian of that deity in the shape of the Govindadevji icon of Vrindavan.¹⁰⁸

Govindadevji was originally installed in a Vrindavan temple by Rūpa Goswāmi during the first half of the sixteenth century, and moved to a new home in the Kanak Vrindavan gardens south of Amer later some years later.¹⁰⁹ During the construction of Jaipur, Sawai Jai Singh moved him to a new residence in the Jai Niwas gardens in the City Palace complex. It is unclear how the Kacchawāhā clan became involved with the custodianship of the image and his temple, but in 1633 CE, with the encouragement of Emperor Shahjahan, the Amer Kacchawāhās assumed complete responsibility for Govindadevji's well-being.¹¹⁰ In 1669 CE, allegedly in response to the iconoclastic tendencies of the Mughal emperor Aurangzeb, the Govindadevji image was removed by Ram Singh I (not Mirza Raja Jai Singh I, as is often alleged) to the more secure location of "Govindpur" in the state of Amer.¹¹¹ The record of Govindadevji's travels to Amer is difficult to reconstruct, but it appears that the image, along with companion images, was

neglected. Additionally, the brothers were charged with excavating images of Krishna thought to be buried in Braj, and also to teach the Vaishnava form of worship to the people of Vrindavan, Mathura and other local towns. Bahura, 62-63; Pilania, 117, 24. For a full accounting of the life of Chaitanya in Navadvīpa, see E. Alan Morinis, *Pilgrimage in the Hindu Tradition: A Case Study of West Bengal* (Delhi: Oxford University Press, 1984), 122-64.

¹⁰⁸ Govinda is an alternative name for Krishna that associates him with the pastoral landscape of Braj. The root "go" means "cow," while "vinda" means "protector." "Devji" is an honorific denoting Govinda's status as a deity.

¹⁰⁹ According to Govindadevji's caretakers, Rūpa Goswāmi unearthed the image in a mound at Gomātīlā between 1525 and 1534 CE. See R. Nath, "Śrī Govindadeva's Itinerary from Vrindāvana to Jayapura, c. 1534-1727," in *Govindadeva: A Dialogue in Stone*, ed. Margaret H. Case (New Delhi: Indira Gandhi National Centre for Arts, 1996), 161; Roy, 161.

¹¹⁰ Monika Horstmann and Heike Bill, *In Favour of Govinddevji: Historical Documents Relating to a Deity of Vrindaban and Eastern Rajasthan* (New Delhi: Manohar, 1999), 3. This volume is an invaluable source of documentation for historians of the cult of Govindadevji, since it provides not only a narrative of the life of the image, but also facsimiles, transcriptions, translations and analyses of revenue grants and deeds associated with the administration of Govindadevji and his temple. These grants were written in Persian and Rajasthani (a broad category that covers several dialects of Dhundhārī and Mārwarī).

¹¹¹ *Ibid.*, 13-14. Horstmann also argues that Aurangzeb did not destroy the temple at Vrindavan as is usually supposed, although "the sanctuary was dismantled and figures on the doorway of the *jagmohan* (the space in front of the sanctuary) were defaced."

moved frequently, perhaps in an attempt to safeguard it from Aurangzeb's agents.¹¹² It is not until 1707 CE, during the reign of Sawai Jai Singh, that Govindadevji made a verifiable appearance at Govindpur, a site allegedly consecrated especially for him by Mirza Raja Jai Singh (Jai Singh I). By 1713 CE, grants indicated that Sawai Jai Singh was actively trying to construct an appropriate abode for the image, first in a garden temple of Kanak Vrindavan gardens on the banks of Mānsāgar reservoir south of Amer, and finally in his current home in Jai Niwas gardens, just north of the Chandra Mahal in Jaipur's City Palace.¹¹³

The tale of the Govindadevji image's meandering fate demonstrates the long-standing relationship of the Kacchawāhās with the built environment and religious landscapes of Mathura, Vrindavan, and the greater region of Braj, and suggests that over time, the association of the Kacchawāhās with the region intensified rather than diminished, particularly during the reign of Sawai Jai Singh. As Monika Horstmann argues, "the Kachavāhā munificence is visible everywhere in Braj," primarily in connection with the cult of Krishna, but also in relation to other building projects.¹¹⁴ The projects in the region of Vrindavan and Mathura were so extensive that "the Kachavāhās' attachment to the sacred land of Kṛṣṇa became, in acts of political and religious symbolism, converted into a visible inventory, and the grants which the family made perpetuated their dynastic presence. [Govindadevji] was the symbol of Kachavāhā

¹¹² Both Pilania and Horstmann have tried to piece together Govindadevji's itinerary through grant documents and related literary texts. See Ibid., 14-16; Pilania, 237-46.

¹¹³ Whether Govindadevji's stay in Jai Niwas has been continuous is a matter of some debate. Apparently, the Kanak Vrindavan temple was still being expanded several years after Govindadevji's installation in Jai Niwas. In addition, there was some discussion as to whether the image should be returned to the Jat dominated region of Braj. See Horstmann and Bill, 19-25.

¹¹⁴ As just a few examples of Kacchawāhā patronage, we can look at the Saṭī Burj tower at the Viśrām Ghat of Mathura, sponsored by Raja Bhagavantdās (r. 1573-1589). Raja Bhagavantdās also reportedly built the Haridev temple at Govardhan, a sacred hill near Vrindavan. Raja Bhagavantdās' son, Mān Singh, sustained the Kacchawāhā relationship with Braj, extravagantly expanding Rūpa Goswāmi's Govindadevji temple in Vrindavan between 1576 and 1590 CE. See Catherine Asher, "Kacchavāhā Pride and Prestige: The Temple Patronage of Rājā Māna Simha," in *Govindadeva: A Dialogue in Stone*, ed. Margaret H. Case (New Delhi: Indira Gandhi National Centre for Arts, 1996), 216; Horstmann and Bill, 2; Nath, 163.

glory.”¹¹⁵ Moreover, “if we are looking for the personal religious attachment on the part of a Kachavāhā, it is most of all [Sawai] Jaisingh II...who comes into view.”¹¹⁶ And indeed, extensive literary evidence suggests that Sawai Jai Singh took seriously his engagement with the Goswāmis of Vrindavan, exchanging letters with Goswāmi Shyāmācharanjī on matters pertaining to Krishna in the Bhāgavata, Mahābhārata, and Vāyupurāna, among other subjects.¹¹⁷ During his tenure in Mathura and Agra as *fauzdāra* (c. 1723 CE), the Maharaja Dhiraja sought to increase his Vaishnava knowledge through personal audiences with the priests of Vrindavan, and this interaction, combined with long-standing clan conventions, may have prompted his loyalty to Govindadevji, which resulted in the installation of the image of the deity in Jaipur.

Given these close and on-going connections between Sawai Jai Singh and Braj, the relative absence of attention given to the observatory at Mathura during and after the eighteenth century seems odd. This lack seems particularly strange since Mathura is located quite close to Jaipur, and stands along the pilgrimage triangle of Delhi-Ajmer-Agra that ran through the capital city of the state of Amer. If any cultural landscape was available for symbolic exploitation, it was the one blanketing the region of Mathura and Vrindavan. Sawai Jai Singh inherited a countryside saturated with symbols of Kachavāhā beneficence, and because of his continued protection of Govindadevji, the landscape could only have grown more dense with references to the king and his clan. It is possible that the observatory did function as an important representative of the Maharaja Dhiraja’s power, and that this activity was simply never recorded in the archive, or perhaps was lost at some point between the first half of the eighteenth century and today. However, it seems more likely that Sawai Jai Singh never assigned any significant communicatory role to the observatory, possibly because no room could be made for a space of

¹¹⁵ Horstmann and Bill, 7.

¹¹⁶ Ibid.

¹¹⁷ Bahura, 65; Pilania, 128-30.

scientific inquiry in a region so deeply committed to the cult of Krishna. In a city over-crowded with pilgrims, the observatory simply could not compete with Govindadevji and the Krishna *līlā* embedded in the forests, lakes, and wells of the region. This assertion is speculative at best, but at times it seems as if the very existence of the observatory almost comes down to conjecture—the paucity of archival and architectural evidence implies that the observatory was of secondary importance not just in the religious landscape of Braj, but the greater network of Sawai Jai Singh’s observatories, as well.

To be true to the sources, both archival and architectural, is to admit that the possibilities for consolidating political or cultural capital through the construction of astronomical instruments outside the walls of the pilgrimage city Ujjain are even fewer. Although not as thoroughly cloaked as the observatory in Mathura, the instruments at Ujjain were not as readily available for scrutiny as they were outside Shahjahanabad, or even in the quasi-public space in Jaipur. As was the case in Shahjahanabad, this observatory was built outside the walls of the city and had the benefit of an association with the Jaisinghpura south of the city on the banks of the Kshipra River. The Maharaja Dhiraja had been granted control over this sector of the imperial *purā* after his appointment as governor of Malwa in 1713.¹¹⁸ The instrumentation in Ujjain was roughly of the same scale as that on the rooftop of the Kans ka Kilā in Mathura. The Samrāt Yantra in Ujjain measured only 22 feet in height, much more in line with the scale of the human body than either of the similar instruments at Jaipur or Shahjahanabad (figure 2.17). The

¹¹⁸ An early map shows a *purā* surrounded with crenellated walls, standing tight against the banks of the Kshipra River. Within the walls, which are marked occasionally with gates, stands a quadripartite *chār bāgh*, as well as other geometrically delineated spaces. See Map 62 in Gopal Narayan Bahura and Chandramani Singh, *Catalogue of Historical Documents in Kapad Dwara, Jaipur*, vol. II. Maps and Plans (Amber: Jaigarh Public Charitable Trust, 1990), 23, 64–65, Plate XIV. A note on the map reads: “बाग पातसाही में पुरो बसायौ दीवान मैहमद सईद हाल सु सौ यौ पुरो सरकार का पुरा में बसायौ छै सो ईका जतन श्रीमहाराजाजी करसी नत्र ई को फिसाद ज्यादा छै, सिरकार पुरो बेरान होसी जी जतन सिताब कीज्यो।” “The pura is settled within the imperial garden. Diwan Muhammad Said should hand it over. Since the pura is within the government’s pura, it should be managed by the Maharaja; otherwise many disturbances might arise and the imperial pura would be barren. Therefore, early steps should be taken in this matter.”

masonry instruments were still quite bulky and over-engineered for their functions, but they failed to make a declarative statement of authority just through their presence in the local landscape. As in size, the instruments here were limited in number. Only a single Samrāt Yantra, Digamśa Yantra, Dakṣinottara Bhatti Yantra, and a Naḍīvalaya were built on the riverbank.¹¹⁹

A cursory examination of the historical record suggests that this observatory could have frequently hosted Sawai Jai Singh and his traveling court. Muhammad Shah appointed Sawai Jai Singh *subedār* (governor) of Malwa twice, once in October 1729 CE, and again in October 1732 CE, and it is usually assumed that the observatory in Ujjain was constructed during one of these two tenures. In reality, Sawai Jai Singh rarely graced the city of Ujjain with his royal presence during these periods. Instead, he spent his time roaming greater Malwa, pursuing the military policy of Muhammad Shah against the Jats and Marathas. For example, the Maharaja Dhiraja left Amer for Ujjain on October 23, 1729 CE, after his first appointment as *subedār* (governor), but when Maratha forces captured Mandu while he was still en route to the city, the king was forced to bypass Ujjain entirely and head for the occupied city of Mandu.¹²⁰ He eventually arrived in Ujjain in December of that year, but did not linger long in the neighborhood.¹²¹ By April 6, 1730 CE, he had already traveled from Malwa to Pancholas to defend the city of Bundi from an assault by Maharao Budh Singh, and he spent the balance of April camped at Indore.¹²² Formally, he continued to serve as governor of Malwa until November of 1730 CE; however, he remained in the region only until May 1730 CE, at which time he headed back to Jaipur. The

¹¹⁹ The Śanku Yantra at Ujjain was added in 1938 CE by the astronomer Govinda Sadāśiva Apte, who was appointed Superintendent of the observatory September 1, 1930 CE. See Finance Department, *The Gwalior Civil List, LXXI* (Lashkar: Aligarh Press, 1936), 74; Sharma, *Sawai Jai Singh and his Astronomy*, 227. The edge of this instrument is also marked with the year 1938 CE.

¹²⁰ Bhatnagar, 204.

¹²¹ Sarkar, 178.

¹²² Bhatnagar, 206, 18.

total length of his absence from his home state was approximately seven months, but very little of that time was spent in Ujjain's Jaisinghpura.¹²³ While it is certainly possible that the Maharaja Dhiraja was consulted on the construction or use of the observatory at Ujjain during 1729-1730 CE, there is no record of any pause in his military campaigns against the Marathas and Maharao Budh Singh. Sawai Jai Singh was appointed governor of Malwa once again in 1732 CE, and left Jaipur for that region on October 20, 1732 CE.¹²⁴ This second tenure in Malwa, which has been described as "brief and inglorious," seems even more unlikely to have encompassed astronomical work at Ujjain, as he was almost instantly expelled from the region by the Marathas.¹²⁵ Although the possibility of the Maharaja Dhiraja's presence at the observatory exists, the archive speaks against it rather emphatically, leaving us to wonder how intensive his work at the observatory could have been during his tenure as governor of Malwa.

Obviously, the instruments still extant in Ujjain demonstrate that the observatory was constructed at some point in time, and according to the narrative in the preface to the *Zīj-i Muḥammad Shāhi*, this occurred only after the successful construction of the instruments at Shahjahanabad.¹²⁶ But as is the case with the Mathura observatory, no records exist today to demonstrate that the instruments were used to gather corroborating observations, or to represent the court of Sawai Jai Singh to the local citizenry. This state of affairs is as perplexing as the one encountered in Mathura, as both cities seemed primed to absorb any cultural or political messages the observatories were capable of expressing. Moreover, as both cities functioned as significant pilgrimage centers, even during the eighteenth century, we might think that these

¹²³ Ibid., 204-07.

¹²⁴ Ibid., 210.

¹²⁵ G. S. Cheema, *The Forgotten Mughals: A History of the Later Emperors of the House of Babar, 1707-1857* (New Delhi: Manohar Publishers & Distributors, 2002), 169.

¹²⁶ Shastri offers a completion date of 1734 CE, the same date he assigns to the observatory at Jaipur. However, we know from construction records that the observatory at Jaipur is coeval with the capital city founded in 1728 CE, so we might be skeptical of Shastri's claim. Shastri, xiv.

messages would possess a certain amount of mobility since pilgrimage, even when primarily understood as a religious practice, enabled the transmission and exchange of information, ideas and rituals. As Surinder Bhardwaj points out, “the number of Hindu sanctuaries in India is so large and the practice of pilgrimage so ubiquitous that the whole of India can be regarded as a vast sacred space organized into a system of pilgrimage centers and their fields.”¹²⁷ The seepage of pilgrims and information across the boundaries of these fields was a constant, turning what might have once been a static structure of worship into a fluid system of interrelated landscapes thoroughly saturated with motion. If the observatories in Ujjain or Mathura were at all capable of sending out signals or cultural messages to an itinerant public, traces of them should appear in pilgrim guides, or as part of oral histories describing the Ban-Yātrā at Mathura or Kumbh Mela at Ujjain. Yet, these sources say nothing in regard to the astronomical observatories in those cities.

The silence—or silencing—of the Mathura and Ujjain observatories in the historical record prompts a similar set of questions to the fifth observatory constructed in Varanasi. The instruments of the Varanasi observatory were distributed across the two roofs of the Mān Mahal, a palace built under the patronage of Mān Singh I of Amer in 1614 CE on the Mānmandir Ghat (figure 2.18).¹²⁸ At first glance, this observatory, too, seems ideally positioned to have communicated to a local or pilgrim population on the move, particularly as it was located next to the main bathing ghat in that city. However, the instruments on the roof of the Mān Mahal were almost completely obscured from public view. Any individual arriving at the palace on foot

¹²⁷ Surinder Mohan Bhardwaj, *Hindu Places of Pilgrimage in India: A Study in Cultural Geography* (Berkeley: University of California Press, 1973), 6.

¹²⁸ In his *Travels in India*, published in 1676 CE, Tavernier describes the palace as attached to a great temple (pagoda), and the site of a college in which the children of Mirza Raja Jai Singh I were being educated in Sanskrit by several Brahmins. Jean Baptiste Tavernier, *Travels in India*, trans. V. Ball, vol. II (London: Macmillan and co., 1889), 234-35.

could see only the top of the gnomon of the large Samrāt Yantra, and even that instrument disappeared from sight upon closer approach to the building. The clearest, but still partially occluded, view of the observatory was obtained from the Ganges. The side wall of the Digamśa Yantra was visible on the right side of the Mān Mahal to anyone approaching the ghat from the river; however, its legibility as an astronomical instrument is doubtful. It might have been noted as an oddity, but it failed to act as a dominant feature in a façade already threatening to dissolve into aesthetic chaos. Indeed, The Mān Mahal was noted in early English-language tourist literature not for the observatory, but for its *jarokha* windows and the arcuated in-fill in the central façade that resulted from a late addition to the palace. Prinsep described it as “one of the most picturesque objects for the artist’s pencil” due to the “antiquated irregularity of its front, enhanced by the expanse of never-ending steps at its base, and a back-ground well suited to the effects of light and shadow.”¹²⁹ And although the building had direct ties to the Kacchawāhā clan through the original patronage of Mān Singh, there is no record of Sawai Jai Singh making an appearance at this site, or even in this city. The connection back to Amer through the instruments was necessarily much weaker than even those of Ujjain and Mathura, where at least the possibility existed of locating the royal body within the grounds of the observatory.

Ultimately, there is little to suggest that the more distant observatories produced much scientific or cultural capital for the Maharaja Dhiraja of Amer, and a closer look at the observatories in Mathura, Ujjain, and Varanasi only serves to raise more questions as to the communicatory possibilities of these smaller spaces. Setting aside the issue of functionality and the employment of the instruments as part of an observational program, we can posit several reasons that these outlying observatories could not perform the same symbolic work as those in Shahjahanabad or Jaipur, even though they were all located within properties associated with the

¹²⁹ James Prinsep, *Benares Illustrated, in a Series of Drawings* (Calcutta: Baptist Mission Press, 1831-34), n.p.

Sawai Jai Singh and the Kacchawāhā clan. First, it is probable that during the twenty or so years between the ground-breaking at Shahjahanabad and Sawai Jai Singh's death in 1743 CE, the Maharaja Dhiraja realized that his observatories were not the communicative tools that he once wished them to be, and he himself decided not to press them into use as objects representative of his power and interests. While he could hope that the large-scale instruments at Shahjahanabad and Jaipur would invoke images of his power to marshal raw materials and labor efficiently enough to complete such massive building projects, he probably could not expect anyone to immediately comprehend the Ptolemaic science behind the operation, even if they understood it that it was due to his patronage. The instruments simply were not as visually and culturally transparent as Timurid-inspired tombs, and we have good reason to doubt the legibility of the observatories as both sites of science and as monuments to power and politics.¹³⁰ A persistent inability to read the observatories has been thoroughly documented in the records from the past 200 years, and there have been continual intrusions into these spaces to make them more comprehensible. For example, over the course of the nineteenth and twentieth centuries, more and more changes were introduced into the grounds in an effort to rationalize the space at Delhi, and to make it a comprehensible component of a historical narrative of a Mughal/Persian capital city. The observatory has been enclosed with a fence, and the space around the instruments has been assigned characteristics commonly associated with the Mughal pleasure garden, such as a

¹³⁰ As Melia Belli points out, Rajput kings had similar recourse to funerary monuments as expressions of power and kingship in the form of *chatrīs*, the cenotaphic form of the symbolic umbrella. As permanent markers, *chatrīs* were rooted in the traditions of Indo-Islamic tomb building, in that Indic funerary structures were constructed of ephemeral materials in the pre-Islamic age, and developed into permanent monuments only after the arrival of Islam on the subcontinent. Because *chatrīs* were built at a noticeably smaller scale than later Mughal tombs (e.g., Humayun's Tomb in Delhi or the Taj Mahal in Agra), it has long been assumed that they carried relatively little symbolic weight in the cultural landscape of Rajput kingship. Belli's study challenges this accepted position, and argues successfully that *chatrīs* participated strongly in multiple political and social conversations well into the era of British colonial rule. For a discussion on the role *chatrīs* played in the construction of the public identity of the Kacchawāhā rulers, see Melia Belli, "Royal Umbrellas of Stone: Memory, Political Propaganda, and Public Identity in Rajput Funerary Architecture" (University of California, Los Angeles, 2009), 63-112.

reflecting pool (now a flower bed) and axially (sidewalks at right-angles, drawing the eye along a straight line) (figure 2.19).¹³¹ In addition, a red “royal” plaster, reminiscent of the imperial sandstone building projects of Akbar and other Mughal emperors, has been applied to the exterior surfaces of all the instruments, even though early photographs seem to indicate an original lack of a harmonizing finish plaster on the instruments.¹³²

This same impetus toward rationality occurs at the observatory in Ujjain as well. Originally the Samrāt Yantra and Naḍīvalaya were the only two instruments possessing a noticeable spatial relationship to each other, as the Naḍīvalaya was sited on axis with the gnomon of the Samrāt Yantra (figure 2.17). However, at some point during the twentieth century, the Digaṃśa Yantra was pulled into balance with these instruments through the introduction of a small Hanuman temple in line with the door of that instrument (figure 2.20). The addition of this new element forced the four structures into a cross-axial arrangement, and provided another organizational element around which the open space of the observatory could be arranged (map 2.2). Though the instruments might seem—and might always have seemed—to be mysterious and functionally opaque, the observatory as a whole now possesses a spatial and visual uniformity that it lacked in its original state. Given the repeated and ongoing interventions

¹³¹ The reflecting pool is shown clearly in Hermann Kern, *Kalenderbauten: Frühe Astronomische Großgeräte aus Indien, Mexico und Peru* (Munich: Die Neue Sammlung, 1976), 62.

¹³² The changes to the instruments seem to have progressed slowly over the past two hundred years. In 1852, the Archaeological Society of Delhi petitioned the Jaipur Raja for funds to repair the Samrāt Yantra. In 1909-10 CE, Gokul Bhavan, assistant to Garrett and Guleri for the restoration of the Jaipur observatory (c. 1901 CE), restored the rest of the damaged instruments. In 1951, a portion of the Miśra Yantra was restored by the Astronomer Royal of Jaipur. Finally, in 1993, the Astronomical Society of India proposed an extensive restoration of the Delhi instruments. The complex is maintained today in various states of (dis)repair by the Archaeological Survey of India, but there are always plans afoot for more restoration of the instruments. See “3rd October 1850,” *Journal of the Archaeological Society of Delhi* (January 1853): 67-68; “3rd June, 1852,” *Journal of the Archaeological Society of Delhi* (January 1853): 71; “6th January, 1853,” *Journal of the Archaeological Society of Delhi* (January 1853): 74; G. S. D. Babu and V. R. Venugopal, “Programme for the Restoration of the Masonry Instruments at Delhi Jantar Mantar,” *Bulletin of the Astronomical Society of India* 21, no. 3-4 (9 1993): 481-83; Sharma, *Sawai Jai Singh and his Astronomy*, 97-98; Dhananjay Mahapatra, “ASI to restore Jantar Mantar, preserve antiquity,” *The Times of India*, December 21, 2007, 5; Richi Verma, “Conservation plan soon for yantras,” *The Times of India*, December 21, 2007, 5.

into the sites at Delhi and Ujjain in pursuit of clarity, it appears that few visitors were able to accurately assess the purpose and function of the observatory and were simply impressed by size and scale. In short, Sawai Jai Singh could not rely on the expressive capabilities of the observatories, and we should be skeptical of interpretations of Sawai Jai Singh's scientific or architectural agendas that rest on the visual strength of the instruments alone.

Other possibilities for the relative unimportance of the outlying observatories appear when the distribution of the observatories across the greater landscape of northern India is given further study. The more distant the observatory from the spot at which Sawai Jai Singh was then standing, the less control he had over the finished product. The observatories at Mathura, Ujjain, and Varanasi might reveal less about his intentions and more about the ways in which his intentions were mediated, communicated, or even rejected by other agents involved in the design and construction process. As we will see in our consideration of the observatory in Jaipur (Chapter Three), many different individuals, none of whom held Sawai Jai Singh's privileged relationship with the project, were applying various skill sets to work at the observatories at any given time. Though the design concept implemented at all of the observatories is credited to Sawai Jai Singh himself, neither the work of constructing the instruments nor the process of observing after they were complete was his responsibility alone. He was not the exclusive agent of change at either Shahjahanabad or Jaipur, the two sites at which he was most likely to be present, and affected even less the three sites at which he seldom, if ever, made an appearance. The instruments could have been small and cost-effective either by order of the Maharaja Dhiraja, or by a choice made locally. Without being present, Sawai Jai Singh had little control over the final product, but even if he had, given his decisions to turn brass into stone into less stone, he might have realized that outsize equinoctial sundials were hardly a good investment.

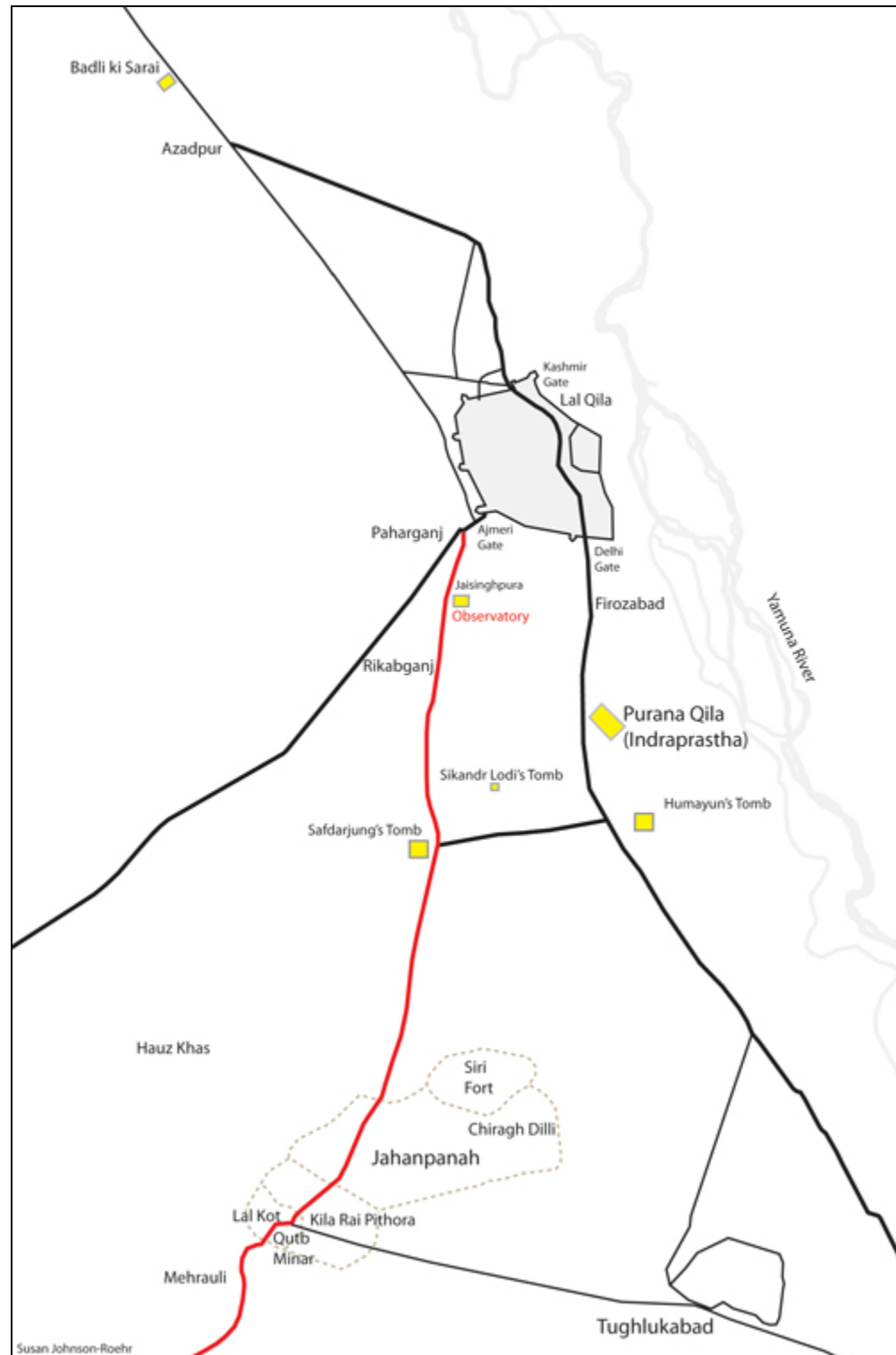
Regardless of the reason for the peripheral status of the observatories at Mathura, Ujjain, and Varanasi in the larger project of gathering accurate observational data, or in an attempt by the Maharaja Dhiraja of Amer to convey strength of his political position through architectural patronage, the fact that these three observatories played very small roles in these tasks is incontrovertible. As Joseph Tieffenthaler indicated, these outliers were but “weak imitations” of the instruments in Shahjahanabad and Jaipur and truly did not represent the capacity for scientific creativity exhibited by Sawai Jai Singh and his astronomers at those sites. Although the astronomical observatories were assigned a position of privilege through a historiography emanating from a seat of British colonial power in Varanasi, the crucial elements of the system were to be found more than half way across the subcontinent, in the capital cities of the Mughal emperor Muhammad Shah and the Maharaja Dhiraja of Jaipur and Amer, Sawai Jai Singh II.

2.4 Recentering

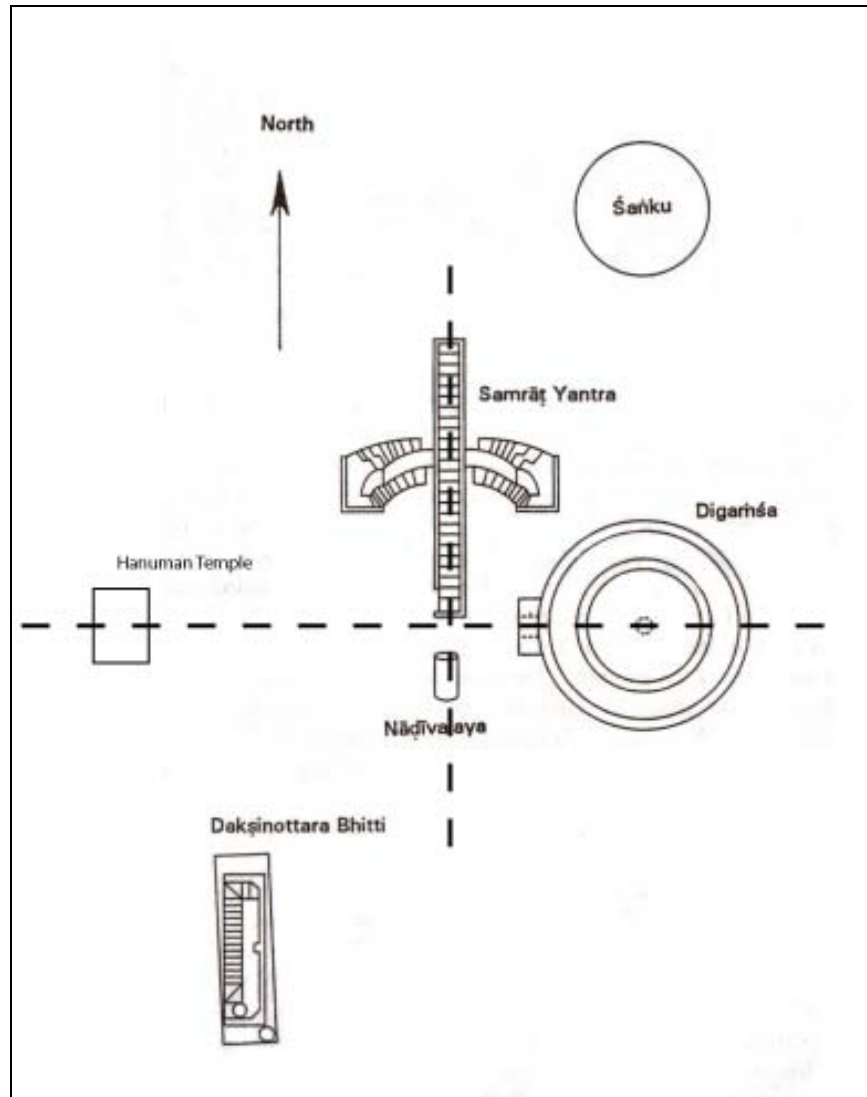
The historical interplay between the observatories in Shahjahanabad and Jaipur thwarts the attempt to model the design development of the observatories along the lines of a simplistic core-periphery relationship. Groundbreaking for stone instruments occurred first in the Jaisinghpura of Shahjahanabad, some seven years before the construction of the streets and bazaars of the new city of Jaipur. It is therefore tempting to assign to the observatory in the Mughal capital a position of greater significance, since it was the point of origin of all the instruments, in addition to being located in close proximity to the center of Mughal power during the reign of Muhammad Shah. However, the Maharaja Dhiraja’s attention seems to have quickly shifted away from Shahjahanabad once the walls of Jaipur began to take form. There were probably many reasons for this change in focus: Sawai Jai Singh may have been expecting to spend more time in Jaipur and less time away from his kingdom leading the emperor’s military

campaigns; he may have found the Jaipur location more expedient in terms of the availability of labor and material resources; he may have wished for more oversight during the construction process on a day to day basis. Most likely, after the arguable success of his venture in Shahjahanabad, the Maharaja Dhiraja may have seen in greater clarity the political potential in the combined images of science and ceremony. While he may have been hoping to pursue his astronomical studies closer to home, simply as a matter of convenience, he realized that, as the buildings of the city of Jaipur rose from the Dhundhar plains, so too did the number of possibilities for symbolic representations of his power and prestige. Jaipur, as a designed landscape, offered a fresh opportunity, upon which the Maharaja Dhiraja could control and manipulate both audience and architecture in service of his throne.

2.5 Maps



Map 2.1. Delhi area with Qutb Road, showing location of observatory in Jaisinghpura. Adapted from Fanshawe.



Map 2.2. Plan of observatory, Ujjain, showing axuality of temple and instruments.
Adapted from Sharma, *Sawai Jai Singh and His Astronomy*, 219.

2.6 Figures



Figure 2.1. Archibald Campbell, View of Observatory, Benares, 1777 CE. Watercolor. Courtesy of Royal Society, London.

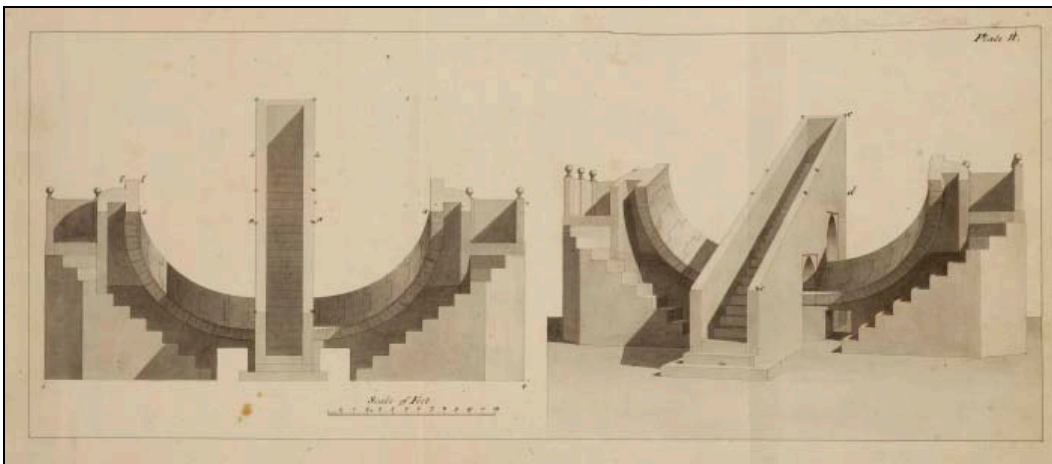


Figure 2.2. Archibald Campbell. Samrāt Yantra, Benares, 1777 CE. Courtesy of Royal Society, London.

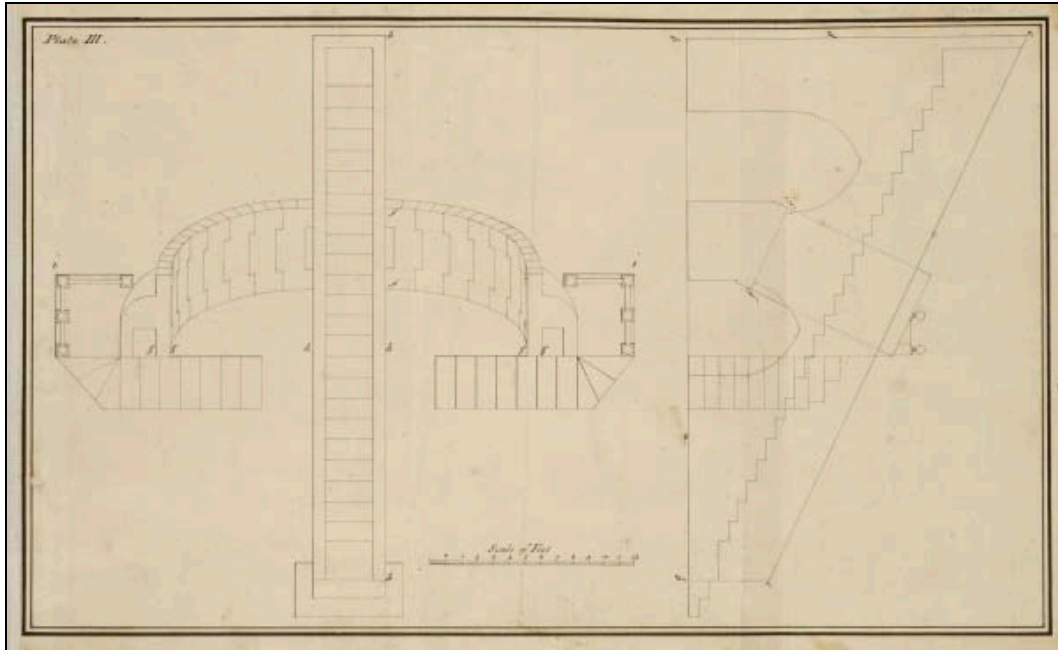


Figure 2.3. Archibald Campbell, Measured Drawing, Samrāt Yantra, Benares, 1777 CE. Courtesy of Royal Society, London.

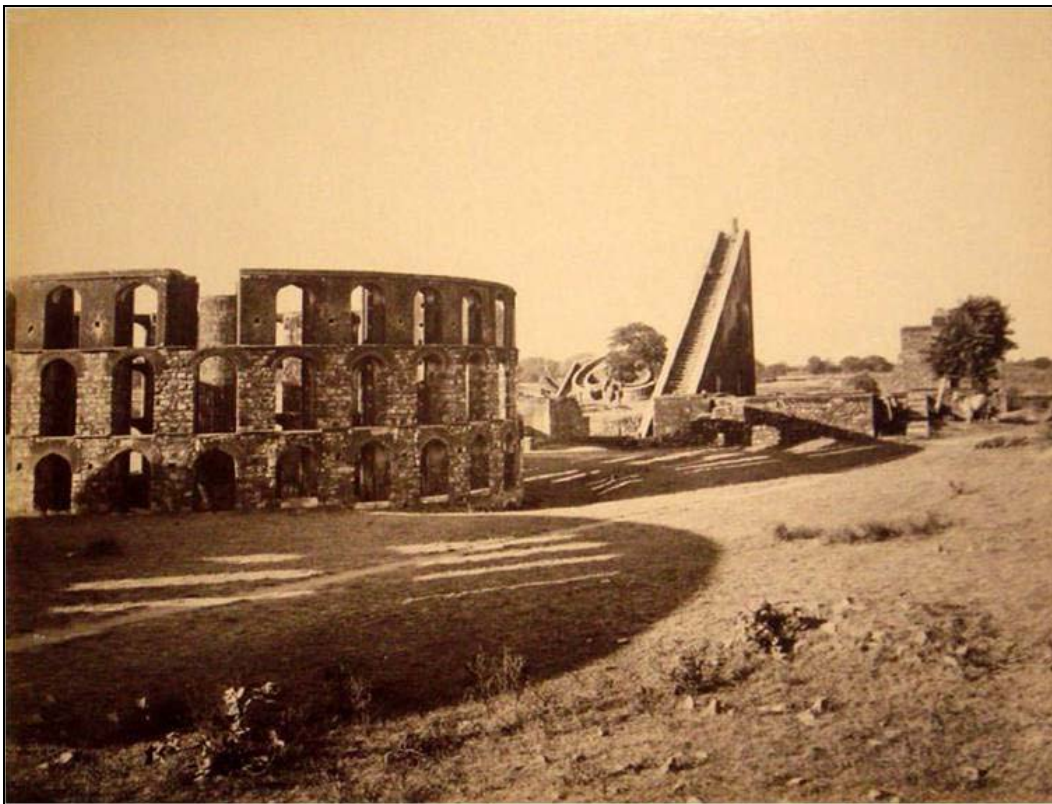


Figure 2.4. Lala Deen Dayal, Delhi Observatory, c. 1880 CE.



Figure 2.5. Samrāt Yantra, Delhi, February 2009 CE.



Figure 2.6. Raised platforms of Jaya Prakāśa Yantra (Rāma Yantra behind), Delhi, June 2007 CE.



Figure 2.7. Remnants of Scaled Surfaces, Jaya Prakāśa Yantra, Delhi, June 2007 CE.



Figure 2.8. Rāma Yantra, Delhi, March 2009 CE.



Figure 2.9. Rāśivalayas, Jaipur, March 2009 CE. Courtesy of David K. Troux.

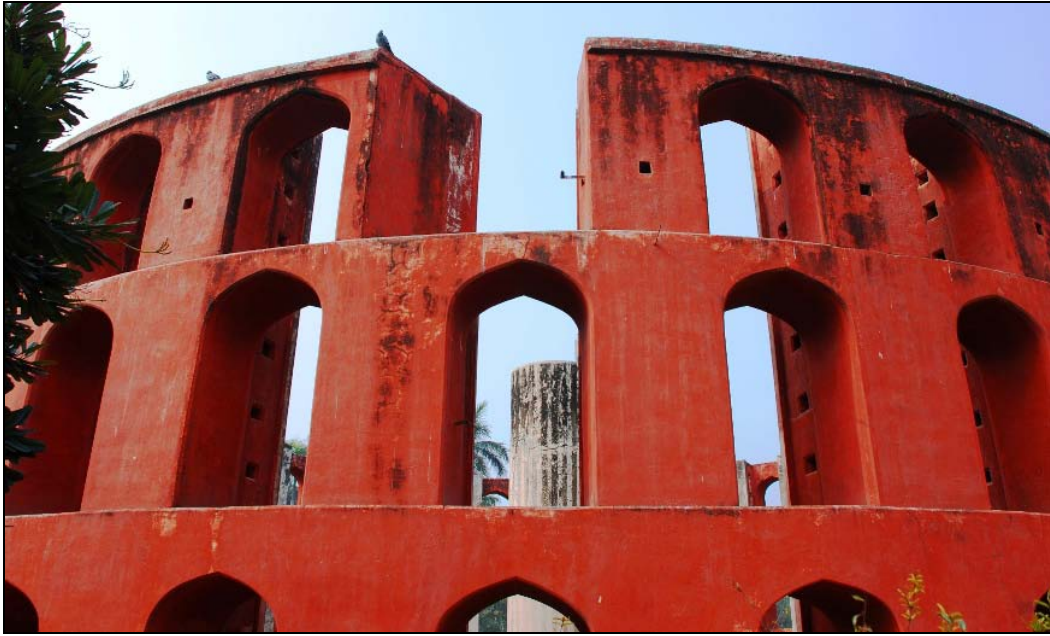


Figure 2.10. Rāma Yantra, Arcade, Delhi, March 2009 CE.



Figure 2.11. Scales, Interior Rāma Yantra, Delhi, March 2009 CE.



Figure 2.12. Perforated Scales, Interior Rāma Yantra, Delhi, June 2007 CE.



Figure 2.13. Rama Yantra, Jaipur, 2006 CE.



Figure 2.14. William Orme, "Multara Fort (on the Jumna)," from *24 Views in Indostan* by William Orme, Plate 20. Based on a painting by Francis Swain Ward, c. 1770 CE. Courtesy of the British Library, London.



Figure 2.15. Thomas and William Daniell, *Oriental Scenery*, Vol. 3, Plate 22. Courtesy of British Library, London.



Figure 2.16. Robert Montgomery Martin, "An Old Fort at Muttra," Engraved by R. Sands, c. 1860 CE. From *The Indian Empire, Illustrated*, Vol. 3, following p. 56.



Figure 2.17. Samrāt Yantra with Naḍivalya (foreground) and Digamśa Yantra (right), Ujjain, July 2007 CE.



Figure 2.18. Photograph of the Observatory, Varanasi, from the Kitchener of Khartoum Collection: *Views of Benares*. Presented by the Maharaja of Benares by Babu Jageswar Prasad, 1883 CE. Courtesy of the British Library, London.



Figure 2.19. Former reflecting pool, now flowerbed, Delhi, June 2007 CE.



Figure 2.20. Hanuman Temple as viewed from inside of Digamśa Yantra, Ujjain, July 2007 CE.

CHAPTER THREE

INSTITUTIONS IN THE INTRAMURAL LANDSCAPE

As patron and astronomer, the Maharaja Dhiraja Sawai Jai Singh II of Amer and Jaipur simultaneously directed information, materials, and people through intersecting networks distributed across various communicatory landscapes as part of a larger endeavor of producing and gathering astronomical knowledge. A multi-scalar analysis of the cultural landscape in which the observatories were embedded reveals the roles played by specific landscape elements, and highlights the challenges inherent in safeguarding the movement of ideas and people. To more fully understand the function of the observatories within these landscapes, we need to employ a methodological approach that, in addition to drawing our attention to the living and historic landscape, foregrounds the notion that scale affects the types and forms of knowledge production. That is, the extent, not just the typology or location, of the landscape also determined the form of knowledge set in motion by Sawai Jai Singh and his advisors. Knowledge shuttled between people, departments, institutions, cities, and nations and, depending on the distance involved in these transactions, it moved to different places, in different ways, for different reasons.

This is made visible nowhere more clearly than in the city of Jaipur, where the observatory participated in a network of knowledge production involving multiple institutions and labor pools operating within the walls of the city. An examination of this intramural network confirms one obvious point: the Maharaja Dhiraja needed to control the numerous data produced through observation at Jaipur and to create and safeguard the texts and transcriptions associated with said data within the palace workshops and libraries at Jaipur and Amer. However, the introduction of scale as an analytic reveals that this type of information might be

the most difficult to pinpoint in the city landscape. That is, direct evidence of the daily observation program in Jaipur remains elusive in the archives.¹ What comes to the fore in a study of this intramural network is what might be considered ancillary, rather than purely astronomical, knowledge, produced and circulated as part of the process of constructing and operating the observatory in the first decade of its existence. An analytical cross-section of the cityscapes of Jaipur and Amer during the second quarter of the eighteenth century reveals that astronomical or scientific knowledge was not the only, or possibly even the primary, category of knowledge circulating within the city walls. Instead, a dense system of communication regarding fiscal, construction, and labor practices, shaping and shaped by the landscape, emanated from the core of the observatory. The construction of the city observatory, a necessary procedural step before observations could commence, relied on a closely monitored bureaucracy, responsible for mobilizing at a controlled pace multiple governmental workshops, workers, commodities, orders, and materials within the city walls. While the intent of the Maharaja Dhiraja was to enable an observation program with an end goal of producing a definitive

¹ While we would expect some trace of daily observations to be preserved in the Rajasthan State Archives (RSA) or the archives of the City Palace Museum, as far as we know, no such records exist today. A nightly observational program can be implied only from a few sources in addition to the instruments themselves, such as the preface to the *Zīj-i Muḥammad Shāhī*, in which the Maharaja Dhiraja claimed to have gathered observations from each of the five observatories, and several remarks contained in Sanskrit treatises written at court. Jagannātha Samrāt, one of the senior astronomers at Jaipur, used data allegedly gathered at the Delhi observatory when explaining certain calculations in his translation of Ptolemy's *Almagest*, as shown in Ramasvarupa Sharma, ed. *Samrāt-Siddhāntah Avāntara Paṭhabhedasamanvitah Siddhāntasārakaustubhah*, 3 vols., vol. 2 (New Delhi: Indian Institute of Astronomical and Sanskrit Research, 1967), 1216-21. This dearth of informal observational notes has led to a disagreement within a small group of historians of science, some of whom argue that the *Zīj-i Muḥammad Shāhī* represents only an updated version of the 1727 CE reprint of Philippe de la Hire's astronomical tables, not an original compilation based on new observational data. See Raymond Mercier, "The Astronomical Tables of Rajah Jai Singh Sawa'i," *Indian Journal of History of Science* 19(April 1984): 143-71; Virendra Nath Sharma, "Zīj-i Muhammad Shahi and the Tables of de La Hire," *Indian Journal of History of Science* 25 (1990): 34-44; Benno van Dalen, "The Origin of the Mean Motion Tables of Jai Singh," *Indian Journal of History of Science* 35, no. 1 (2000): 41-66. Although not involved in the *Indian Journal of History of Science* dispute, Sanskrit scholar David Pingree later concurred with the opinions of Mercier and van Dalen, partly as a result of his scrutiny of a manuscript now held in Sawai Man Singh Museum II Khasmohor Collection (Ms. 5183). This appears to be a record of discrepancies between observations of the moon taken from Jaipur and the lunar longitudes recorded in the tables of de la Hire and the *Siddhāntasindhu* (*Zīj-i Shāh Jahān*). See David Pingree, "Philippe de La Hire at the Court of Jayasimha," in *History of Oriental Astronomy*, ed. S. M. Razaullah Ansari (Dordrecht: Kluwer Academic Publishers, 2002), 124, 130.

collection of stellar and planetary tables, he was also forced to engage in and stabilize a system for circulating other necessary information and materials throughout the process of building and maintaining the observatory. The information and relationships produced by this system, as much as scientific or astronomical activity, dominated the intramural knowledge network of Amer and Jaipur.

3.1 Primary Sources

This chapter focuses primarily on the observatory at Jaipur (*Sawai Jāyapura*), which was constructed as part of the new capital city of the state of Amer under the patronage of the Rajput king, Maharaja Dhiraja Sawai Jai Singh II.² The historiographical implications of the selection of this particular observatory as the paragon of a local scientific institution in India of the eighteenth century are not negligible, and we should remain conscious of the intellectual hazards implicit in these choices. On a superficial level, it appears as if the intellectual emphasis has shifted from the earlier focus of colonial interests on Varanasi, as almost without exception, post-Independence studies have focused on the observatories in Shahjahanabad and Jaipur, relegating those built at Ujjain, Mathura, and Varanasi to the margins of academic inquiry. However, the reasons for this change have little to do with methodological concerns, but are instead related to issues of scope and accessibility. Although the instrumentation was roughly the same across all five observatories, it is certainly true that the observatories at Shahjahanabad and Jaipur exhibit a monumentality lacking at Ujjain, Varanasi, and Mathura. The tallest equinoctial sundials (Samrāt Yantra) stand at Shahjahanabad and Jaipur (the gnomons are 21.3 meters and 22.6 meters

² The original construction records for the new city clearly designate the city *Sawai Jāyapura*. In Bakhatarama Saha's *Buddhi-Vilāsa* (1770), the author alternately referred to the city as *Sawai Jāyapura* and *Jāyanagar*. The spelling of the current name was regularized as "Jeypore" by treaty in 1818 CE, but from the end of the nineteenth century forward, the spelling "Jaipur" was used more consistently in official documents. Bakhatarama Saha, *Buddhi-vilasa*, ed. Padma Dhar Pathak (Jodhpur: Rajasthan Oriental Research Institute, 1964); Ashim K. Roy, *History of the Jaipur City* (New Delhi: Manohar Publishers & Distributors, 1978), 49-51.

tall, respectively), while the shortest are at Ujjain and Varanasi (6.75 meters and 6.8 meters, respectively).³ And although the general typology and functionality of the instruments are similar at all the observatories, both the Delhi and Jaipur sites contain a few exceptional components: exclusive to Jaipur are the Kapāla Yantra and the Rāśivalayas; unique to Delhi is the Mīśra Yantra (figure 3.1). In addition to these combining factors of monumentality and singularity, visitation numbers for Delhi and Jaipur are higher because the monuments are easily reached by scholars and tourists.⁴ The remains of the Delhi observatory today stand just a five minute walk from Connaught Place and the Tibetan Market on Janpath, both major attractions for foreign and domestic visitors to the city. From here, to reach the well-maintained Jaipur observatory, one boards the Shatabdi Express at the New Delhi railway station; a short six hours later, the train arrives in Jaipur, where the standard tour of the old city begins at the City Palace, just across the road from the observatory gate. So, the curious (and I include in this category

³ Although the observatory at Mathura is no longer extant, we can use Tieffenthaler's description to roughly compare its instrumentation to the other four observatories. Tieffenthaler described the primary instrument at the Mathura observatory as "a sundial which represents the *axis mundi*, constructed of lime (or in masonry) with a height of twelve Parisian feet." See Joseph Tieffenthaler, Anquetil du Perron, and James Rennell, *Description Historique et Géographique de l'Inde*, trans. Jean Bernoulli, 1 ed., 3 vols., vol. 1 (Berlin: Chrétien Sigismond Spencer, 1786), 201.

⁴ The observatory at Delhi has been a featured monument of the standard tour of north India for nearly two centuries. The number of tourist descriptions of the Delhi observatory produced during the nineteenth century suggests that it became a stop on the tourist route soon after the conclusion of the military campaigns of General (later Lord) Lake in northern India in 1803. For Major William Thorn's description of the observatory, which he visited while serving in Lord Lake's company, see William Thorn, *Memoir of the War in India, Conducted by General Lord Lake, Commander-in-Chief, and Major-General Sir Arthur Wellesley, Duke of Wellington; from its Commencement in 1803, to its Termination in 1806, on the Banks of the Hyphasis* (London: B. Clark, 1818), 171-73. Typical descriptions of the site from the nineteenth century can be read in Fanny Parks Parlbay, *Wanderings of a Pilgrim in Search of the Picturesque: During Four-and-Twenty years in the East*, 2 vols., vol. 2 (London: P. Richardson, 1850), 209-12; Carr Stephen, *Archaeology and Monumental Remains of Delhi* (Allahabad: Kitab Mahal, 1967; reprint, 1967), 69-70; Joseph H. Garcin de Tassy, "Description des monuments de Delhi en 1852, d'après le texte Hindoustani de Saiyid Ahmad Khan," *Journal Asiatique* Tome 16, no. Cinquieme Serie (December 1860): 536-43; Leopold von Orlich, *Travels in India, Including Sind and the Punjab*, trans. H. Evans Lloyd, 2 vols., vol. 2 (Lahore: East & West Publishing Company, 1976), 19-20. More recently, the observatory has come to feature prominently in popular guidebooks, moving from a marginal position as a visually striking oddity to an integral part of the story of a Persian/Mughal Delhi. For comparison, see Eugene Fodor, William Curtis, and Robert C. Fisher, eds., *Fodor's Guide to India 1967* (New York: David McKay Company, Inc., 1967), 247; David Abram et al., *The Rough Guide to India*, 6th ed. (New York: Rough Guides, 2005), 109, 128.

architectural historians) need to expend relatively little energy to reach either of these destinations.

The situation is quite different for the two extant observatories in Ujjain and Varanasi. The latter city is at least reachable by air travel, and in theory, the observatory is well located for visitors, as the Mān Mandir Ghat, on which the observatory sits, is next to the “Main Ghat” (Dasaswamedh Ghat) on the Ganges. In practice, however, the observatory is difficult to find along the river bank. The signage is small, and the entrance gate is reached only after branching off the main route to the ghat and passing through a small vegetable market. And, in fact, many tourists never approach Mān Mandir Ghat on foot, passing by it completely on boats rented up river from Kedar or Raj Ghats. The observatory at Ujjain presents an even greater challenge as a travel destination. The city of Ujjain is accessible only by automobile or train, and even the Jaipur Express takes something in the range of eight to ten hours to make the trip from start to finish. As far as the Mathura observatory is concerned, it is possible to visit its former location on Kaṇs ka Kila, but nothing allows us to experience a space that was demolished some time before 1857 CE.

In some ways, the disproportionate amount of attention given to the Delhi and Jaipur observatories today compensates for the gaps left in the historical records due to the colonial focus on the observatory at Varanasi. Unfortunately, while size and ease of access obviously contribute to the designation of these observatories as emblematic of Sawai Jai Singh’s astronomical work, the privileging of these two sites in recent academic discourse can be understood as another manifestation of the colonial limitations imposed on our analyses as described in Chapter Two. Contemporary accounts of the observatories written across multiple disciplines—architecture, art history, history of science, astronomy, and so on—draw directly on

interpretations of the observatories written in the eighteenth century by British colonials Barker, Williams, and Hunter.⁵ As discussed earlier, these three authors assumed the observatories were Hindu in origin, ancient in age, and unchanging in structure and purpose. One particular after-effect of this version of history was the erasure of any sense of difference among the observatories, despite the great geographical distances separating them, and this became the standard interpretation. As part of the process of building an argument for a “Hindu science” that was unlikely to change in character or application, these early commentaries combined to create an account in which all five observatories were assumed to function and look alike. For example, while the earliest English language article on the observatories, penned by Robert Barker, provided descriptions and measured drawings of a single observatory at Varanasi, later historians transferred both his words and images to the other observatories as well. In William Hunter’s hands, Barker’s instrument ‘A’, the large Samrāt Yantra, traveled from the banks of the Ganges in Varanasi to take up residence in Shahjahanabad, even though the two instruments were of different sizes and constructed of different materials. Hunter also placed instrument ‘A’ on the banks of the Shipra River at Ujjain. And, in an interesting moment of reversal, when he turned to reconsider the instrumentation at Varanasi, he framed his explanation in terms of the sites he had only just defined as identical to those resting above the Ganges, suggesting that “A. (of Sir Robert Barker’s plate) is the *Semrat-yunter*, described Dehly observatory, No. I. and Oujein observatory, No. VI,” and Barker’s ‘B’ “is the equinoctial dial or *Naree-wila* of No. V. Oujein observatory.”⁶ The instruments at all locations were assumed by Hunter to be mutually

⁵ Robert Barker, “An Account of the Bramin’s Observatory at Benares,” *Philosophical Transactions of the Royal Society of London* 67 (1777): 598-607; William Hunter, “Some Account of the Astronomical Labours of Jayasinha, Rajah of Ambhere, or Jayanagar,” *Asiatick Researches* 5 (1799): 177-211; John Lloyd Williams, “Further Particulars Respecting the Observatory at Benares, of Which Account, with Plates, is Given by Sir Robert Barker, in the LXVIIth Vol. of the Philosophical Transactions. In a Letter to William Marsden, Esq. F.R.S. from John Lloyd Williams, Esq. of Benares,” *Philosophical Transactions of the Royal Society of London* 83 (1793): 45-49.

⁶ Hunter, 202.

interchangeable. This act of substitution and conflation might seem minor, but it permitted future historians to base their interpretations of all of the observatories on the description of a single observatory in Varanasi, as if no differences existed among the sites. Knowledge of one instrument was assumed transferable to another, since “Hindu science” allowed for no variability of form, material or purpose. Even when writing about the observatories today, it would seem there is no need to look beyond the built environment immediately in front of us—the instruments at Ujjain can tell us nothing more than those at Delhi or Jaipur. This is exactly the reasoning of Bonnie McDougall, who opened her analysis of the Jaipur observatory with an extended description of the Delhi observatory, and of William Blanpied, who did not travel to Ujjain to verify his incorrect claim that the observatory was nothing more than a jumble of decaying ruins on the banks of the Shipra River.⁷ Although there are a multitude of factors contributing to the manner in which scholars portray the observatories today, with monumentality and access being only two of the most obvious, the legacy of colonial history is long-lasting, ensuring that Jaipur and Delhi remain emblematic of not just Sawai Jai Singh’s entire observational program, but of an eternally stagnant and unproductive “Hindu science.”

To continue to cast either Delhi or Jaipur in the role of synecdoche for the totality of Sawai Jai Singh’s work not only does a disservice to the outlying observatories of Ujjain, Mathura, and Varanasi, but risks prolonging early British stereotypes and misunderstandings,

⁷ When outlining the history of the observatories, both MacDougall and Blanpied relied on the scholarship of Hunter and G. R. Kaye, an archaeologist commissioned in 1915-16 CE by the Archaeological Survey of India to document the observatories’ remnants (see Chapter Two). Kaye himself leaned heavily on the conclusions reached by Hunter about the instruments. See George Rusby Kaye, *The Astronomical Observatories of Jai Singh* (Calcutta: Superintendent Government Printing, 1918); Bonnie G. MacDougall, “Jantar Mantar: Architecture, Astronomy, and Solar Kingship in Princely India,” *Cornell Journal of Architecture* 5 (1996): 16; William A. Blanpied, “Raja Sawai Jai Singh II: An 18th Century Medieval Astronomer,” *American Journal of Physics* 43, no. 12 (December 1975): 1028. The observatory in Ujjain was restored in the early 1920s under Gokul Chand Bhavan of Jaipur and has been kept in a reasonable state of repair ever since. See *Administration of the Gwalior State During the Year 1922-1923 (From 1st July to 30th June)* (Lashkar: Alijah Darbar Press, 1924), 57; *Administration of the Gwalior State During the Year 1923-1924 (from 1st July to 30th June)* (Lashkar: Alijah Darbar Press, 1927), 196.

insidious in their ability to remain cloaked in the rational language of history writing. Noting this, I should add an explanatory note for this chapter's focus on the knowledge network operating around and through the observatory at Jaipur, and an admission that my own privileging of this institution relates directly to the availability of archival records for this particular site. Fortunately, we can still interact with the built environment at four of the five original observatories. Each has been heavily restored and altered over the past 250 years, but even so, something remains of the original scale and scope of the instruments and their surrounding landscapes. Archaeologically speaking, thanks to the documentation and analysis of the observatory grounds by Andreas Volwahren, scholars know something about the construction methods and measurements of all the extant sites.⁸ However, if we wish to supplement these physical traces in the built environment with written material, we face the prospect of a rather difficult engagement with the archive. There remains a general lack of sources related to Ujjain, and the historical record is almost completely silent in regard to the observatory at Mathura. The situation is slightly, but not much, improved with reference to Delhi and Varanasi. The earliest English-language descriptions of the Mathura, Varanasi, and Ujjain observatories by Barker, Hunter and Williams, which included the first visual recording of any of the observatories (see figures 2.1-2.3, previous chapter), were written a half century or more after the completion of the observatories.⁹ Around that same time, Thomas and William

⁸ Andreas Volwahren, *Cosmic Architecture in India: the Astronomical Monuments of Maharaja Jai Singh II* (New York: Prestel, 2001). For measured drawings of the Jaipur observatory, see pp. 89-101, 113; for the Delhi observatory, see pp. 113, 148-55; for the Varanasi observatory, see p. 147. For a description of construction models and methods, see pp. 119-46.

⁹ We also have a few general descriptions in French and German written by Jesuit priests during the era of construction, but as will be discussed in Chapters Four and Five, they appear to have gained little intellectual purchase in the learned societies of eighteenth-century Britain. A representative selection of Jesuit commentary can be seen in Claude Boudier, Letter to Étienne Souciet, 19 January 1732, fol. 125r-26v, GBro 088, Fonds Brotier, Les Archives des Jésuites de Paris, Vanves; ———, Letter to Étienne Souciet, 18 January 1736, fol. 143r-45v, GBro 088, Fonds Brotier, Les Archives des Jésuites de Paris, Vanves; ———, Letter to Etienne Souciet, 1733, fol. 133r-34v, GBro 088, Fonds Brotier, Les Archives des Jésuites de Paris, Vanves; Manuel Figueredo, "Letter No. 595," in

Daniell produced the first known aquatints of the Delhi observatory, two romantic portrayals of a decaying, mystical landscape (figures 3.2-3.3). In terms of visual documentation, these were the only depictions in circulation in Europe and possibly South Asia until the advent of photography, after which point the Delhi observatory in particular began to appear repeatedly on tourist postcards (figure 3.4).¹⁰ Until now, only these limited European records have been used to write the history of the observatories but, as my historiographical analyses in the preceding chapters demonstrates, these sources come with their own problems, the most significant of which is their tendency to close down any discussion of the observatories as loci of creative or productive work. Unfortunately, only for the Delhi and Jaipur observatories do we have alternative primary sources written in South Asian languages, produced by the people who designed, built, and used the sites. Even primary sources relating to Delhi are thin, consisting of Sawai Jai Singh's preface to the *Zīj-i Muḥammad Shāhī*, several pages in the *Samrāt Siddhānta*, and a few mentions of the observatory as a stopping place in the chronicles of Sawai Jai Singh's travels.¹¹

For the Jaipur observatory, on the other hand, we have an abundance of primary sources related to both the built environment and the written archive. The remarkable survival rate of monument and document can probably be explained by the fact that throughout the first half of the eighteenth century, this location remained the closest to Sawai Jai Singh physically, at least when he was resident in his own kingdom. This was where the Maharaja Dhiraja himself likely spent the most hours observing, and it was the site that held the largest number of instruments. It

Der Neue Weltbott mit allerhand Nachrichten dern Missionariorum Societatis Jesu, ed. Joseph Stocklein (Augsburg: 1726), No. 595; Tieffenthaler, du Perron, and Rennell, 128, 201-02, 316-18, 347.

¹⁰ Also produced in the mid-nineteenth century was Sir Thomas Theophilus Metcalfe's album *Reminiscences of Imperial Delhi*, a collection of paintings depicting Mughal and pre-Mughal monuments in the city, accompanied by Metcalfe's handwritten commentary. The Delhi observatory was featured in this album, but although reproductions of this image circulate freely today, at the time of its production in 1843 CE, the painting was intended for private consumption.

¹¹ *Zīj-i Muḥammad Shāhī*, Add. 14373, Asia, Pacific and Africa Collections, British Library, London; Sharma, ed. *Samrāt-Siddhāntah Avāntara Paṭhabhedasamanvitah Siddhāntasārakaustubhah*, 1216-21; Dayānat Khān Najūmī, VS 1782, 563-64, Vol. 19, DK, RSA, Bikaner; Nizām Khān Najūmī, VS 1782, 674-75, Vol. 20, DK, RSA, Bikaner.

was also the observatory nearest to the astronomical library started by the Rajput ruler in 1706/07 CE (VS 1763), enabling the literate astronomers working in Jaipur to take advantage of written sources unlikely to be available at the remote observatory sites.¹² The Jaipur observatory and its associated institutions are now well documented in numerous archival sources held in the Rajasthan State Archives (RSA) in Bikaner, Rajasthan.¹³ For instance, tucked away in various collections of *Imārat Khāna* (Building Department) records dating back to 1728/29 CE (VS 1785), we find expenditure lists for materials used during the construction of the instruments, as well as the pay scales and the identities of astronomers and categories of day manual laborers. The *Aṭhsaṭhī Imāratī* (Building Department Annual Summaries),¹⁴ *Jamā Karch Imāratī* (Building Department Expenditure/Income Records), *Roznāma Imāratī* (Building Department Daily Records), and *Tozī Syāha Imāratī* (Building Department Accounts) are obviously strong sources of statistics related to construction methods and materials, but they also can be mined for information on labor practices, caste divisions, political hierarchies, and bureaucratic relationships.¹⁵ Many of the astronomy books and manuscripts copied by court scribes and used by the astronomers in the observatory are listed in the *Pothī Khāna* (Book and Manuscript Department) inventories now held in the RSA. In the *Dastūr Kaumvār* (Registry of Gifts of Protocol), we find memoranda describing a variety of gifts given as payment in kind to high-

¹² Between August 3, 1706 and March 1, 1707 CE, Sawai Jai Singh commissioned the transcription of thirteen Sanskrit astronomical manuscripts including the *Suryasiddhānta* and Mahendra Sūri's *Yantrarāja* ("Instructions for Instrument Making," the first manual on the astrolabe written in Sanskrit). Three of these manuscripts were copied by Nātha in Gujarat, the remaining ten by Tulārāma in Ahmadabad. For a complete list, see David Pingree, "An Astronomer's Progress," *Proceedings of the American Philosophical Society* 143, no. 1 (1999): 73-74.

¹³ The Rajasthan State Archives (RSA) were established originally in Jaipur in June 1955 CE. The headquarters, along with all records from the period prior to 1900 CE, relocated to Bikaner in 1963 CE. There are now seven Regional Branches of the RSA at Jaipur, Jodhpur, Ajmer, Kota, Bharatpur, Alwar and Udaipur.

¹⁴ Literally translated, *aṭhsaṭhī* means "three and a half years," or even more literally, "half of seven years." However, the *Aṭhsaṭhī Imāratī* for Jaipur clearly summarizes expenditures for only a single year, rather than multiple years.

¹⁵ The RSA collections related to Jaipur consist of loose-leaf bundles, bound together with twine, and although a good effort is made to keep the sets organized, the unbound pages are not always found in order. Months of records are missing, either because they are misfiled within other months or years, or because they have been lost completely at some time during the past two and a half centuries.

ranking astronomers associated with the observatory, while in the *Daftar Nasūkhā Punya* (Memoranda of the Religious Gifts Office), we can trace monetary gifts and monthly salaries for Europeans and their assistants who provided service to the observatory at Sawai Jai Singh's invitation.¹⁶ In addition to this large collection of Court-produced records written in the local dialect of Rajasthani, we can also consider multiple sets of European records, including an immense corpus of correspondence of produced by Jesuit priests from France and Austria.

Despite the tantalizing richness of these sources, our reliance on this archive and on Jaipur as the model observatory places us in the unenviable position of furthering the historiographical damage already inflicted on these sites by the history writing of the late eighteenth century. Even though it is likely that Jaipur and Shahjahanabad were indeed the primary scientific centers in play between 1721 and 1743 CE, we should be open to a reevaluation of this assumption should other archival material come to light. We can admit the likelihood that the stories of the operations at Varanasi, Ujjain, and especially Mathura will remain hidden within a colonial history designed to erase any notion of agency, mobility and action, but at the same time, we should continue to press against the historical record with the hope that the slightest opening in the literature will provide an opportunity to reconnect all of the observatories commissioned by Maharaja Dhiraja Sawai Jai Singh II.

3.2 Intramurality and the City

Imagining the position of the Jaipur observatory in geographically proximate networks of both intellectual and material exchange requires an interrogation of accepted vocabulary and a redefinition of terms. When describing the observatory of Jaipur and its relationship to the larger

¹⁶ For a description of the *Dastūr Kaumwār*, see Chapter Two, fn. 60. The *Daftar Nasūkhā Punya* chronicles gifts given primarily to priests and temples throughout northern India, but also includes several mentions of gifts and remuneration made to Europeans associated with Sawai Jai Singh and the observatories.

cityscape, I argue that the term “intramural” should be deployed in place of “local” and “indigenous” as the grounding vocabulary for the discussion. Given the volume of scholarship produced on the theoretical models of indigeneity and locality in science, in addition to the extensive and profitable studies of indigenous design and regionalism within the discipline of architecture, the introduction of a third term specifically to discuss the landscape configurations in Jaipur and Amer might seem to possess a dubious utility.¹⁷ However, as this chapter will demonstrate, the parameters of intramurality capture more completely the attempted distribution of knowledge through the circulatory system residing inside the walls of Sawai Jai Singh’s capital city.

The language of indigeneity is often applied to the practices of science at the observatories, particularly in reference to the instrumentation identified by historians as Hindu in origin, and initially, a consideration of the theoretical possibilities of an indigenous network, grown out of the restricted physical environment immediately surrounding the observatory, appears to offer a healthy reward. Since one endeavor of this dissertation is to intervene in and redirect the history of the observatories away from its colonial origins, the enormous corpus of literature on indigenous architectures would seem an obvious starting point. Indeed, journals such as *Traditional Dwellings and Settlements Review (TDSR)* do important and deliberately political work in recovering and analyzing indigenous landscape conventions that have been

¹⁷ Analyses of both locality and indigeneity have surfaced repeatedly over the past decade in the leading journals associated with disciplines concerned with geography, science, and global studies. See, for example, Trevor J. Barnes, “The Place of Locational Analysis: A Selective and Interpretive History,” *Progress in Human Geography* 27, no. 1 (2003): 69-95; Richard C. Powell, “Geographies of Science: Histories, Localities, Practices, Futures,” *Progress in Human Geography* 31, no. 3 (2007): 309-29; A. I. Sabra, “Situating Arabic Science: Locality versus Essence,” *Isis* 87, no. 4 (1996): 654-70; David Wade Chambers and Richard Gillespie, “Locality in the History of Science: Colonial Science, Technoscience, and Indigenous Knowledge,” *Osiris* 15 (2001); Steven Shapin, “Placing the View from Nowhere: Historical and Sociological Problems in the Location of Science,” *Transactions of the Institute of British Geographers New Series*, 23, no. 1 (1998): 5-12.

overwhelmed by a European colonial insistence on the rationalization of space.¹⁸ Similarly, the emerging field of Indigenous Knowledge Studies (IKS), as a self-conscious attempt to confront “the detrimental legacy of the Western knowledge hegemony and power of cultural supremacy” on indigenous knowledge systems and the populations out of which those worldviews developed, has been particularly effective in grappling with issues of territory, space, and communication.¹⁹ However, I am reluctant to embrace the assumption that the theoretical underpinnings of IKS can be universally applied to all subaltern populations and their environments, including the cityscape of Jaipur. In Philip Nel’s description of the intellectual framework of IKS, the author notes “the ideological and/or ontological positions towards IKS are often linked to its temporal border (i.e. to the local communities prior to colonialism); its spatial context (i.e. indigenous communities affected by displacement); and to its distinctiveness (i.e. authentic to communities identifying themselves as different from the recently arrived people).”²⁰ In other words, the application of IKS tools depends on our ability to recognize and locate an authentic, indigenous

¹⁸ As many scholars have pointed out, this rationalization of space was not as rigorous or transparent as colonial powers might have wished; although residential, institutional, and public space was seized and re-organized by the British government in India, the dividing line between “us” and “them” was shaky at best. See Peter Scriver and Vikramaditya Prakash, “Between Materiality and Representation: Framing an Architectural Critique of Colonial South Asia,” in *Colonial Modernities: Building, Dwelling and Architecture in British India and Ceylon*, ed. Peter Scriver and Vikramaditya Prakash (London: Routledge, 2007), 20, but particularly Swati Chattopadhyay, “Blurring the Boundaries: The Limits of ‘White Town’ in Colonial Calcutta,” *Journal of the Society of Architectural Historians* 59, no. 2 (2000): 154-79. *TDSR* has of late embraced a wider variety of theoretical approaches to traditional and indigenous building forms, but until recently, the majority of the articles published in the journal have focused on domestic architecture. In the same vein as *TDSR* is the work of Paul Oliver, and more recently, the wide-ranging architectural survey of Crouch and Johnson. More specific to the construction and interpretation of space in India is the work of V. Chakrabarti (Sachdev) and Y. Pandya. See Dora P. Crouch and June G. Johnson, *Traditions in Architecture: Africa, America, Asia and Oceania* (Oxford: Oxford University Press, 2001); Paul Oliver, *Dwellings: The House Across the World* (Oxford: Phaidon, 1987); ———, *Encyclopedia of Vernacular Architecture of the World*, 3 vols. (Cambridge: Cambridge University Press, 1997); Vibhuti Chakrabarti, *Indian Architectural Theory: Contemporary Uses of Vastu Vidya* (Delhi: Oxford University, 1999); Yatin Pandya, *Concepts of Space in Traditional Indian Architecture* (Ahmedabad: Mapping Publishing, 2005). For an analysis of the changing definition of “tradition environments” in *TDSR*, see C. Greig Crysler, “Writing Spaces: Cultural Translation and Critical Reflexivity in Traditional Dwellings and Settlements Review,” *Traditional Dwellings and Settlements Review* 11, no. 11 (2000): 51-59.

¹⁹ Philip J. Nel, “Indigenous Knowledge Systems: Contestation, Rhetorics and Space,” *Indilinga: African Journal of Indigenous Knowledge Systems* 4, no. 1 (2005): 6.

²⁰ *Ibid.*, 7.

population displaced from a particular landscape by colonial pressure. In the case of Jaipur, it is impossible to identify an authentic, aboriginal population. While certainly the written history of the observatories was shaped heavily by European colonialism, as most of the early documentation of the observatories was penned by British colonial administrators and Jesuit priests, the Maharaja Dhiraja Sawai Jai Singh II, as the leader of a semi-independent Rajput state, was in negotiation not primarily with Europeans, but with a Mughal state that was itself hardly a newcomer to the region. While European colonialism shaped the afterlife of the observatories, at the time of the construction and initial implementation of the observation program at Jaipur, the affected local community had long been in flux under an always changing Mughal and Rajput rule. Not only do complications introduced by the migration of labor (consider, for instance, the relocation of stoneworkers from Amer by Imperial order during the construction of the Taj Mahal in Agra)²¹ thwart our attempts to identify an “authentic” local community, but so too does the fact that Jaipur was a newly constructed city, intended to incorporate or displace six pre-existing villages.²² In fact, the majority of the resident population of Jaipur consisted of merchants, bankers and traders invited to the area by the Maharaja Dhiraja in hopes of creating a robust financial community at the crossroads of the Delhi and Sanganer

²¹ The *farmāns* directed to Mirza Raja Jai Singh I from Shah Jahan are reproduced and translated in W. E. Begley and Z. A. Desai, eds., *Taj Mahal: The Illumined Tomb* (Cambridge: Aga Khan Program for Islamic Architecture, 1989), 163-73. The *farmāns* orders Jai Singh to make available “whatever the number of stone-cutters (*sang-bur*) and carts-on-hire (*araba-i-kiraya*) for loading stone that may be required by the aforementioned [imperial agent] Mulukshah,” and to provide “the wages of the stone-cutters and the rent-money for the carts...with funds from the royal treasurer (*tahwildar*)” in support of the Emperor’s building efforts in Akbarabad (Agra). The workers were expected to transport white marble from the quarries at Makrana to the buildings (*ba-‘imarat-ha*) of “the Abode of the Caliphate Akbarabad.”

²² Roy, 45. Roy’s list of villages—Nahargarh, Talkatora, Santosh Nagar, Moti Katla, Galtaji, and Kishan Pol—is somewhat ambiguous. It is not clear from his summary if the city displaced or incorporated these villages. The original site of Jaipur was not large enough to embrace both the villages of Nahargarh and Galtaji—they stood in opposite directions, outside the new city walls—but certainly Talkatora, immediately north of the Jai Niwas gardens, fell inside the development area. The inclusion of the village of “Kishan Pol” in the list creates more confusion than clarity, as this name refers to the Kiśan Pol (Krishna Gate), one of the new gates leading into the town. It is not clear how the village could predate the construction of the eponymous gate.

trading routes south of Amer.²³ Who within this model of fiat cities should be considered a member of an authentic local community?

Even if we could identify an authentic, indigenous population within the walls of the new city of Jaipur, there are other reasons to reject the language of indigeneity in a discussion of the work of Sawai Jai Singh. The styling of observatory spaces as indigenous has served for more than years not to highlight the local contributions to the work conducted in Jaipur, Delhi, and so on, but rather to more effectively marginalize the observatories as non-productive, a-scientific, and irrational spaces. For instance, Robert Barker's initial inquiry into the work conducted with the instruments on the roof of the Man Mahal in Varanasi stemmed from a need to ascertain the antiquity and stagnancy of Brahminic knowledge. Through a detailed examination of the masonry instruments, he intended to sort out the genealogy of astronomy in India, distilling scientific practice into two distinct schools of thought, the dynamic Arabic and the torpid Hindu.²⁴ In his opinion, the structures of the observatory could be marshaled as evidence of "the purity of [Hindu] religion and customs," confirming his earlier assertion that the local populace was weighed down by an unquestioned adherence to tradition and custom.²⁵ This identification of the indigenous, assumed to be Hindu, with a non-productive history, continues to affect the way in which we describe and discuss all of the observatories. Setting aside the basic truth that the work completed at the observatories was more of a synthesis of many styles of learning and observing, and the result of a deliberate and willing search for multiple knowledges, we should be aware of the hazards still inherent in the assumption of a Hindu indigeneity as the basis of the Maharaja Dhiraja's observational program.

²³ Ibid., 41.

²⁴ Just as Barker and Hunter did not distinguish between "Hindu" and "Vedic" thought, so too did they fail to differentiate between "Arabic," "Mughal," and "Islamic" sciences.

²⁵ Barker, 606.

In the place of indigeneity, then, we need an alternate approach, one that remains attentive to local knowledge systems produced at and through these sites. Following the geographic turn in science studies inaugurated by Thomas Kuhn's *The Structure of Scientific Revolutions*, I would assert that all knowledge is local; that is, it is embedded in local practices of production, whether those are labor, political, or social practices.²⁶ Though not all historians of science accept the epistemological position that knowledge is socially constructed, an impressive number of scholars working on the spatialization of knowledge, including Steven Shapin and Bruno Latour, argue that science is a product of social and political relations relevant to a particular position and moment in time.²⁷ A benefit of accepting the tenet that locality matters is that it encourages us to think spatially, and allows us to consider the means and purpose for emplacing knowledge within a limited landscape. However, it is one thing to declare that all knowledge is locally situated (turning locality into a universal condition), and another to produce a methodology that takes into account the specifics of a single urban landscape. In other words, we need a theoretical tool that allows us to demonstrate not just that spatiality matters, but that specific landscape configurations create and mobilize a specific, contingent knowledge. Although the observational work undertaken at the Jaipur and Delhi observatories followed similar operational guidelines and produced congruous results, the observatories occupied divergent geographies that resulted in different construction, labor, and science practices. One way to combat the historical practice of conflating one space with the next is to pay attention to these differences, and to consider locality not as a universal feature of knowledge, but as a

²⁶ As Steve Shapin points out, one result of Kuhn's description of the mechanics of scientific progress was "a pluralist sensibility...Science was not one thing—conceptually and methodologically unified...it was a variety of practices whose conceptual identities were the outcomes of local patterns of training and practice." This concept of "locality" in science would spur on a search for the diverse places and sites underpinning the practice of science in the fields of science studies and geography. Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1962); Shapin, 6.

²⁷ Bruno Latour, *Science in Action* (Cambridge: Harvard University Press, 1987), 219-57; ———, *We Have Never Been Modern* (Cambridge: Harvard University Press, 1993), 117-22; Shapin, 5-12.

product of a scaled landscape occupying a particular geography and time period. This notion of specificity threatens to disappear in discussions centered on the “universal local,” and in deploying a vocabulary much more reflective of the built environment of the walled city of Jaipur, we can counteract that threat of loss.

A final impetus behind the introduction of an intramural analytic is to force a reconsideration of the tendency of conceptual models of science and knowledge exchange to collapse urban space into a unified whole. Four decades of increasingly precise modeling of colonial and global science networks have left us with a city defined alternately as a node, an intersection, or a terminus, each of which lacks depth and dimension.²⁸ Intramurality adds texture to these urban simplifications, and draws attention to the actual boundaries raised by the architecture and landscape in Jaipur and Amer that both prohibited and enabled the movement of knowledge and its carriers. These demarcations are numerous: the mud brick walls of the observatory, the numerous masonry walls of the City Palace and its multitude of *chowks* (courtyards), the stone city walls of Jaipur, and the fortified walls and ramparts extending between Amer and Jaipur. The intramural simultaneously gestures to a contained and bound knowledge, available or comprehensible only to a privileged few, and to all that which stands outside the wall, hovering in a region of ambiguity, poised for departure. Moreover, it speaks to the dissolution of the division between interior and exterior, as the built environment of Jaipur

²⁸ These history of these modeling strategies is captured in the work of Tony Ballantyne, *Orientalism and Race: Aryanism in the British Empire* (Houndmills, Basingstoke: Palgrave, 2002); George Basalla, “The Spread of Western Science,” *Science* 156, no. 3775 (May 5 1967): 611-22; ———, “The Spread of Western Science Revisted,” in *Mundialización de la ciencia y cultura nacional*, ed. A. Lafuenta, A. Elena, and M.L. Ortega (Madrid: Ediciones Doce Calles, 1991), 599-603; David Wade Chambers, “Locality and Science: Myths of Centre and Periphery,” in *Mundialización De La Ciencia Y Cultura Nacional*, ed. A. Lafuenta, A. Elena, and M.L. Ortega (Madrid: Ediciones Doce Calles, 1991), 605-18; Chambers and Gillespie, “Locality in the History of Science: Colonial Science, Technoscience, and Indigenous Knowledge,” 221-40; Roy McLeod, “On Visiting the 'Moving Metropolis': Reflections on the Architecture of Imperial Science,” *Historical Research of Australian Science* 5, no. 3 (1982): 1-16; Paolo Palladino and Michael Worboys, “Science and Imperialism,” *Isis* 84, no. 1 (March 1993): 91-102; Lewis Pyenson, “Cultural Imperialism and Exact Sciences Revisted,” *Isis* 84, no. 1 (March 1993): 103-08.

sends up multiple signals, most of which indicate that Sawai Jai Singh planned for a certain permeability of the city. The initial construction of the instruments required a drawing in of resources from beyond the city walls, so although Jaipur was designed as a fortified city, equally important during the early years of its construction were the gates that provided access to and from the major trading roads circumscribing the town. The six original gates planned for the city—the Chand Pol (Moon Gate) on the west side of the city, the Suraj Pol (Sun Gate) to the east, the Dhruv Pol (North Gate) in the northern wall, the Kishan Pol (Krishna Gate, leading south toward Ajmer), the Shiv Pol (Shiva Gate, leading south toward Sanganer), and the Ghat Darwaza (Mountain Gate, leading southeast toward Ghūmi Ghat), all on southern wall—acted concurrently as a means of passage, control, boundary, and slippage (map 3.1, figure 3.5).²⁹

These gates take on an added importance with the realization that Sawai Jai Singh needed to sustain a functioning political center at Amer while the new capital city of Jaipur (including the observatory) was under construction. The daily operation of the observatory required a constant flow of communications between patron and builder, and the accepted model for knowledge movement supposed a direct and unmediated connection between the Maharaja Dhiraja's residence in the Chandra Mahal of the City Palace and the observatory located near the Tripolia Gate (figure 3.6). While this connection undoubtedly developed over time, during the first years of the observatory's existence, the Chandra Mahal—indeed, the entire City Palace complex—was in such a state of controlled chaos that much of the administrative work of running the Rajput state remained centered at the older palaces of Amer. The *Aṭhsaṭhī Imārātī*

²⁹ On the necessity and form of city walls and gates for security, see George Michell and Antonio Martinelli, *The Royal Palaces of India* (London: Thames and Hudson, 1994), 28. The archive is mostly silent in regard to the construction of the city walls, with their presence only implied in the accounting records of gate building contained in the *Imārat Khāna*. For example, in 1729/30 CE (VS 1786), 1331r-2a-0p was spent on the Chand Pol, with an additional 2345r-0a-0p spent on the Chand Pol doors in the following year. Bhādvā Sūdi 3 VS 1786 to Bhādvā Sūdi 2 VS 1787, fol. 28, Bundle No. 2, AI, RSA, Bikaner; Bhādvā Sūdi 3 VS 1787 to Bhādvā Sūdi 2 VS 1788, fol. 54, Bundle No. 3, AI, RSA, Bikaner.

and *Roznāma Imāratī* make clear that although the observatory was under construction by 1728/29 CE (VS 1785), work at the Chandra Mahal, or *Mahal Satakhāna* (Seven-Storied Palace), did not begin until 1733/34 CE (VS 1790).³⁰ It is unlikely that Sawai Jai Singh himself resided at Jaipur before the completion of the Chandra Mahal; he spent large parts of the years 1728-1730 CE outside of both Amer and Jaipur.³¹ The women of the Court certainly lingered at Amer until the completion of the City Palace *Zenāna* Mahal and Majlis, an extensive conglomeration of buildings and gardens, record of which first appeared in the *Roznāma Imāratī* in 1733/34 CE (VS 1790).³² The maintenance of two court spaces, with all of the bureaucratic departments associated with the running of the government and construction of a new capital city, unquestionably demanded a secure communication and transportation corridor between the new palace at the center of Jaipur and the palace at Amer. In order for Sawai Jai Singh to actively participate in construction and scientific work at the observatory, he and his retinue had to make a short but involved trek from Amer to the central quarter of the new capital. No record

³⁰ The observatory first appears in Bhādvā Sūdi 3 VS 1785 to Bhādvā Sūdi 2 VS 1786, fol. 23r-24r, Bundle 1, AI, RSA, Bikaner. The bulk of the expenditures for the Chandra Mahal appear in VS 1791. See Asāḍh Vadi 4 VS 1791, fol. 2v-3v, Bundle No. 3, RI, RSA, Bikaner; Asāḍh Sūdi 15 VS 1791 fol. 4, Bundle No. 3, RI, RSA, Bikaner; Kāti Sūdi 15 VS 1791, fol. 3v, Bundle No. 3, RI, RSA, Bikaner; Phalguna Sūdi 12 VS 1791, fol. 2v, Bundle No. 3, RI, RSA, Bikaner; Phalguna Sūdi 14 VS 1791, fol. 4v, Bundle No. 3, RI, RSA, Bikaner.

³¹ The Maharaja Dhiraja encamped at Patva, about 66 miles east of Jaipur, from January to April, 1728 CE. In the fall of that year, he departed the Amer region for Udaipur, remaining in that city from September 21 to October 8. At the end of October, he left for Ujjain, but near the end of his journey, he chose to bypass that city and travel directly to Mandu, where he arrived at the end of November. In 1729 CE, he traveled twice to Ujjain. In April 1730, he encamped at Indore, and remained in Malwa until May, at which time he returned to Amer. He stopped at the border of Kota on May 11, 1730 CE, before returning to his court. V. S. Bhatnagar, *Life and Times of Sawai Jai Singh, 1688-1743* (Delhi: Impex India, 1974), 196, 204-06, 213-14, 217-18; Jadunath Sarkar, *A History of Jaipur c. 1503-1938* (Jaipur: Maharaja Sawai Man Singh II Museum, 1984), 178, 192.

³² Caitra Sūdi 14 & 15 VS 1790, fol. 3v, Bundle No. 2, RI, RSA, Bikaner; Baisākh Vadi 15 VS 1790, fol. 3v, Bundle No. 2, RI, RSA, Bikaner; Āsoj Sūdi 14 & 15 VS 1790, fol. 6r, Bundle No. 2, RI, RSA, Bikaner; Pauṣa Sūdi 15 VS 1790, fol. 2v, Bundle No. 2, RI, RSA, Bikaner; Māgha Sūdi 6 VS 1790, fol. 3r, Bundle No. 2, RI, RSA, Bikaner; Māgha Sūdi 14 VS 1790, fol. 3v, Bundle No. 2, RI, RSA, Bikaner. If Tillotson's speculation regarding the development of the *zenāna* space of the Amer palace is correct, and the division between *zenāna* and *mardana* was forced on the architecture only in the later years of the palace's use as primary residence, it is possible that one impetus for a new palace at Jaipur was the ability to clearly separate the two spaces. While the division of gendered space is muddled at Amer, at Jaipur, the *zenāna* was distinctly separated from *mardana* space. See G. H. R. Tillotson, *The Rajput Palaces: The Development of an Architectural Style, 1450-1750* (New Haven: Yale University Press, 1987), 86.

exists of this precise route, but assuming the fortified walls of Jaipur were erected early in the development of the town site, the only practical entry into Jaipur from the north was through the Dhruv Pol. Presumably, the Maharaja Dhiraja's processional route roughly corresponded to the one connecting the two cities today: Sawai Jai Singh and his entourage emerged from the inner courtyards of the Amer Raj Mahal through the ornamental Ganesh Pol, exited the palace on elephant back, and descended the hill to the south, between the palace and Maotha Lake (map 3.2).³³ They made a wide turn around the gardens at the head of the lake, and then followed the eastern embankment of reservoir before descending into the Kanak Vrindavan valley.³⁴ From Kanak Vrindavan, the original road passed beyond a line of fortifications, and skirted first the western banks of the Mān Sāgar, and second the eastern banks of the now-drained Rajamahalka-Talab, to enter the walled city through the Dhruv Pol, north east of the City Palace. From the Dhruv Pol, the procession continued south to the Baḍī Chaupaḍ, the major intersection of the Amer-Sanganer road and the boulevard extending from the Suraj Pol to the Chand Pol. Heading west from the Baḍī Chaupaḍ through the Tripolia Bazaar, the Maharaja Dhiraja and his retinue entered the City Palace through the monumental Tripolia Gate (figure 3.7). The course then took a dogleg to the right across the Chandni Chowk from the Tripolia Gate, around the northwestern corner of the observatory wall. Halfway down this thoroughfare from the Chandni Chowk to the

³³ As R. K. Sharma points out, archival documents only give us a "marginal glimpse" at the maintenance and use of elephants in the Rajput courts. However, it is estimated that the Rajput kings maintained up to 200 war elephants at a time before the introduction of modern warfare. The military use of elephants slowly died out during the eighteenth century, but the *Phīl Khāna* (elephant stables) were preserved in order that the elephants could continue to serve for ceremonial purposes and status symbols. Ravindra Kumar Sharma, "The Rajput Elephant Corps (An Assessment)," in *Cultural Contours of India: Dr Satya Prakash Felicitation Volume*, ed. Vijai Shankar Srivastava (New Delhi: Abhinav Publications, 1981), 390.

³⁴ A second route to Maotha Lake departed directly from the *zenāna* courtyard of Amer palace. This path fronted the palace on its eastern flanks, and hewed more closely to the banks of the lake, passing around the formal garden at the lake's northern terminus before turning directly south toward Kanak Vrindavan.

Sireh Deodī Darwaza (the main public gate), the Maharaja Dhiraja turned right to enter the observatory.³⁵

We have no way of knowing how often the Maharaja Dhiraja made this twisting journey from Amer to the observatory, but each trip was probably well-noted and closely watched by the citizenry. The slow movement of the king's procession south to Jaipur functioned as a political spectacle, providing ample opportunity for the contemplation of Sawai Jai Singh's power against a backdrop of a landscape designed according to his desires. The pageantry of resources inherent in the retinue of a king itself made a powerful assertion about the strength of the ruler; to combine it with evidence of Sawai Jai Singh's ability to manipulate and manage the spaces of a new city must have made the statement of control even more emphatic. And nowhere was Sawai Jai Singh more capable of activating the latent power of the landscape with his presence in this manner than in the spaces between Kanak Vrindavan and the Dhruv Pol of Jaipur. Although this space is typically neglected in studies of the planned town of Jaipur, archival sources demonstrate that an intermediary space between Jaipur and Amer developed along the embankment of the Mān Sāgar (Lake) during the construction of the new capital. Even before the founding of Jaipur, Sawai Jai Singh had already marked this piece of the road as an area of political and religious significance. In 1713 CE, he ordered the Kanak Vrindavan gardens, resting at the head of the Mān Sāgar in the valley leading up to Amer, prepared to receive the image of Govindadevji, the most significant of the deities revered by his Kacchawāhā clan.

³⁵ Today, the ceremonial route from the Tripolia Gate crosses the Chandni Chowk (Tripolia Square) to directly enter the courtyard of the Mubarak Mahal, passing north through the Rajendra Pol to the original *Diwān-i Ām* (now the *Diwān-i Khās*). However, Maharaja Sawai Madho Singh II enabled this route with the introduction of the Rajendra Pol into the south wall of the *Diwān-i Ām* courtyard between 1835 and 1880 CE and the construction of the Mubarak Mahal c. 1890 CE. In fact, the courtyard of the new Mubarak Mahal encroached upon the northwest corner of the observatory space, possibly prompting the relocation of the Dakṣinottara Bhatti Yantra to the opposite end of the observatory in 1876 CE. See Vibhuti Sachdev and Giles Tillotson, *Jaipur City Palace* (New Delhi: Roli Books, 2008), 45; Virendra Nath Sharma, *Sawai Jai Singh and his Astronomy* (Delhi: Motilal Banarsidass Publishers, 1995), 130; Tillotson, 215, n. 49.

Regular devotions for Govindadevji were conducted at the gardens from November 1719 CE until such time the deity could take up permanent residence in the Govindadevji Temple of the City Palace in Jaipur. The result of Govindadevji's extended presence in Kanak Vrindavan was the transformation of the former market road leading south from Amer into a path of state-sponsored pilgrimage on a daily basis.³⁶ When the construction of the new city began, the Court continued to cultivate this already charged space by distributing a certain number of courtiers and merchants in garden houses along the interurban strip between Kanak Vrindavan and the Dhruv Pol of Jaipur.³⁷ This stretch of road pierced the fortified walls surrounding the Amer, opening a previously bounded area to devotees and merchants alike.³⁸ A vital component of the new urban development project, the Mān Sāgar embankment, along with the lingering participation of Amer in this network, created a complicated local network of transfer and exchange. The intramural about which we are thinking was encapsulated not simply by the walls

³⁶ Monika Horstmann and Heike Bill, *In Favour of Govinddevji: Historical Documents Relating to a Deity of Vrindaban and Eastern Rajasthan* (New Delhi: Manohar, 1999), 19-21.

³⁷ In 1728/29 CE (VS 1785), the court began investing funds in the Mān Sāgar embankment and the Jal Mahal (Water Palace) in the center of the lake (the palace is referred to as alternately as the Jal Mahal and the Jal Mandir in construction records) (7691r-12a-0p). In 1729/30 (VS 1786), 707r-1a-0p was spent on unspecified embankment improvements, and 267r-5a-0p was spent on the embankment road. Project expenses rose considerably in 1730/31CE (VS 1787), with 3440r-1a-0p being spent on unspecified embankment projects. 2529r-4a-0p was dedicated specifically to embankment repair. In 1733/34 CE (VS 1790), several projects along the embankment were in progress, including more work on the Mān Sāgar palace. The *Imārat Khāna* produced materials and labor for these undertakings throughout the year, with expenses ranging from 8r-8a-0p up to 24,240r-0a-0p per month. 1733/34 CE (VS 1790) appears to be the year in which the lakeside projects were completed. See Bhādvā Sūdi 3 VS 1785 to Bhādvā Sūdi 2 VS 1786, fol. 21, 62-66; Bhādvā Sūdi 3 VS 1786 to Bhādvā Sūdi 2 VS 1787, fol. 52-53; Bhādvā Sūdi 3 VS 1787 to Bhādvā Sūdi 2 VS 1788, fol. 93, 102; Baisākh Vadi 14 VS 1790, fol. 5r, Bundle No. 2, RI, RSA, Bikaner; Jeṭh Vadi 8 VS 1790, fol. 6r, Bundle No. 2, RI, RSA, Bikaner; Āsoj Sūdi 14 & 15 VS 1790, fol. 6v. For plans of the Mān Sāgar improvement and the Jal Mahal, see descriptions nos. 198, 216, and 225, Gopal Narayan Bahura and Chandramani Singh, *Catalogue of Historical Documents in Kapad Dwara, Jaipur*, vol. II. Maps and Plans (Amber: Jaigarh Public Charitable Trust, 1990), 39-40, 112-13. See also Bhādvā Sūdi 3 VS 1786 to Bhādvā Sūdi 2 VS 1787, fol. 41; Bhādvā Sūdi 3 VS 1787 to Bhādvā Sūdi 2 VS 1788, fol. 91; Āsoj Sūdi 14 & 15 VS 1790, fol. 6v.

³⁸ The fortifications running between the citadel of Amer and the new town of Jaipur, the remains of which still dominate the view from Jaigarh, date back to at least the twelfth century. Satya Prakash, "Jaipur and Its Environs—A Study in Architecture," in *Cultural Heritage of Jaipur*, ed. Jai Narayan Asopa (Jodphur: United Book Traders, 1982), 21.

of the observatory, palace, or city, but by the walls surrounding and dividing the state of Amer, most of which pre-dated Sawai Jai Singh's tenure on the cushion throne of Amer and Jaipur.

We can assume a slight tightening of the network once Sawai Jai Singh permanently relocated to the Chandra Mahal, but not a complete closure of the porous city boundaries. The walls of Jaipur were surely intended to provide some security to the merchants and traders living and working inside, but the major source of protection was established outside the city in the form of a chain of new hilltop fortresses (Sudarśangarh [Nahargarh], Jaigarh, Amargarh, Hathroi, and Shankargarh [Moti Dūngri]) (figure 3.8). Guarded from above in all directions, the defense of the city was not necessarily predicated on walls, and unlike the typical Rajput city, the town itself need not have functioned as a military stronghold.³⁹ The forts also safeguarded the planned development outside the city walls, such as the new havelis going up on the Mān Sāgar embankment, and other spaces exterior to the city proper (the road to and temple at Galtaji, the Charan Mandir, the royal cenotaphs at Gaitor, and so on). This is a decidedly complex vision of intramural motion, specific to the cityscape of Amer and Jaipur. The network of communication and fiscal exchange covered a noticeably shifting space, located inside and outside the walls of the new city.

3.3 Constructing Jaipur

The observatory was one component within an expansive construction project. Archival documents make it clear that even if the Maharaja Dhiraja carried out occasional astronomical work before 1728/29 CE (VS 1785) in Amer or in the *sarahad* (the southern bounds of the state), the bulk of the construction of the masonry instruments and ancillary structures in the observatory were completed as part of an intense period of building following the foundation

³⁹ Yaduendra Sahai, "Sawai Jai Singh, Patron of Architecture," in *Cultural Heritage of Jaipur*, ed. Jai Narayan Asopa (Jodhpur: United Book Traders, 1982), 32.

ceremony of the new capital of Jaipur on November 29, 1727 CE (Pauśa Vadi 1, VS 1784).⁴⁰ Sawai Jai Singh allegedly made the decision to move his Court permanently from its location in Amer in the Aravalli Hills to the open spaces of a nearby alluvial plain just after the conclusion of his final war against the Jats in the month of November 1722 CE (Kāti VS 1779).⁴¹ On his return to Amer after battle's end, he recognized that although the fortified palace had served his family well as a stronghold in times of war, it was too small to accommodate a Court with ambitions of territorial expansion.⁴² Despite the fact that Amer was his ancestral home and he had expended both creative energy and financial resources on additions to the palace, such as the monumental Ganesh Pol and the Jaleb Chowk, Sawai Jai Singh decided to halt further expansion at Amer and invest in a new capital city (figures 3.9 and 3.10).⁴³ In practical terms, this means that the observatory was not an isolated building project, but rather one part—and a small one at that—of a city-wide development plan. As distinctive as the observatory seems now, at the time of its initial construction it would have been lost in a flurry of building activity. It is difficult to imagine now, but almost overnight, in the place of single-story village dwellings rose extensive blocks and boulevards, lined with shops, havelis, and temples constructed of stone. Wells were

⁴⁰ The *sarahad*, used as a place of leisure by the Maharaja Dhiraja when in residence at Amer, originally encompassed the land on which the observatory now stands. It is possible that the king visited these grounds periodically for viewing the night sky with brass instruments, but no records of these observations exist today. Sahai reports that many of the structures used during hunting expeditions in the *sarahad* were later converted into permanent buildings in new city. For example, the *bārahdarī* at the northern end of the Jai Niwas gardens was developed into the Badal Mahal, while a similar pavilion at the opposite end became the base for the Govindadevji temple. Sahai also believes the Chandra Mahal was superimposed on an already-standing building. Given this, it is also possible that some pre-existing building, such as a protective hut, was also converted for the beginning of the observatory. ———, “Jaipur Architecture,” *Kalāvritt: Quarterly Magazine of Art* 32(April-June 1993): 10.

⁴¹ G. P. Pilia, *Enlightened Government in Modern India: Heritage of Sawai Jai Singh* (Jaipur: Aalekh Publishers, 2002), 20-31; Sarkar, 170.

⁴² It is also possible that the wells of the palace and the surrounding city by this time were overextended and contaminated, a condition that may have influenced the decision to relocate the seat of government. Pilia, 204.

⁴³ Tillotson, 102-3..

sunk at major crossroads,⁴⁴ canals were dug,⁴⁵ entire lakes were displaced by dam-building projects,⁴⁶ and roads were laid not just within the new city proper, but outside the walls as well, with improvement projects extending to Galtaji and Ghūmi Ghat in the east, along the Mān Sāgar embankment and to Amer in the north, and into all of the surrounding mountains to connect the new fortresses. The 120-acre City Palace complex gradually grew in the central quarter of the city. The observatory, located inside the Tripolia Gate and covering approximately 4% of City Palace property, was a minor construction project when compared to the work completed in the rest of the city. In fact, it is quite possible that before the construction of the lofty large Samrāt Yantra, the majority of the townspeople remained completely unaware of the observatory project.⁴⁷

The accounts of the *Imārat Khāna* can be used to work out a construction timeline for the city as a whole, but most of the attempts to determine an exact founding date for the observatory remain highly speculative and somewhat contradictory. In their handbook of restoration work undertaken at the observatory site in 1901-02 CE, Lieutenant Arthur ff. Garrett and Pandit Chandradhar Guleri suggest that the original construction of the stone instruments in Jaipur

⁴⁴ Sahai, “Jaipur Architecture,” 11. Hendley reports that by the middle of the nineteenth century, the water in all the city wells had become brackish and non-potable. Thomas Holbein Hendley, *The Jeypore Guide* (Jaipur (Jeypore): Raj Press, 1876), 19.

⁴⁵ Sarkar, 206. Because the city was constructed on a bed of quick-draining alluvial soil and sand, one of the first building projects called for canals to bring water from the Jhotwāda and Darbhavatī Rivers. The Kapadwara collection of the City Palace contains multiple eighteenth-century maps on paper and cloth, a handful of which have been concretely identified as depicting these two canal projects. See description nos. 116, 119, 153, 214, 312 in Bahura and Singh, 29, 30, 39, 49, 81-82, 111-12, 139; Sarkar, 206-06.

⁴⁶ Roy, 142. Multiple dam projects have affected the size and location of the Mān Sāgar, Jai Sāgar (Talkatora), and Sarswati Kund at Galtaji. See description nos. 29, 86, 117, 201, 222 in Bahura and Singh, 20; 26; 30; 39-40; 55; 71; 81; 110; 113.

⁴⁷ Based on *Roznāma Imāratī* records for VS 1790-1792, Sharma speculates that construction of the massive Samrāt Yantra began in VS 1792 (1735/36 CE). Allegedly, a payment of 10,800r-0a-0p was made for lime in that year, and an individual named Rāmadāsa Patela was paid 11,335r-0a-0p for work completed in conjunction with the observatory. Sharma suggests that the large sums of money involved in these transactions indicate the construction of some larger instrument. Unfortunately, the *Roznāma Imāratī* records for the years VS 1790-1792 appear to be unavailable for examination. Of the four bundles catalogued at the Rajasthan State Archives, none corresponded precisely to the dates provided by Sharma. See Sharma, *Sawai Jai Singh and his Astronomy*, 122.

commenced around 1718 CE and finished in 1734 CE.⁴⁸ In an archaeological study conducted in 1915-16 CE, G. R. Kaye proposes the entire observatory was constructed c. 1734 CE.⁴⁹ Based on a close reading of the preface of the *Zīj-i Muḥammad Shāhī*, V. S. Bhatnagar concludes that the Shahjahanabad observatory was completed in 1721 CE, and the other four observatories by the end of 1728 CE, the year he proposed as the “publication date” for the *zīj*.⁵⁰ Andreas Volwahren does not commit to a date in his doctoral dissertation, nor in the monograph derived from that treatise, but notes only that, according to documentary evidence (for which he did not provide a citation), the Jaipur observatory was completed by 1734 CE.⁵¹ Vibhuti Sachdev and Giles Tillotson speculate that observational efforts began outside the walls of Shahjahanabad in 1724 CE, meaning that work at the Jaipur observatory was necessarily initiated and completed at some later date.⁵² In perhaps the most detailed consideration of the possibilities of the observatory’s origins, V. N. Sharma also hesitates to provide a definitive date of founding for the

⁴⁸ Garrett and Guleri posited a construction date of 1710 CE for the Delhi observatory. This is rather doubtful because Sawai Jai Singh was out of favor with the court of Bahadur Shah at that time. The 1901-2 CE restoration of the Jaipur observatory was—inexplicably—part of the larger famine relief project for which Garrett was “loaned” to the darbar of Maharaja Madho Singh by the North West Railway via the Foreign Office. See Arthur ff. Garrett and Chandradhar Guleri, *The Jaipur Observatory and Its Builder* (Allahabad: Pioneer Press, 1902), 14; Government of India, September 1900, *Retention of the services of Lieut. A. ff. Garrett by the Jaipur Darbar for a further period of 2 months from the 28th August 1900*, Foreign Department, Internal, Nos. 86-89, 1-11; Government of India, May 1901, *Transfer of Lieutenant A. ff. Garrett for employment in the Jaipur State during the absence on furlough of Mr. C. E. Stotherd*, Foreign Department, General-B, Nos. 240-247, 1-28; Government of India, January 1901, *Extension of the services of Lieut. A. F. F. Garrett, R. E., on famine duty with the Jaipur Darbar up to the 3rd November 1900*, Foreign Department, Internal-B, Nos. 1-2, 1-5.

⁴⁹ Kaye, 53.

⁵⁰ V. S. Bhatnagar, “Sawai Jai Singh's Contribution to Culture,” in *Cultural Heritage of Jaipur*, ed. Jai Narayan Asopa (Jaipur: 1982), 65.

⁵¹ Andreas Volwahren, “Zur Architektur der Sternwarten des Maharaja Jai-Singh-II von Jaipur” (Technischen Hochschule Munchen, 1969); Volwahren, *Cosmic Architecture in India: the Astronomical Monuments of Maharaja Jai Singh II*, 65.

⁵² Sachdev and Tillotson, 106. Bahura also gives 1724 CE as the founding date of the Shahjahanabad observatory. Gopal Narayan Bahura, *Literary Heritage of the Rulers of Amber and Jaipur: with an Index to the Register of Manuscripts in the Pothikhana of Jaipur (I. Khasmohor Collection)* (Jaipur: Maharaja Sawai Man Singh II Museum, 1976), 57.

observatory but argued that since several of the instruments appear on a map dated to 1728 CE, construction must have commenced at least a few years before that time (map 3.3).⁵³

If we take Sawai Jai Singh's statement in the preface to the *Zīj-i Muḥammad Shāhī* at face value, he ordered the construction of the Shahjahanabad observatory shortly before those at Jaipur, Varanasi, Mathura, and Ujjain.⁵⁴ As he described, before the construction of the stone instruments commenced in Shahjahanabad, observations had been attempted with brass instruments, but "finding that the brass instruments did meet the ideas which he had formed of accuracy...he constructed in the Abode of the Caliphate Shahjahanabad, which is the seat of empire and prosperity, instruments of his own invention..."⁵⁵ After completing a certain number of observations with these instruments in Shahjahanabad, the Maharaja Dhiraja then "constructed instruments of the same kind in Sawai Jayapura and Mathura and Benares and Ujjain."⁵⁶ The expenditures for the early endeavors in brass were probably minimal, and as such, do not seem to be captured in any existing accounting records. And, since the scribe of the *Zīj-i Muḥammad Shāhī* did not include a calendar date for the Shahjahanabad project, projecting a timeline for the completion of the other four observatories is difficult. Conventionally, however, the observatory at Jaipur is assumed to predate the other three sites, with work initiated just slightly before the formal founding date of the new city. This would make the instruments roughly coeval with the

⁵³ Map No. 15, Sawai Man Singh II Museum, Jaipur, Rajasthan. See Sharma, *Sawai Jai Singh and his Astronomy*, 121-22. Unfortunately, the dating of the map to which Sharma refers is not conclusive. Sharma assigns to it the year 1728 CE because it does not depict the structure known today as "the astronomer's room," a small building constructed in 1728 CE, according to a plaque affixed to its southern wall. The astronomer's room does appear on a map clearly produced some time after Sawai Jai Singh's death (Map No. 23, Sawai Man Singh II Museum). The inclusion of this building on the later map may suggest that had it existed, the room would have been included in the earlier version of the observatory plan as well. However, it is equally possible that as a non-essential structure, the building was simply left off the earlier map, complicating any attempt to conclusively date the map based on its inclusions. Despite the interpretive possibilities of the maps, we cannot accept a pre-1728 founding date without more developed supporting evidence. See ———, *Sawai Jai Singh and his Astronomy*, 128-29.

⁵⁴ *Zīj-i Muḥammad Shāhī*, fol. 4v.

⁵⁵ *Ibid.*, fol. 4r.

⁵⁶ *Ibid.*, fol. 4v.

rest of the buildings in Jaipur.⁵⁷ Though not particularly precise, the assumption that the observatory was built c. 1728 CE jibes with the dates extrapolated from an analysis of the accounting records produced as part of the construction of Jaipur. Ordinarily, we would not look for the design of scientific instruments in a collection of construction documents, but because these particular instruments were built of stone and obviously required a great deal of unskilled labor to erect, in addition to skilled labor for finish work, the financial records for the design and construction of the instruments were managed through the newly regularized *Imārat Khāna*, one of the bureaucratic offices adapted by Sawai Jai Singh II from the Mughal system of administration.⁵⁸ It is very likely that the *Imārat Khāna* was created, or at least standardized, in response to the massive scale of development in the new city. As we can see from the various account books from this department, the simultaneous construction of city walls, gates, bazaars, havelis, tanks and wells, lakes, temples, palace, and observatory required an immense and dedicated effort to coordinate the purchase, delivery, and deployment of materials and labor. Of course, the earlier addition of the Jaleb Chowk and Ganesh Pol to the Raj Mahal at Amer under

⁵⁷ In fact, there is some small debate over the precise date for the groundbreaking ceremony for the new city. Bakhtarama Saha's *Buddhi-vilāsa* gives the date as Pauśa Vadi 1, VS 1784 (November 28, 1727 CE), but the according to the *Bhojansara*, a historical narrative poem written at Sawai Jai Singh's court, the ceremony was conducted two weeks later, on Pauśa Sudi 1, VS 1784 (December 13, 1727 CE). See Saha, 8-9; P. K. Gode, "Two Contemporary Tributes to Minister Vidyādhara, the Bengālī Architect of Jaipur at the Court of Sevai Jaising of Amber (A.D. 1699-1743)," *Indological Studies* Dr. C. Kunhan Raja Presentation Volume (1946): 289, 291; Roy, 44, 236.

⁵⁸ Humayun is recorded as having imported the Persian *karkhāna* (workshop) system to Agra, but it was under Akbar that the Mughal system of *karkhānas* was standardized according to resources available in India. Akbar's system of 36 imperial *karkhāna* was well described in Abu al-Fazl's *Ain-i Akbari* ("Institutes of Akbar"), and also by foreign visitors to Mughal territories such as François Bernier. See Abul Fazl 'Allami, *The Ain I Akbari*, trans. H. Blochmann (Calcutta: Baptist Mission Press, 1873), passim; François Bernier, *Voyage dans les États du Grand Mogul* (Paris: Arthème Fayard, 1981), 194-95. For an excellent description of the various *karkhāna* systems (imperial, princely and great amiri, and merchant) operating in Shahjahanabad c. 1639-1739 CE, see Stephen Blake, *Shahjahanabad: The Sovereign City in Mughal India, 1639-1739* (Cambridge: Cambridge University Press, 1991), 105-12.

the watch of Sawai Jai Singh was not a trivial project, but it hardly compared to the building of the new City Palace, much less to the project of constructing the entire new city.⁵⁹

3.4 Building the Observatory

At the time of Jaipur's founding, Vidyādhara, a descendent of the Bengali priest Ratnagarbha Savarbhauma Bhattachārya, was serving as director of the *Imārat Khāna*.⁶⁰ Oral and literary traditions place Vidyādhara in a significant role in the city's creation, crediting him with both the initial city plan and the unified aesthetic of the new capital.⁶¹ However, despite numerous panegyrics to his involvement in the design of Jaipur, scholars frequently hesitate to consider him a designer, assigning him instead to a supervisory, as opposed to a creative, position.⁶² It may be more appropriate to consider him more of a construction manager than an architect in the present sense of the word. He was deeply involved in the construction, and indeed, responsible for authorizing all expenditures and certifying income and monies collected for the Maharaja Dhiraja through the *Imārat Khāna*. It was Vidyādhara who coordinated the entire building production: deliveries of raw materials, payment of workers, assignation of

⁵⁹ Michell and Martinelli, 162.

⁶⁰ Ratnagarbha was brought to Amer by Raja Man Singh when that Maharaja installed the image of Shila Devi in the Amer fort. One of Ratnagarbha's seven daughters was married to another Bengali Brahmin, Rajendra Chakravarty. It was Rajendra's son, Santendra Chakravarty, who fathered Vidyādhara. Roy, 43. Roy based his biography on a family history dictated by descendents of Vidyādhara, collated and published in the *Bangiya Sahitya Parishad Patrika*, Vol. XI, in 1905. See also Bimalacharan Deb, "Vidyādhara," *Annals of the Bhandarkar Oriental Research Institute*, Baroda 28 (1947): 212-18.

⁶¹ Vidyādhara's name appears repeatedly in court ballads in connection with the building of the new city of Jaipur. For example, according to the *Bhojansāra* by Girdhari in 1739 CE, ten years after the founding of the new capital, it was to Vidyādhara that Sawai Jai Singh explained his vision for his city. Thus, "Sawai laid the foundation of Jaipur, the description of which is as follows: — Couplet — He laid out many streets, and thus enhanced the joy of heart. He said to Vidyādhara that a city should be founded here (182)." [अथ सवाई जैपुर बसायौताकौवर्नन ॥ दोहा ॥ पुराकरे बहु हरष करी मनमहिमोद बढाय | विद्याधर सौ बोलि कहि सहरसु एक बसाय ॥18 v॥] See Gode, 286-89; Roy, 233-35. In 1749 CE, Shri Krishna Bhatta, the court poet of Ishwari Singh, chronicled the reign of Sawai Jai Singh in his *Īśvaravilāsa Mahākāvya*, and included a lengthy song of praise for Vidyādhara and his accomplishments. Kṛṣṇa Bhaṭṭ, *Īśvaravilāsa Mahākāvya*, trans. Madhuranatha Shastri (Jaipur: Oriental Research Institute, 1958), 191-93. For an English translation see Roy, 42-43.

⁶² For example, Sachdev argues that Vidyādhara played no creative role in the design of the city but was limited to a position of bureaucratic control. See Vibhuti Sachdev, *Building Jaipur: the Making of an Indian City* (New Delhi: Oxford University Press, 2002), 46.

building plots, approval of building plans, and so on.⁶³ It is obvious from the placement of his seal throughout the *Imārat Khāna* records for this period that his duties were many and important, and as head of the *Imārat Khāna*, he functioned as a stand-in for the Maharaja Dhiraja for the duration of the construction process (figure 3.11).⁶⁴ In fact, so highly regarded was Vidyādhār by Sawai Jai Singh that at the end of 1728/29 CE (VS 1785), just one year into the project of building an entire city, the king appointed him to the position of *Deś Dīwān* (Chief Minister). As such, he plainly represented the interests of the Rajput state during those periods when the Maharaja Dhiraja was away from his home.

As Vidyādhār was in charge of construction requisitions for the entire city, so too did he manage the materials delivered to the observatory. A bill of goods for the observatory first appears in the *Imārat Khāna* accounts in 1728/29 CE (VS 1785), the same year in which Vidyādhār ascended to the position of *Deś Dīwān*. Generally speaking, these accounts tracked collections and expenditures for the *Imārat Khāna* as a whole, which means they represented work from across the entirety of Jaipur and its environs. The general scheme was this: whenever a building was approved, the *Imārat Khāna* provided the raw materials for that project in advance of and throughout the life of the project. At the end of a fiscal period (usually thirty days), *tehevildars* (finance officers) for designated parts of the city would collect on the debts in cash and goods to cover the cost of previously delivered materials. If the projects were civic or royal, the *Imārat Khāna* also paid the labor costs for these projects. Since the observatory was a royal project, there was seldom any recovery income tracked (the Court did not bill itself for

⁶³ Roy, 41-42, 51-52. Roy quotes a letter sent from Sawai Jai Singh to the merchant Ghasiram Murlidhar, offering him free land for a haveli if Murlidhar agreed to relocate his business to the new city. The merchant was instructed to act according to the instructions of Vidyādhār when constructing his building.

⁶⁴ For example, his seal is stamped in the *Roznāma Imārātī* on a twice daily basis, once on the first page of the collection accounts, once on the first page of the expenditure accounts. Deb also credits Vidyādhār with the introduction of Hindi-language record keeping, stating that previous to Vidyādhār's tenure in the *Imārat Khāna*, the royal seal was inscribed in Persian, but in VS 1772 (c. 1715 CE), the minister convinced the Maharaja Dhiraja to stamp his edicts with a seal inscribed in Hindi. Deb, 214.

buildings it constructed for its own use), so only the expenses involved in the building process appeared in the accounts.⁶⁵

It is not clear which instruments were designed and completed first, other than the brass astrolabes described in the *Zīj-i Muḥammad Shāhī*, but the majority of the masonry instruments at Jaipur shared a similar construction approach in that they required a progression from excavation to stonework, from stonework to plasterwork, and from plasterwork to the inscription of scales. In the earliest stages of design, a wax or wooden model of the proposed instrument may have been constructed, either by one of the astronomers, or even by the Maharaja Dhiraja himself.⁶⁶ For some of the instruments, a digger needed to complete a certain amount of excavation and leveling after the building outline was scribed on the ground. As the instructions provided by Jagannātha in the *Yantraprakāra* indicated, the subterranean bowls of the Jai Prakāś and the Kapāla Yantras each required a substantial amount of this type of work:

On a ground made level with water describe first a circle of any radius (*karkaṭa*). After determining the cardinal points (*diksādhana*) there, draw east-west and south-north lines. Dig out [the earth] within the circle to form a concave hemisphere (*kapāla*). Prepare in metal or wood a semi-circular ring (*valayādhara*), i.e. a half of the circle [first drawn], and rotate this ring around in the excavated pit. If it moves smoothly around, then the instrument is correctly made.⁶⁷

⁶⁵ After 1792 VS (1735/36 CE), we can find small amounts of cash and goods being transferred back into to the court coffers from the observatory in the *Syāha Imāratī*, but nothing on the scale that we see generated during the building of private havelis, bazaars, and so on. See Bhādvā Sūdi 2 VS 1792, Bundle No. 9, SI, RSA, Bikaner; Pausa Sūdi 14 VS 1792, Bundle No. 9, SI, RSA, Bikaner.

⁶⁶ Joseph du Bois, a European resident at Sawai Jai Singh's court in 1732 CE, claimed that the Maharaja Dhiraja fabricated the wax model for what appears to have been the Samrāt Yantra. The king then gave it to his workmen for full-scale construction. Vidyādhara was also thought to possess particularly impressive model-making skills, so it is possible he was responsible for modeling required by the *Imārat Khāna*. Deb, 214; Raymond Mercier, "Account by Joseph Dubois of Astronomical Work under Jai Singh Sawa'i," *Indian Journal of History of Science* 28, no. 2 (1993): 159, 162.

⁶⁷ Jagannātha Samrāt, "Yantraprakara of Sawai Jai Singh," in *Supplement to Studies in History of Medicine and Science*, ed. Sreeramula Rajeswara Sarma (New Delhi: Department of History of Medicine and Science, Jamia Hamdard, 1987), 14, 46.

The large Samrāt Yantra required the excavation of a substantial pit, which was then leveled with the use of water channels to receive the base of the gnomon and the quadrants (figure 3.12).⁶⁸ On the other hand, the Rāma Yantra, a smaller instrument designed to measure altitude and azimuth, was built entirely above grade (figure 3.13).⁶⁹ In the case of this instrument, after leveling the ground, followed by the inscription of a perfect circle with chalk, the stonemason laid a quartzite block plinth, bringing it to true by again running water into leveling channels. The vertical members spaced around the perimeter of the Rāma Yantra's plinth consisted of stone stacked without the benefit of mortar, the taller blocks alternating with thinner slabs that functioned as headers.⁷⁰ Approximately 1.2 meters above the upper surface of the plinth, radial sandstone sectors, scaled for azimuth measurements and leveled in relation to the plinth, interrupted the piers. The piers continued upward above the radial sectors, culminating at a stone anchor ring stabilizing the otherwise free-standing piers.⁷¹ Masons notched the piers to allow for the insertion of resting boards for use during observation sessions. The vertical walls were

⁶⁸ Jagannātha indicated in both his Sanskrit translation of Ptolemy's *Almagest* and the *Yantraprakāra* that water was used to level the ground when building the Digamṣa Yantra and Jai Prakāś Yantra. Although not mentioned in these treatises, it is clear that the same procedure was used to level the ground for the quadrants of the Samrāt Yantra, as the channels used for leveling are still visible today. Sharma, ed. *Samrāt-Siddhāntah Avāntara Paṭhabhedasamanvitah Siddhāntasārakaustubhah*, 1034, 1042; Samrāt, 14, 22, 46, 65.

⁶⁹ The Rāma Yantra consists of two complementary structures, identical in construction. The separate units are designed such that if one was superimposed vertically upon the other, the radial sectors would combine to make a solid surface. By splitting the instrument in two pieces, the designer created empty space so that an observer could stand between the radial sectors to take measurements.

⁷⁰ We should probably be cautious in our interpretation of the formal characteristics of any of the instruments not clearly described in the *Samrāt-Siddhāntah* or the *Yantraprakāra*, as all of the observatories have been subjected to multiple restoration and reconstruction processes. At Jaipur, entire instruments were relocated during the restoration of 1876 CE under Sawai Ram Singh II. The observatory underwent renovation again in 1891 CE under Sawai Madho Singh II, during which time the Rāma Yantras were rebuilt. A large scale restoration was undertaken by the same Maharaja in 1901-1902 CE, resulting in a complete reconstruction of some of the instruments, including all twelve Rāśivalayas. The scales of the large Samrāt Yantra were replaced with marble in 1945 CE, and the entire observatory underwent repairs, including the resurfacing of all of the major instruments under the supervision of the Archaeology and Museum Department in 2007. See Garrett and Guleri, 1; Sharma, *Sawai Jai Singh and his Astronomy*, 130-31; Volwahren, *Cosmic Architecture in India: the Astronomical Monuments of Maharaja Jai Singh II*, 138.

⁷¹ As noted in Chapter Two, this method of stabilizing the vertical elements of the Rāma Yantra is quite different from that used in Shahjahanabad, where the vertical members are integrated into a system of stacked arcades, acting much more like pilasters than free-standing piers. Additionally, the Rāma Yantra is partially below grade in Shahjahanabad.

probably treated originally with *chunā* (quicklime plaster) and *gerū* (wash), while the stone sectors were marked with the necessary alt-azimuth scales. Today, the horizontal scales for the Rāma Yantra are etched directly into the stone, but it is more likely that in the original configuration, rough quartzite stone was covered with *chunā*, and the scales were subsequently etched into the polished white surface (figure 3.14).⁷²

Typically, the *Aṭhsaṭhī Imāratī* give a total expense for *masāla-ajūra* (raw materials and remuneration), followed by an itemized list of the materials raw goods to the observatory over the course of the year. The lists of materials in the *Aṭhsaṭhī Imāratī* for the observatory for the years 1728-1733 CE (VS 1785-1788) are completely consistent with the construction methods described above. In 1728/29 CE (VS 1785), the *Imārat Khāna* dedicated a total of 2802r-11a-0p to observatory expenses.⁷³ Of that amount, 1401r-15a-0p went toward the following materials: *kalī* (unslaked lime) (587r-3a-0p); *chunā* (348r-1a-0p); stone and stone baskets; gravel; bricks; water; wooden objects; sewing; weaving; flour; grit (burnt sand); baskets; oil; cloth; paint/dye; and utensils.⁷⁴ The division of labor at the observatory was not articulated in this set of accounts, but assuming that the largest numbers indicate volume rather than value of the materials, a greater part of the total wage expenditure went toward the slaking of lime on site, stonework, and whitewash application.⁷⁵

In 1729/30 CE (VS 1786), the amount spent on the observatory grew significantly, more than quadrupling from the year before, perhaps reflecting an increase in the size or extent of new

⁷² In the *Zīj-i Muḥammad Shāhī*, Sawai Jai Singh indicates that the instruments at the observatory in Shahjahanabad were constructed “of stone and lime.” Evidence of a similar treatment can be seen on the degraded surfaces of the Jai Prakāś Yantra in Delhi. Joseph Tieffenthaler’s 1744 CE description of the instruments in the Jaipur observatory as “artistically fabricated in very white whitewash or gypsum” is consistent with the practice of scales marked on a plaster surface. Tieffenthaler, du Perron, and Rennell, 317; *Zīj-i Muḥammad Shāhī*, fol. 4r.

⁷³ Bhādvā Sūdi 3 VS 1785 to Bhādvā Sūdi 2 VS 1786, fol. 23. When recompensing workers for their labor, the *Imārat Khāna* often provided two types of pay, a first in *rupee-anna-paise* form, and a second in *taka-poiśe* form. See Chapter Two, n. 63 for more information on the currency standards in South Asia during the eighteenth century.

⁷⁴ The remainder of the 2802r-11a-0a (1400r-12a-0p) went toward wages, unspecified. Ibid., fol. 23-24.

⁷⁵ For a summary of the cost of building materials in the era of Akbar, see 'Allami, 222-24.

instrumentation. During this year, a total of 12,535r-15a-0p was spent at the observatory, with approximately half of this amount (5960r-7a-0p) covering remunerations.⁷⁶ Judging from the 6139r-14a-2p spent on a greatly expanded list of materials, the work undertaken at the Jaipur observatory during VS 1786 represented not only the need for an increase in variety of building tasks to be completed but a demand for more specialized labor as well. Again, the majority of the materials' budget was dedicated to *chunā* and *kalī* (2398r-14a-0p and 2031r-10a-0p, respectively), but several new expenses were included in the materials list such as clay stone, chipped gravel, coal, paper, grit, water, bamboo, color/paint, asafoetida resin, white tint/chalk, black ink, jaggery, borax, sand, sal-ammoniac, shellac, and lac, in addition to many other requested substances (a total of 45 in all).⁷⁷ This longer list of materials suggests that work on the site had progressed well beyond excavation, grading, and even the mortar-less masonry work practiced through northern India at this time. The entries for water, resin, grit, color, white chalk, sand, borax, sal-ammoniac, and jaggery undoubtedly represent the production and application of scratch, brown, and finish coats on the instruments. Coal could have been used to facilitate the slaking of lime on site, while bamboo was the wood of choice for scaffolding.

For the next two years, the bills of materials were quite similar to those issued in 1728/29 and 1729/30 CE. In 1730/31 CE (VS 1787), *chunā* (504r-1a0p) and *kalī* (2992r-5a-2p) continued to account for the primary material costs, although clay (619r-9a-0p) and stone/stonework (564r-15a-0p) also represented a large part of the expense list.⁷⁸ In 1731/32 CE (VS 1788) the list of raw materials came with the standard inclusions of *chunā* (2703r-6a-2p),

⁷⁶ Bhādvā Sūdi 3 VS 1786 to Bhādvā Sūdi 2 VS 1787, fol. 20r-22r.. Of this wage total, 5458r-7a-0p was marked as *dadnī* (wages owed). An additional 502r-0a-0p was given to the *ijārādāra/ijāredāra* (leaseholder). An additional 435r-9a-0p was given as monthly offerings to *paṇḍīji* (probably the resident Brahmin priest at an onsite temple throughout the year. This amount was apparently not included in the annual total for *punya arth* (charitable gifts), as that total was only 128r-10a-0p. See Bhādvā Sūdi 3 VS 1786 to Bhādvā Sūdi 2 VS 1787, fol. 12r.

⁷⁷ Bhādvā Sūdi 3 VS 1786 to Bhādvā Sūdi 2 VS 1787, fol. 20-22.

⁷⁸ Bhādvā Sūdi 3 VS 1787 to Bhādvā Sūdi 2 VS 1788, fol. 30-31.

kalī (3543r-0a-0p), coal, chalk, stone, and sewing/stitching.⁷⁹ Over the course of these four years, an impressive volume of raw goods was consumed at the observatory, despite the fact that the project remained a relatively minor one in comparison to the construction of the city as a whole from year to year.⁸⁰

It is undoubtedly useful to know what was included in the *Imārat Khāna* supply rooms, and what was available for use in the construction of astronomical instruments. These records obviously suggest a congruence of the materials with what we know about building practices at the observatory. However, these records are also intriguing for what they do not include in their pages. That is, an examination of the itemized materials reveals some interesting gaps in the inventory, suggesting that in the process of designing the observatory, Sawai Jai Singh ran up against insurmountable limitations. For example, nowhere do any of the available bills of delivery mention red sandstone or white marble, an unexpected absence given the preferred royal aesthetic for red sandstone buildings with white marble trim.⁸¹ Most, if not all, of the exposed (non-scaled) surfaces of the instruments were covered not with an imperial sandstone but with a *chunā* plaster, treated additionally with *gerū*, a red ochre wash.⁸² The procurement of quality stone was not a small problem during the construction of the new city, and apparently these

⁷⁹ Sāvna Sūdi 10 VS 1788 to Bhādvā Sūdi 2 VS 1789, fol. 37r-38r, Bundle No. 4, AI, RSA, Bikaner.

⁸⁰ For example, in VS 1786, the observatory was only the fourth largest project in the city. In that same year, the *Koth-bādar va Jāsvādī Jāyapura* (Jaswadi Palace in Jaipur), the mansion for a dignitary from Jaswadi (in present-day Madhya Pradesh), consumed a tremendous 79,792r-5a-0p. The second largest project of the year, Shri Maharaji Kavarji's *Rahāsi* (Retreat), ate up 41,025r-11a-0p. The third largest project in the city that year, the *Sarvatomukh Mahal* (the Many-Sided Palace, or Chandra Mahal) required an outlay of 26,602r-10a-2p, or just over twice the amount spent on the observatory. These and a few other larger projects stand out among a host of smaller projects like the construction the Charna Mandir (1149r-7a-0p), Persian wheels (a total of 559r-1a-0p paid in VS 1786 for materials, wages, oxen, and payment to the Thakur), the Jal Mandir (502r-0a-2p), and an oxen stable (26r-11a-0p). See Bhādvā Sūdi 3 VS 1786 to Bhādvā Sūdi 2 VS 1787, fol. 15-18; 23-24; 35-37; 40; 43; 51.

⁸¹ The preference for this general style dates back to the large-scale monuments sponsored by Akbar, such as Humayun's Tomb in Delhi. Ebba Koch, *Mughal Architecture: An Outline of Its History and Development (1526-1858)* (Munich: Prestel, 1991), 50; Glenn D. Lowry, "Humayun's Tomb: Form, Function, and Meaning in Early Mughal Architecture," *Muqarnas* 4 (1987): 140-42.

⁸² *Gerū* can also be produced with yellow ochre, depending on the soil pigments used to tint the wash. The soil for the red *gerū* was mined ten miles (16.09 km) east of Jaipur, north of the village of Kanota (Kanauta), and carried into Jaipur by donkey. Sahai, "Jaipur Architecture," 13.

difficulties extended to the observatory as well. The nearest red sandstone quarries were over 80 miles (128.75 km) from Jaipur in the princely state of Karauli and firmly under control of Maharaja Gopal Singh.⁸³ Moreover, Karauli stone was of a spotted variety and not as dark as the preferred red sandstone quarried in the mines governed by the Maharaja of Marwar (later Jodhpur) Abhai Singh.⁸⁴ The Danau mines, owned by Jaipur and situated about 24 miles (38.62 km) away from the city, produced only a coarse, gray sandstone, unsuitable for finish work. Slightly better in quality was the gray metamorphic quartzite sandstone quarried from the hills beneath Amagarh and Sundarśangarh (Nahargarh) at the perimeter of the city. This type of stone, used for the rough stonework on city houses and the rubble cores of the observatory instruments, is visible today in the exposed scale of the Rāma Yantra and does not match the quality ordinarily associated with an imperial or princely project (figure 3.14). However, when faced with an absence of quality stone, the laborers at the observatory fell back on local building materials and methods to complete their project, employing *chunā* and *gerū* to produce a uniform appearance to harmonize with other architecture in the city.

The builders adopted a similar solution when faced with task of finishing the scaled surfaces of the instruments. Today, most of the scaled surfaces in the observatory are made of white marble, but this is the result of recent restoration, not original design.⁸⁵ The procurement of fine white marble by Vidyādhara's *Imārat Khāna* was a near impossibility. The marbles quarried at the Jaipur mines were yellow, and turned more so with age. The next closest marble mine of quality was to be found 36 miles (50.5 km) distant from Jaipur, at Raiwala, but these marbles tended toward gray and were much coarser than the higher quality material at the

⁸³ Karauli is on the southern route to Agra from Jaipur, via Gangapur and Dholpur, on today's National Highway 11B.

⁸⁴ Sahai, "Jaipur Architecture," 13.

⁸⁵ For example, the bowls of the Kapāla and Jai Prakāśa Yantras are made entirely of marble today.

Makrana mines of the Nagaur district.⁸⁶ The Makrana marbles (used most famously in the Taj Mahal built under the patronage of Shah Jahan) were a pure, milky white, and they retained their luminous quality when treated properly. However, Makrana marble, like the unobtainable red sandstone, was controlled by the Maharaja of Marwar. When forced to choose between an inferior yellow marble, or a treatment with white *chunā*, the choice probably seemed clear to the Maharaja Dhiraja and his builders.⁸⁷

The use of stone—or lack thereof—in these instruments is intriguing, because it so clearly demonstrates the paradox of Sawai Jai Singh’s power as a ruler of an independent state. On the one hand, he possessed the right, as head of state, to break down the Nahagarh and Amagarh escarpments wholesale in order to procure rubble-quality stone for his building projects, an activity that marked the landscape quite visibly and irreversibly, and as such, served as a permanent demonstration of his ability to mobilize resources within his own principality. On the other hand, he was either unable to negotiate a deal with the Maharaja of Marwar, or unable to reach deeply enough into the court coffers to produce the money, for the marble and sandstone requisite for a building project of such a high stature.⁸⁸ This is a remarkable conjunction of the visibility and erasure of power in a single site: while capable of marshalling enough labor to irreversibly scar the foothills of the Aravallis in pursuit of stone, he was

⁸⁶ Sahai, “Jaipur Architecture,” 13.

⁸⁷ Unfortunately, the precise formulae for the *chunā* plaster and *gerū* wash used on the instruments have not been found. Recently, the original *chunā* applied in the Sheesha Mahal at the Taj Mahal was analyzed to reveal its composition as 1 part burnt lime, 1 part ground shells, Gujarati calciferous stone or marble dust, 1/8 part gum from the *babul* or neem tree, 1/8 part sugar mixed with the juice of the fruit of the bel tree, and a bit of egg white. Plant fibers were added to stabilize and strengthen the plaster. After it dried, the surface was polished with a *kauri* (cowrie shell) and chalk powder until it reached a pearly white sheen. The materials listed in the *Aṭṣaṭhī Imārātī* for VS 1786 (c. 1729 CE) includes many of these same, or similar, materials. Bhādvā Sūdi 3 VS 1786 to Bhādvā Sūdi 2 VS 1787, fol. 20-22; Ebba Koch, *The Complete Taj Mahal and the Riverfront Gardens of Agra* (London: Thames and Hudson, 2006), 95.

⁸⁸ Most likely, the decision to use locally quarried stone was a financial one, as Sawai Jai Singh and the Maharaja of Marwar were on fairly good terms as political allies in 1728 CE. A decade later, however, Maharaja Abhai Singh was forced to surrender in a battle against the Maharaja of Bikaner, in whose defense Sawai Jai Singh rallied his troops. Sawai Jai Singh forced Abhai Singh to sign a treaty that gave Jaipur full control of the Suba of Ajmer, and required him to consult with the head of Amer before appointing his counselors. Roy, 7-8.

powerless to participate in the customary imperial building practices. Sawai Jai Singh (or Vidyādhār, as his representative) was forced simultaneously to innovate and to fall back on known and local construction techniques, building entirely new types of structures with a completely conventional skillset. This brings into question the perception that the relatively unguarded and open design of Jaipur demonstrated the strength and influence of the Maharaja Dhirajā Sawai Jai Singh II.⁸⁹ While the king might have been considered the “pre-eminent power in Rajasthan” by the year of his death in 1743 CE, at the outset of this project, financial or political conditions inhibited his aspirations to absolute control over his environment.⁹⁰ In this way, the observatory becomes an expression of limitation, not of the untrammelled authority typically credited to his position.

3.5 Locating Labor

Despite these obstacles, Sawai Jai Singh was not politically or fiscally frail, however. While many of the financial records from the observatory and the construction methods employed to build the instruments at the observatory present a contradiction, the same sources of information reveal a remarkable level of power in relation to the control of the local labor pool. The Rajput ruler could move people around in the urban landscape at will, and in this way, to facilitate—even demand—an exchange of knowledge by bringing three disparate labor groups together in a single space in order to design and erect a collection of instruments capable of producing accurate observational results. Casual or day laborers, mid-level *jyotiṣī* (astronomer/astrologers), and high-ranking *paṇḍits* and *najumī* (Brahmin and Islamic

⁸⁹ This general tone can be read in Vibhuti Sachdev’s discussion of “the city as self-assertion,” in which she defines Jaipur as a challenge to “the waning Mughal court,” as well as in the many depictions of the city as a place where traders could operate “in an atmosphere of complete security and fearlessness.” As Tillotson points out, however, although the city occupied an open plain, and gave the impression of an unguarded openness, Sawai Jai Singh did not fail to build a fort close to the city in case he needed to retreat from danger quickly. Pilania, 221; Sachdev, *Building Jaipur: the Making of an Indian City*, 36-38; Tillotson, 172.

⁹⁰ Roy, 8.

astronomers) collaborated to produce finely designed and fabricated instruments despite the restrictions on materials and money made evident by the final product.

Historians of science have closely examined the scientific production of the most privileged astronomers on the staff of Sawai Jai Singh; however, more attention could still be given to the interaction of this class of “employees” with those workers charged with the actual construction of the observatory. It often seems that the story of Jai Singh’s observatories is one of buildings and spaces devoid of people, and the accounting records do little to contradict this impression. Partly, this is a legacy of a colonial historiography that tended to erase any signs of agency and labor at the five locations. However, the lack of human presence in the written histories can also be attributed to the ways in which the original building projects were documented in the offices of Vidyādhār and the *Imārat Khāna*, in that only the highest ranked astronomical staff was ever accounted for by name. Most of the day labor in the city, including that of the observatory, was written anonymous through accounting practices. In fact, in the records for the observatory, no member of the lowest class of laborers was identified individually; instead, pay was recorded in terms of assigned job tasks. For instance, according to the *Roznāma Imāratī* for 1733/34 CE, on March 25, 1733 CE (Caitra Sūdi 10 VS 1790), the *Imārat Khāna* marked a total of 1596r-0a-2p + 3421th|0p for distribution at the observatory to cover costs for the 34-day period of February 16, 1733 CE to March 24, 1733 CE (Phālguna Sūdi 2 VS 1789 to Caitra Sūdi 9 VS 1790). Of this amount, the total owed for wages was 879r-0a-0p + 1371th|25p.⁹¹ This remuneration was broken down only as far as occupation: payments were made to craftsmen, carpenters, stone cutters, blacksmiths, diggers/laborers, bricklayers, roofers,

⁹¹ Caitra Sūdi 10 VS 1790, fol. 2v, Bundle No. 2, RI, RSA, Bikaner.

grinders/craftsmen, and to others charged with similar manual labor tasks.⁹² In the next month, Vidyādhara again settled the monthly account with the laborers with an expenditure of 1154r-0a-0p/1190th-0p.⁹³ Once more, we see three different types of craftsmen, blacksmiths, stone cutters, carpenters, diggers, machinists/turners, but no additional indications as to who these workers were, where they came from, or how they learned their building skills.⁹⁴ Over the next two years, no masons, craftsmen, or bricklayers were named in the *Roznāma Imāratī*. While we can use these general labor categories to speculate on the development of instrumentation on site, or the types of tasks that needed to be completed (for example on June 9, 1734 CE (Asāḍh Vadi 4 VS 1791), six years after the start of construction, there was still a need for craftsmen, carpenters, roofers, stonecutters, diggers, porters, blacksmith, lime crusher, grinders/craftsmen, machinist/turner, crew leaders, and others), it remains almost impossible to discern anything substantive about the social, religious, or political identities of the workmen charged with fulfilling these tasks.⁹⁵

This might have been the standard accounting practice, with the *Imārat Khāna* recording all workers' wages in terms of the completed task. This seems not to have been the case with the work conducted at the observatory, however. In this same collection of daily accounting records, we can read nine instances of remuneration, occurring over a stretch of twenty five months, made to the *jantra ka jotiṣi* (observatory's astronomers) for their roles in carrying out the precision finish work on the instruments. Folded into the daily summary for March 20, 1733 CE (Caitra Sūdi 5, VS 1790), for example, is a list detailing payments made on that day to the

⁹² For the wages of laborers in the time of Akbar, see 'Allami, 225-26.. See also Tripta Verma, *Karkhanas Under the Mughals From Akbar to Aurangzeb: A Study in Economic Development* (Delhi: Pragati Publications, 1994), 146-47.

⁹³ Jeth Sūdi 5 VS 1790, fol. 4r, Bundle No. 2, RI, RSA, Bikaner.

⁹⁴ Ibid., fol. 4v.

⁹⁵ Asāḍh Vadi 3 VS 1791, fol. 4rv, Bundle No. 3, RI, RSA, Bikaner.

astronomers for one month's labor from February 17, 1733 CE to March 17, 1733 CE (Phālguna Sūdi 3 VS 1789 to Caitra Sūdi 2 VS 1790). For this thirty-day period, a group of twenty astronomers divided amongst themselves a total of 158r-0a-0p.⁹⁶ Thirteen of the astronomers (Shrīpatī, Gangāpatī, Anand Rām, Chand Rām, Sūdhjī, Gangā Vīsan, Govinda Rām, Dev Kīsan, Jīvan Jośi, Fateh Chand, Kīsan Dīkhat, Dīla, and Ratnā) were paid what appears to be a standard wage of 7r-8a-0p.⁹⁷ Three of the astronomers (Rām Kīsan, Dhūv Rām, and Govinda) were paid significantly more, 12r-0a-0p, or almost 0r-6a-2p per day, assuming they, too, worked thirty days in a month. Mayā Rām received 6r-0a-0p for the month, Mauji Rām 5r-0a-0p, Gūlam Husain 9r-0a-0p, and a second Govinda Rām the least of all, 4r-8a-0p. The pay of the crew leader, Mauji Rām, was supplemented with an additional 6r-0a-0p, elevating him to the second highest pay scale.⁹⁸ This month reflects well the structured system used to account for the labor provided by the *jyotiṣī* at the observatory, as the wages remained quite consistent over the following two years. Although a few of the names disappeared from the payrolls, to be substituted with others, during the course of twenty-five months, the majority of these astrologer/astronomers appeared to have remained in place at the worksite, receiving the same rate of recompense for the duration.

Admittedly, not much more can be gleaned from these records in terms of personal information than from the accounts detailing the wages earned by the day laborers. However, the fact that the accountant saw fit to name each astronomer individually, not once, but at every pay period, suggests that certain tasks completed at the observatory were valued more highly, and were expected to be carried out by an entirely separate group of workers. Two different skill sets were employed at the observatory simultaneously, and as the successful completion of the

⁹⁶ Caitra Sūdi 5 VS 1790, fol. 4r, Bundle No. 2, RI, RSA, Bikaner.

⁹⁷ Or, 7-1/2 rupees. This 7r-8a-0p, reflecting a payment for a full thirty days of service, works out to four annas, or 1/4 rupee, per day.

⁹⁸ Caitra Sūdi 5 VS 1790, fol. 4r-5r.

observatory reveals, clearly the communication systems between the two groups worked efficiently. Moreover, these two groups apparently managed to absorb the knowledge possessed by a third class of laborers, the highest-ranked astronomers in Sawai Jai Singh's court. These astronomers typically worked not inside the observatory proper, but in a separate area of the City Palace. These were literate scholars, frequently referred to with the honorific of *paṇḍit* (priest), *-ji* (sir) or *jyotiṣa rai* (royal astronomer), and were rewarded handsomely for their endeavors. These are intellectuals about whom we know a great deal—not simply their names, but the name and caste of their parents, the cities in which they were born, and in some cases, even the location of their residence in the city of Jaipur. This group included extremely literate individuals such as Jagannātha Samrāt, author of the *Samrāt Siddhānta* and the *Yantraprakāra*, and Kevelrāma, credited with the composition of the *Tārāsāranī*. Despite the discrepancy in rank and education, these valued members of the Maharaja Dhiraja's intellectual circle managed to deliver their knowledge to the onsite labor at the observatory in a manner that facilitated the timely fabrication of unique astronomical instruments, precedents for which would not have been familiar to the stone masons, diggers, and *jyotiṣī*.

According to recent studies in the geographies of knowledge, this type of interaction reflects precisely how knowledge is produced and circulated in a localized network. For example, in their assessment of the knowledge spaces of Motor Sport Valley in Oxfordshire, England, Henry and Pinch posit a close relationship between the circulation of knowledge and “the continual ‘churning’ of people,” a phenomenon that accurately describes the intersection of skill groups and knowledge carriers at the observatory. In the case study described by Henry and Pinch, this “churning,” or “a process of circulating and producing embodied knowledge within the knowledge community and regional production culture” is the result of lateral transfers

within the limited geography of Motor Sport Valley.⁹⁹ That is, in the business of automobile design, employees at all levels constantly shift among production centers, without moving higher in the corporate hierarchy. However, these workers bring with them their previous knowledge about production and design, which they then pass to the workers at the same level in the destination corporation. From there, the knowledge passes both upward and downward within the corporate hierarchy through contact and conversation. Henry and Pinch conclude that although “this process may not change the pecking order within the industry, this ‘churning’ of personnel raises the knowledge base of the industry as a whole within the region.”¹⁰⁰

Conceivably, then, a similar model could work in Jaipur, despite the sharp divisions in labor classes due to caste or literacy. Brought together with a mutual goal of building and operating the observatory at Jaipur, astronomers from various regions of the country (Jagannātha Samrāt originated in a Brahmin village in Maharashtra, while Kevelrāma hailed from Modhasa [Modesa] in Gujarat) encountered an unfamiliar group of stone masons, blacksmiths and *jyotiṣī*, with whom they discussed the practical matters of constructing an accurate scientific instrument.

The interaction among these three groups highlights not just the manner in which information moves among people but also implicates certain spatial configurations in the process of exchange. The transfer of knowledge between the highest- and the lowest-ranked worker requires an examination of sites of production located exterior to the observatory, since astronomers such as Jagannātha Samrāt and Kevelrāma did not work on the grounds of the observatory on a hourly or even daily basis. By 1730/31 CE (VS 1787), the observatory was functioning as a scientific institution, one thoroughly entangled with other governmental

⁹⁹ Nick Henry and Steven Pinch, “Spatializing Knowledge: Placing the Knowledge Community of Motor Sport Valley,” in *Mapping Strategic Knowledge*, ed. Anne Sigismund Huff and Mark Jenkins (London: Sage Publications, 2002), 155.

¹⁰⁰ Ibid.

institutions then in the process of relocating to the completed sections of the City Palace.¹⁰¹ And while the observatory was obviously a source of knowledge production, both in terms of the inventive construction of instruments and the observation work carried on at night, there existed another, externally located, work area of equal importance, the nearby Jaleb Chowk. In many ways, this *chowk*, a gated courtyard housing administrative office, *karkhāna*, and *jalebdārs* (guards), became the demonstrative space of power and knowledge, supplementing and often replacing both the observatory and the *Imārat Khāna* as the site of control and construction of knowledge.

In the third year of the construction of Jaipur, Sawai Jai Singh ordered the completion of a walled courtyard to the west of the Sireh Deoḍi Darwaza (main public gate) to the City Palace complex, east of the *Diwān-i Ām* (public audience hall), and immediately north of the observatory (map 3.4).¹⁰² According to the *Buddhi-vilāsa*,

The lord [Sawai Jai Singh] laid down the courtyard quite adjacent to the main palace, where the thirty-six *kārkhānās* were located. The only change was that the king gave his

¹⁰¹ Although the *Imārat Khāna* accounts demonstrate that large-scale construction continued at the observatory site for many years, astronomical observations on site were underway by the third or fourth year of the observatory's life, if not before. In 1730/31 CE (VS 1787), the materials requisitions in the *Aṭhsaṭhī Imāratī* concerning the observatory included a short list of contingent expenditures, totaling 105r-8a-0p. These included such miscellaneous expenses such as carpets on which the astronomers could sit (8r-13a-0p), braziers (1r-3a-0p), a book written by the *paṇḍit* (2r-12a-0p), and a court courier (5r-6a-0p). These assorted items—the carpets, the braziers and the courier—indicated that although major construction was still underway (a total of 13,553r-4a-0p was billed from the observatory that same year for manual and astronomical labor, as well as building materials), some type of observation or recording program that required both the extended presence of the *jyotiṣī* and the ability to move information from place to place, had been initiated. Bhādvā Sūdi 3 VS 1787 to Bhādvā Sūdi 2 VS 1788, fol. 30-33.

¹⁰² The expenditure records for 1730/31 CE (VS 1787) indicate that the *Imārat Khāna* approved a total of 81,706r-7a-2p for work at the Jaleb Chowk. 46,601r-4a-0p represented remuneration and rent (10,567r-10a-2p for wages, and 36,033r-9a-2p for leaseholder back payments). However, it is likely that some work in this area began in the previous year. In 1729/30 CE (VS 1786), 33r-15a-0p was spent on the storekeeper's office for the *Farraś Khāna* (Department of Carpets and Floor Coverings). In the same year, the *kacaharī āmil* (executive officer's office) and the *kacaharī mastauḍa* (auditor's office) were at built the cost of 173r-12a-0p and 176r-5a-0p, respectively. These three departments were likely to be located in the Jaleb Chowk area, as they were also part of the *karkhāna* system. Bhādvā Sūdi 3 VS 1786 to Bhādvā Sūdi 2 VS 1787, fol. 31; Bhādvā Sūdi 3 VS 1787 to Bhādvā Sūdi 2 VS 1788, fol. 27-29.

kārkhānās a new Hindi nomenclature by calling them ग्राह [graha] considering the Persian names to be faulty.¹⁰³

This open, quadripartite courtyard, around which stood ranges of single-story offices, was the Jaleb Chowk (figure 3.15). It resembled and was probably based on the courtyard of the same name at Amer, also built under the patronage of Sawai Jai Singh.¹⁰⁴ As with the eponymous courtyard in Amer, the Jaipur Jaleb Chowk was multifunctional. It housed workshops necessary for producing and storing goods demanded by daily and ceremonial life of the Court, such as the *Farraś Khāna* (Carpet and Tent Department), the *Maśal Khāna* (Torch and Lighting Department), the *Khuśbū Khāna* (Perfumes Department), and *Rang Khāna* (the Paint and Color Department), but also accommodated the *jalebdār*, attendants, and retainers of the Maharaja Dhiraja. Troops mustered here for review and ceremonial processions, forging together in a single space the military and the fiscal strengths of the state of Amer and Jaipur.¹⁰⁵ The Jaleb Chowk was accessible by four gates, two of which were distinctly formal/ceremonial. Above the eastern gate was the *Naqqar Khāna* (Drum House), which was charged with sounding the *naubat* four times a day (figure 3.16).¹⁰⁶ The western gate, the Udai Pol, provided access to the quasi-

¹⁰³ Saha, 24; Bahura, *Literary Heritage of the Rulers of Amber and Jaipur: with an Index to the Register of Manuscripts in the Pothikhana of Jaipur (I. Khasmohor Collection)*, 14. This assertion is not precisely correct, as the *Imārat Khāna* (Building Department) seems to have been named as such from at least 1728/29 CE (VS 1785). In addition, early records for the Book Department, specifically those for 1733-1737 CE (VS 1790-1793), were labeled with the Persian appellation (*Pothī Khāna*) while later records dating to 1741-1743 CE (VS 1798-1800) were labeled with the Sanskrit/Hindi nomenclature (*Pustak Graha*).

¹⁰⁴ Tillotson, 102. Maharaja Ram Singh II added the second story and verandas, as well as the Council Chamber for the revenue collector (now the Sawai Man Singh Town Hall), to the Jaleb Chowk. The *karkhānas* remained in this space until the Princely State of Jaipur merged with the state of Rajasthan in 1949. See Joan L. Erdman, *Patrons and Performers in Rajasthan: The Subtle Tradition* (Delhi: Chanakya Publications, 1985), 40; Bijit Ghosh, “The Palace Complex of Jaipur, a Study of Urban Design,” *Urban and Rural Planning Thought* 8, no. 3-4 (1965): 99.

¹⁰⁵ Although one historian suggests that the Jaleb Chowk was “permanent as the place for the collection of the state revenue and occasional as the place of strength, wealth and ascendancy of the king,” I submit that the ascendancy was permanent, regardless of the explicit presence of military force at any given time. Ghosh, 99.

¹⁰⁶ The *naubat* consisted of drum sounds denoting the time, accompanied by other musical instruments. Ramdev P. Kathuria, *Life in the courts of Rajasthan, during the 18th century* (New Delhi: S. Chand, 1987), 106.

public space of the *Diwān-i Ām*.¹⁰⁷ Lesser gates opened to the spaces north and south of the *chowk*, with the southern gate providing access to the gate in the north wall of the observatory. Today, tourism practices and property boundaries conspire to separate the observatory from the Jaleb Chowk. The two areas are separated physically, with the observatory looming behind tall walls topped with *kangura* (curved crenellation) on one side of the high-traffic corridor running between the Sireh Deoḍi Darwaza and the Tripolia Gate (figure 3.17).¹⁰⁸ However, this is quite different from the original palace configuration in which the observatory was both spatially and bureaucratically incorporated into the City Palace.¹⁰⁹ Originally, the observatory was surrounded only by a mud wall, the northern stretch of which was marked by the entrance gate situated across from the entrance to the Jaleb Chowk.¹¹⁰

The space of the Jaleb Chowk, though slightly separated from the observatory proper, became an integral part of the communications and material network supporting work at the observatory, and it served as an intermediary between the highly privileged political spaces of the Maharaja Dhiraja and the more scientific space of the observatory. The *karkhānas* dispersed around the perimeter of the courtyard played more than a minor role in the affairs of state in general, and the observatory in specific, as they enabled the production of purely scientific knowledge—that is, the translation and transcriptions of astronomical treatises, and compilation of astronomical observations and interpretations. Moreover, the creation and storage of this

¹⁰⁷ The *Diwān-i Ām*, although a “public audience hall,” was not open to all members of the public equally.

¹⁰⁸ For instance, visitors to the city must buy separate tickets to the City Palace and the “Jantar Mantar” in order to visit both attractions, since the properties are managed by different groups (Sawai Bhawani Singh Bahadur, the last titular head of Jaipur, still commands the City Palace, while the Department of Archaeology and Museums, Government of Rajasthan manages the observatory).

¹⁰⁹ Although some accounts show the observatory as a “stand alone” expenditure, in most of the daily records, the collection/expenditure tally for the observatory is included in the Palace lists, along with the Seven-Storeyed Palace (Chandra Mahal), the Jaleb Chowk, and so on.

¹¹⁰ Sharma, *Sawai Jai Singh and his Astronomy*, 121. In VS 1793 (1736/37 CE), 200r-0a-0p was spent on the observatory wall. There is an occasional ambiguity in the records, introduced by the use of the word *koṭ*, which can mean “palace,” “fort,” “rampart,” or “wall.” However, since no palace stands within the observatory, we can probably assume that any account for the *jantra ka koṭ* refers to the wall, not the palace, of the observatory. Bhādvā Sūdi 3 VS 1793, fol. 6r, Bundle No. 9, SI, RSA, Bikaner.

knowledge drew on the resources of multiple *karkhānas*, forcing these institutions of material production to work in concert to support the king's astronomical program. Between the Maharaja Dhiraja, the *chowk* and its various workshops, and the observatory developed a very complex but very strictly organized relationship of trade, communication, and movement, one cemented on a daily basis as the king passed through the most productive spaces of the City Palace.¹¹¹

While he had numerous ministers to whom he could ultimately delegate oversight of the observatories, Sawai Jai Singh's personal interest in astronomy ensured that the royal body was seldom hidden from the workers in the *karkhānas* or the *jyotiṣī* in the observatory. The preface of the *Zīj-i Muḥammad Shāhī*, in conjunction with testimony from European residents at the court, makes clear that Sawai Jai Singh had some involvement with observations on a regular basis.¹¹² In spatial terms, the movement of the king between his royal residence in the Chandra Mahal and the observatory necessarily took him through the productive areas of the *karkhānas*. In order to reach the observatory, the Maharaja Dhiraja progressed from his private quarters in the Chandra Mahal, walked across the Pritam Niwas Chowk, through one of four Riddhi-Siddhi Pols (specifically, the Peacock Gate), and into the *Diwān-i Ām*. He then navigated through the three off-set gates before stepping into the Jaleb Chowk and circumambulated the *chowk* under protective awnings before exiting through the courtyard's southern gate, at which point he could cross the lane separating the *karkhānas* from the observatory. This deliberate, complicated path was completely congruent with the principles of Rajput palace design, as the bent entrance was meant to thwart a head-on assault by enemies, forcing them to approach at off angles, around

¹¹¹ For an elucidation of the essential services spaces of the residential Rajput palace, including the *karkhānas* and bazaars, see Michell and Martinelli, 61-66.

¹¹² See, for example, Joseph du Bois' eyewitness account of the observatory at Jaipur, written in 1732 CE, in Mercier, "Account by Joseph Dubois of Astronomical Work under Jai Singh Sawa'i," 161-62.

blind corners. Coincidentally, this labyrinthine construction also brought Sawai Jai Singh in direct contact with the most productive sectors of the palace, the *karkhānas*, on a regular basis, and required him to linger there longer than he might have otherwise. His prolonged presence in the *chowk*, and his forced movement close to his royal workshops on his way to the observatory, repeated on a smaller scale the royal processions made between Amer and Jaipur three years earlier. However, the courtyard also functioned as the *mise-en-scène* for the king's demonstration of strength, much in the same manner as the embankment of the Mān Sāgar, or the permanent mining scars of the Amargarh escarpment functioned for the city at large.

This physical reminder of the Maharaja Dhiraja's interest in the observatory could only propel the employees of the *karkhānas* to consider their own complicated relationship to the astronomical work being conducted nearby. For instance, as was described in Chapter Two, it was customary for Sawai Jai Singh's *najumī* to have been paid by gifts-in-kind in addition to, or in place of, the currency of the realm, and court accounts are replete with records of ceremonial clothing, horses, drums, and other valuable articles, given to these individuals, particularly in the years during which the observatory in Shahjahanabad was under construction. These gifts were precious, and drew on the expertise and resources of multiple *karkhānas*. One of the earliest notations related to Sawai Jai Singh's mostly highly ranked astronomical staff was a note written on December 12, 1718 CE (Mangasir Sūdi 11 VS 1775), concerning the award of an extravagant *sirapāo* (ceremonial dress) from the *Toṣa Khāna* (Department of Valuable Gifts) to Shaikh Asadulā Najumī.¹¹³ This award came officially from the *Toṣa Khāna*, but in fact, many other workshops were involved in its production. For example, the gold thread in the headpiece

¹¹³ Valued at 95r-12a-0p, the costume included a high-walled, *chirā-mukeśī* (threaded turban, 36r-7a-0p), a *phenā gujarātī* (Gujarati-style robe, 22r-12a-0p), a *masarū-būtādār* (high-quality cloth, 31r-6a-0p), and a *sarpec* (gold-threaded covering for the turban, or a diadem, 5r-4a-0p). Sheik Asadulā Najumī, VS 1775, 540, Vol. 18, DK, RSA, Bikaner.

undoubtedly started its life in the *Kirakarā Khāna* (Jewelry Department), while the cloth could only have been made in collaboration with the *Rang Khāna* (Department of Color and Dye). Multiple *karkhānas* contributed in a similar manner to the honorary decoration of the astronomers through Sawai Jai Singh's reign over the city. On November 17, 1719 CE (Kati Sūdi 6 VS 1776), Shaik Asatulā Najūmī received a gift from the *Sileh Khāna* (Department of Armor) valued at 20r-0a-0p.¹¹⁴ To Mirza Abdul Rahamān Najūmī, on January 9, 1721 CE (Pausa Sūdi 11 VS 1777), the Court awarded a horse, a braided rope, and a bridle, all from the *Jīn Khāna* (saddlery).¹¹⁵ One of the court's most frequently rewarded astronomers, Dayānat Khān, was gifted a *sirapāo* from the *Toṣa Khāna* in June 1724 CE (Pratham Asādh 8 VS 1781), and although we do not have an itemization of the components of the *sirapāo*, it undoubtedly drew on the same workshop resources required by the earlier gift to Shaik Asadaulā Najūmī.¹¹⁶ Although the majority of this type of gift went to the *najūmī*, the *Dastūr Kaumvār* also contains references to the high-ranking Hindu astronomers working in Jaipur under Sawai Jai Singh. The astronomer with the longest tenure at Sawai Jai Singh's court, Jagannātha Samrāt, received the occasional ceremonial endowment, in addition to other grandiose forms of recompense, such as a haveli in Hathroi on the Ajmer road southwest of the city.¹¹⁷ On March 24, 1718 CE (Caitra Vadi 8 VS 1774) the court awarded Jagannātha Samrāt with a varnished tambourine, and two years later, in 1719/20 CE (Asoj 8 VS 1776), he received a *sirapāo*.¹¹⁸ These gifts, although less

¹¹⁴ It is possible that this is a misspelling of Sheik Asatulā Najūmī's name, as transcription mistakes frequently appear in the new volumes of the *Dastūr Kaumvār*. Sheik Asatulā Najūmī, VS 1776, 554, Vol. 18, DK, RSA, Bikaner.

¹¹⁵ Mirza Abdul Rahamān Najūmī, VS 1777, 557, Vol. 18, DK, RSA, Bikaner.

¹¹⁶ The gift was valued at 73r-10a-0p. Dayānat Khān Najūmī, VS 1781, 563, 19, *Dastūr Kaumvār*, Rajasthan State Archives, Bikaner.

¹¹⁷ The haveli was awarded near the end of Sawai Jai Singh's life, on Asoj Vadi 9 VS 1798 (October 3, 1741 CE). See Samrāt Jagganathjī, VS 1774, 494, Vol. 15, DK, RSA, Bikaner; Roy, 44.

¹¹⁸ The tambourine was valued at 7r-4a-0p, the *siropāo* at 73r-8a-0p. Samrāt Jagganathjī, 493. Jaganatha Joṣi, VS 1776, 496, Vol. 15, DK, RSA, Bikaner. Drums in particular were a sign of royal favor. In fact, only the Mughal emperor could grant the right of possession of the *naqqara* (kettle drum) and the right to announce the arrival of

frequently awarded than those to Islamic astronomers, drew on the same set of working relationships upon which depended the remuneration for the *najumī*.

The involvement of the various *karkhāna* with the financial and ceremonial sustenance of king and the observatory draws interesting questions about the interdependency of institutions, the literate staff in the City Palace, and the types of fiscal and political relationships necessary to sustain an extended scientific program. But perhaps the most intriguing issue raised by the participation of the royal workshops in this triad relates to the *Pothī Khāna* (Book and Manuscripts Department), which developed a particularly intense relationship with the observatory. Although ostensibly a workshop for the transcription and collection of books and manuscripts, it, too, drew on multiple types of *karkhāna* resources. Upon his ascension to the throne of Amer in 1699 CE, Sawai Jai Singh had inherited a large collection of paintings and manuscripts from his predecessors. His great-great grandfather, Mirza Raja Jai Singh I (r. 1621-1667 CE/VS 1678-1724), amassed a large collection of art and writings, and his great grandfather, Ram Singh I (r. 1667-1689 CE/VS 1724-1746), added to the collection, producing several Sanskrit texts of his own. Sawai Jai Singh's father, Maharaja Bishan (Vishnu) Singh (r. 1689-1699 CE/VS 1746-1756), also acquired a number of scholarly texts during his short reign.¹¹⁹ More importantly, he encouraged both of his sons, Sawai Jai Singh and Bijai Singh, to engage daily with literature in Sanskrit, Persian, Arabic, and Hindi (*bhāṣā*) as part of their education, and to study fully the customary Shastric texts, including lessons in statecraft, armed warfare, and mathematics.¹²⁰ The rulers of the Kacchawāhā clan were well-educated and well-

guests at the palace by playing it. James Tod, *Annals and Antiquities of Rajast'han: or, the Central and Western Rajpoot States of India in Two Volumes*, Popular edition ed., 2 vols., vol. 1 (London: George Routledge & Sons Limited, 1914), 461.

¹¹⁹ Bahura, *Literary Heritage of the Rulers of Amber and Jaipur: with an Index to the Register of Manuscripts in the Pothikhana of Jaipur (I. Khasmohor Collection)*, 38-49.

¹²⁰ Bhatnagar, *Life and Times of Sawai Jai Singh, 1688-1743*, 15.

read, yet the book and manuscript collection handed down to Sawai Jai Singh was noticeably lacking in the discipline of astronomy, and it fell to him to expand his family's intellectual holdings in this area.¹²¹ These additions to the library formed an integral part of the construction and functioning of the observatory, circulating between the Maharaja Dhiraja, his scribes and translators, and the astronomers at work.

As part of the move from Amer to Jaipur, Sawai Jai Singh relocated both the *Pothī Khāna* and the *Sūrat Khāna* (Paintings and Miniatures Department) to the City Palace. As with the other *karkhānas*, these two workshops were established in the Jaleb Chowk under the management of a superintendent, a store-keeper, an accountant, and a small number of attendants in charge of mixing colors and inks, as well as preparing and preserving the writing paper.¹²² In addition to this managerial staff, the *Pothī Khāna* included several scribes, many of whom were skilled in the art of transcribing astronomical treatises.¹²³ While other workers distributed through the *karkhāna* system were undoubtedly industrious in their jobs, the level of production exhibited by the personnel in the *Pothī Khāna* indicates that everyone involved must have been working at a fever pitch around the clock. According to the *Pothī Khāna* inventory for 1733/34-1737/38 CE (VS 1790-1793), in this period of 46 months and 9 days, the department acquired an

¹²¹ In 1715 CE, there were only 32 books on astronomy-astrology in his library. Sharma, *Sawai Jai Singh and his Astronomy*, 277.

¹²² Bahura, *Literary Heritage of the Rulers of Amber and Jaipur: with an Index to the Register of Manuscripts in the Pothikhana of Jaipur (I. Khasmohor Collection)*, 15. It is not clear when the contents of the *Sūrat* and *Pothī Khānas* were relocated into more secure space of the Chandra Mahal, but as Bahura points out, it was customary to install the *khānas* charged with producing and safekeeping the more valuable items closer to the bed chamber of the king, in a strong room (*dholiyā ka Koṭhyāra*).

¹²³ The first thirteen astronomical manuscripts acquired by Sawai Jai Singh were copied by scribes from Ahmadabad and Gujarat; however, most of the scribes worked in the *Pothī Khāna* of Jaipur, and marked the manuscripts with their initial or full names upon completion. For example, Kṛpārāma transcribed the Sanskrit translation of the *Sharh al-Tadhkira*, a sixteenth-century commentary on Nasir al-Din al-Tusi's *al-Tadhkira Fi'ilīm al-Hay'a* (*Memoir on the Science of Astronomy*) written by 'Abd al-'Ali al-Birjandi. Tīkārāma transcribed the *Hayātagrantha* (*Book on Spherical Astronomy*), a Sanskrit translation of 'Ali al-Qūshj's *Risāla dar hay'a* (*Treatise on Spherical Astronomy*) of the fifteenth-century. Ibid., 58; Pingree, "An Astronomer's Progress," 78.

astounding number of books—2500, to be precise.¹²⁴ The majority of these books were related to Vedic and Puranic knowledge, but a good number were associated with neither traditional texts nor epics.¹²⁵ Forty of the books were specifically catalogued as “*Farsī* (Persian) Books,” and although we do not know the titles of these volumes (the scribe noted only the contents, not the titles, of most of the books and manuscripts in the collection), three were described as being related to astronomy.¹²⁶ An additional twenty-four astronomy books, twenty of which were bound, were entered into the ledger as “*fīrengī* (foreign).” Of the twenty tomes, three were identified with the transcribed title of *Istoraya Selesatī*, or, *Historia Celestia*.¹²⁷ The *Pothī Khāna* was not simply a repository for books purchased or acquired as gifts by the Maharaja Dhiraja, however, but a dedicated site of production. The scribes, astronomers, and king collaborated in a seemingly ceaseless cycle of creation and translation of astronomical treatises. Three of the most notable contributions to the accumulation of astronomical knowledge in Jaipur were, of course, the works translated and expanded upon by Jagannātha Samrāt, the *Samrāt Siddhānta* (Ptolemy’s *Almagest*), the *Rekhāgaṇita* (Euclid’s *Elements*), and the *Yantraprakāra*, a treatise on the construction of astronomical instruments.¹²⁸ Kevelrāma, as *Jyotiṣa Rai*, contributed much to the *Pothī Khāna*, composing the *Dr̥kpaḥṣasāraṇī* (a Sanskrit version of Philippe de la Hire’s astronomical tables), as well as several other manuscripts, including the *Tithisāraṇī*, *Rekhāpradīpa*, *Bhramapakṣanirāsa*, and the *Tārāsāraṇī*, a table of fixed stars based

¹²⁴ VS 1790-1793, fol. 1r, Bundle No. 2, Part 1, PK, RSA, Bikaner.

¹²⁵ For example, there were 217 books described as Vedānta Sastra, and 100 as Jujar Ved. 684 concerned the Āgam Ved, and 453 related to the Puranas. 66 were different versions of the Mahabharata, and there 35 copies of the Ramayana, including an edition specifically identified as Valmiki’s version of the epic. Ibid., fol. 23r-28v, 32v-42v, 70r-102v, 120r-140v.

¹²⁶ Ibid., fol. 241r. One of these books was bound, the other two were loose-leaf.

¹²⁷ Ibid., fol. 244r.

¹²⁸ Samrāt, 1-139; Sharma, ed. *Samrāt-Siddhāntah Avāntara Paṭhabhedasamanvitah Siddhāntasārakaustubhah*. For an informative history of these works, see David Pingree, “Indian and Islamic Astronomy at Jayasimha’s Court,” in *From Deferent to Equant*, ed. David A. King and George Saliba (New York: New York Academy of Sciences, 1987), 314-18; M. L. Sharma, “Jagganath Samrat’s Outstanding Contribution to Indian Astronomy in Eighteenth Century A.D.,” *Indian Journal of History of Science* 17, no. 2 (November 1982): 244-51.

on astronomical work conducted under the patronage of Ulugh Begh.¹²⁹ In 1729 CE, Nayanaṣukha, with the help of Muhammad Abida, translated one of astronomy's most notable manuscripts, Naṣīr al-Dīn al Tūsī's version of Theodosius' *Spherics*.¹³⁰ On December 16, 1729 CE, this same astronomer completed a translation of the eleventh chapter of the second book of Naṣīr al-Dīn's *Tadhkira*, along with al-Birjandī's commentary on the chapter.¹³¹ He also translated Naṣīr al-Dīn's *Risālat al-uṣṭurlāb*, a treatise on the use of the plane astrolabe, as the *Yantrarājarisālā bīsa bāba*.¹³² Maharaja Dhiraja Sawai Jai Singh himself is credited with the composition of the Sanskrit *Jayavinodasārini*, a collection of tables (epoch date 1735 CE) for computing *yogas*.¹³³ He also wrote the *Yantrarājaracanā*, a treatise in Sanskrit describing methods for constructing and using an astrolabe.¹³⁴

This short, but intellectually impressive, list reflects just a few of the astronomical works connected to the *Pothī Khāna*. By the date of Sawai Jai Singh's death in 1743 CE, the *Pothī Khāna* inventory listed 188 books and manuscripts on a wide variety of astronomical topics, including spherical astronomy treatises, lunar and stellar tables, and methods for the construction of instruments of observation. Certainly, the type of labor conducted by astronomers such as Jagannātha Samrāt and Kevelrāma differed greatly from that undertaken by the manual laborers working just a few hundred feet away in the observatory. Sawai Jai Singh and his literate cohort possessed a sophisticated knowledge of the history of astronomical instruments, a knowledge so deep they were able to design new forms of instrumentation to replace the ineffective brass triquetrum, armillary spheres, and astrolabes at Shahjahanabad. More importantly, this book

¹²⁹ Pingree, "Indian and Islamic Astronomy at Jayasimha's Court," 320.

¹³⁰ Ibid., 319.

¹³¹ Ibid.

¹³² Ibid.

¹³³ Ibid., 314.

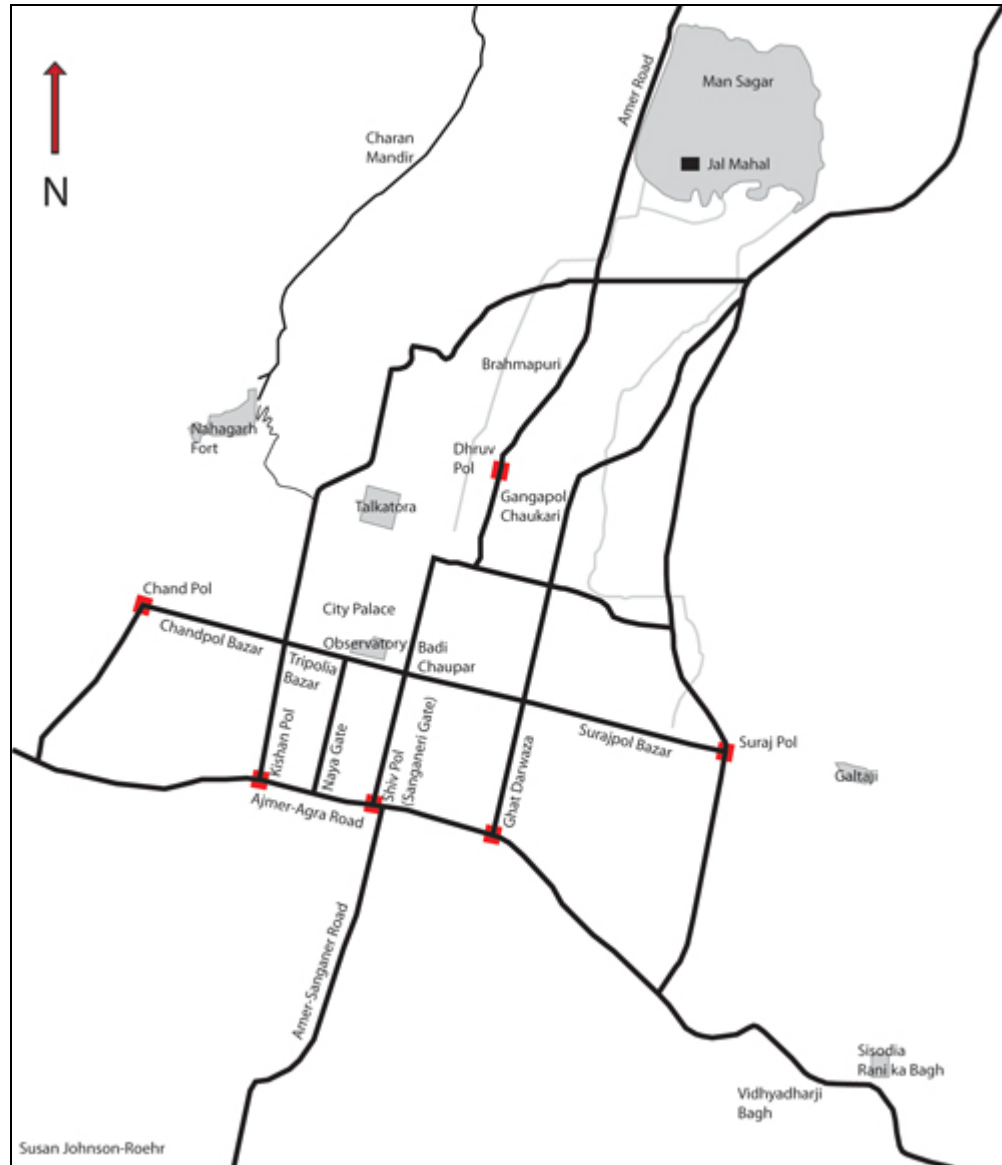
¹³⁴ Ibid.

knowledge, created and supported in the spaces of the Jaleb Chowk, managed to cross the street into the observatory proper, to reach the hands of the builders and *jyotiṣī* in a comprehensible form. Without this transfer, the observatory, and the future scholarship depending on it, would quite likely not exist today.

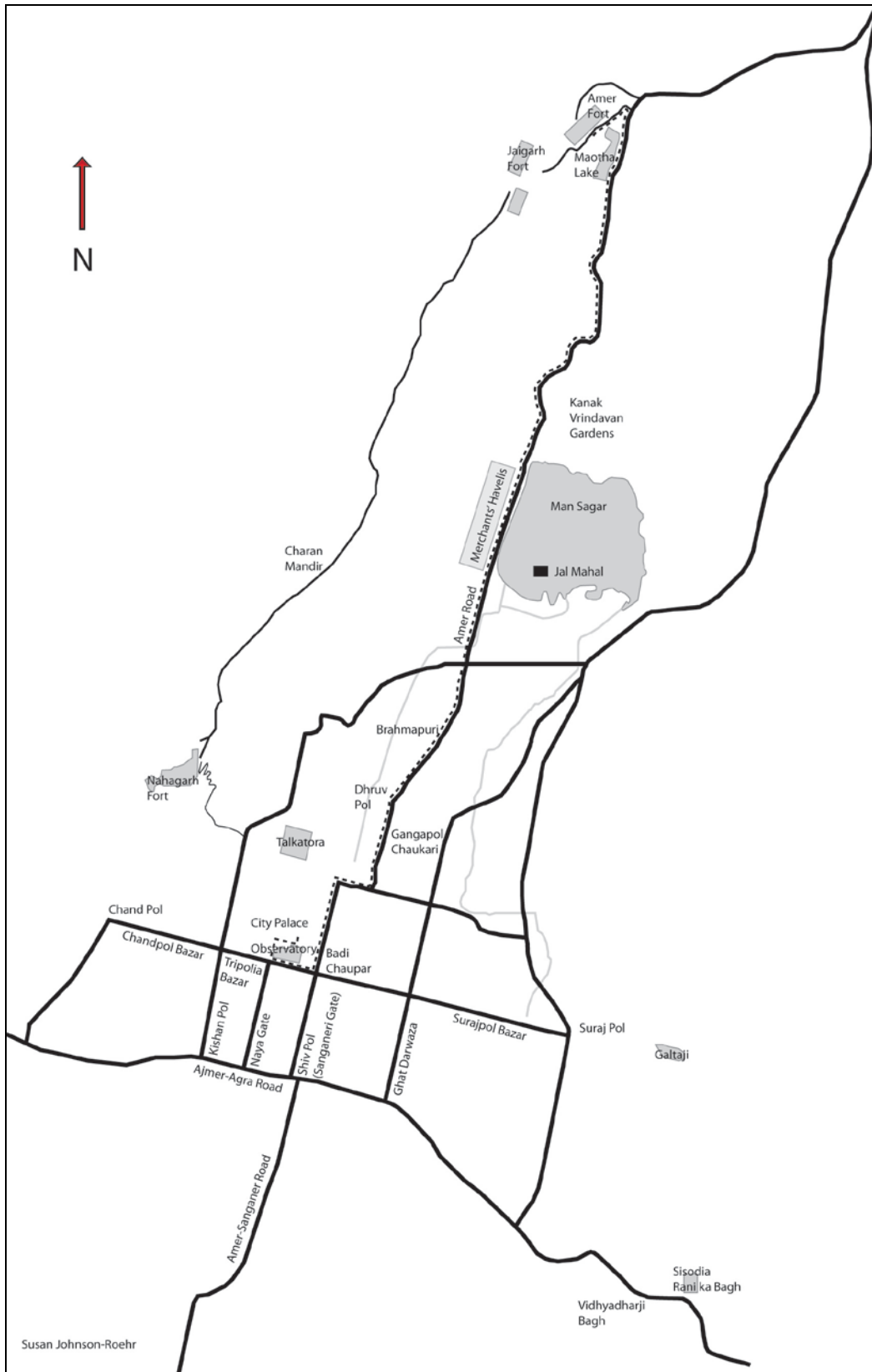
3.6 Beyond the Walls

As this chapter demonstrates, the intersection of power, knowledge, and science at the Jaipur observatory was not a simple encounter. Although the construction and operation of the observatory activated a very concentrated exchange of knowledge and resources, other productive spaces of the City Palace such as the Jaleb Chowk, as well as elements of the larger urban landscape such as the quarries of Nahagarh and the Mān Sāgar embankment, suggest that the intramural network of Jaipur crossed multiple types of boundaries. The intramural might best be described as a series of intrusions and retreats, as the king and his astronomical workers moved from space to space, carrying knowledge and authority with them on their journey. The porosity of this network encourages us to think beyond even the walls, gates and roads of Amer, to the determinedly extramural spaces of Delhi, Mathura, Ujjain, and Varanasi, and beyond. It is easy to imagine Sawai Jai Singh's ability to navigate the intricacies of scientific production in the regions of his own capital, but the successful sustenance and representation of knowledge beyond the bounds of the state of Amer raised a new set of problems, and required a new set of innovative solutions. Chapter Four examines the extramural landscape, and explains the ways in which institutions located outside the conventional reach of the Maharaja Dhiraja's power became entangled in his efforts to install knowledge in a local, intramural environment.

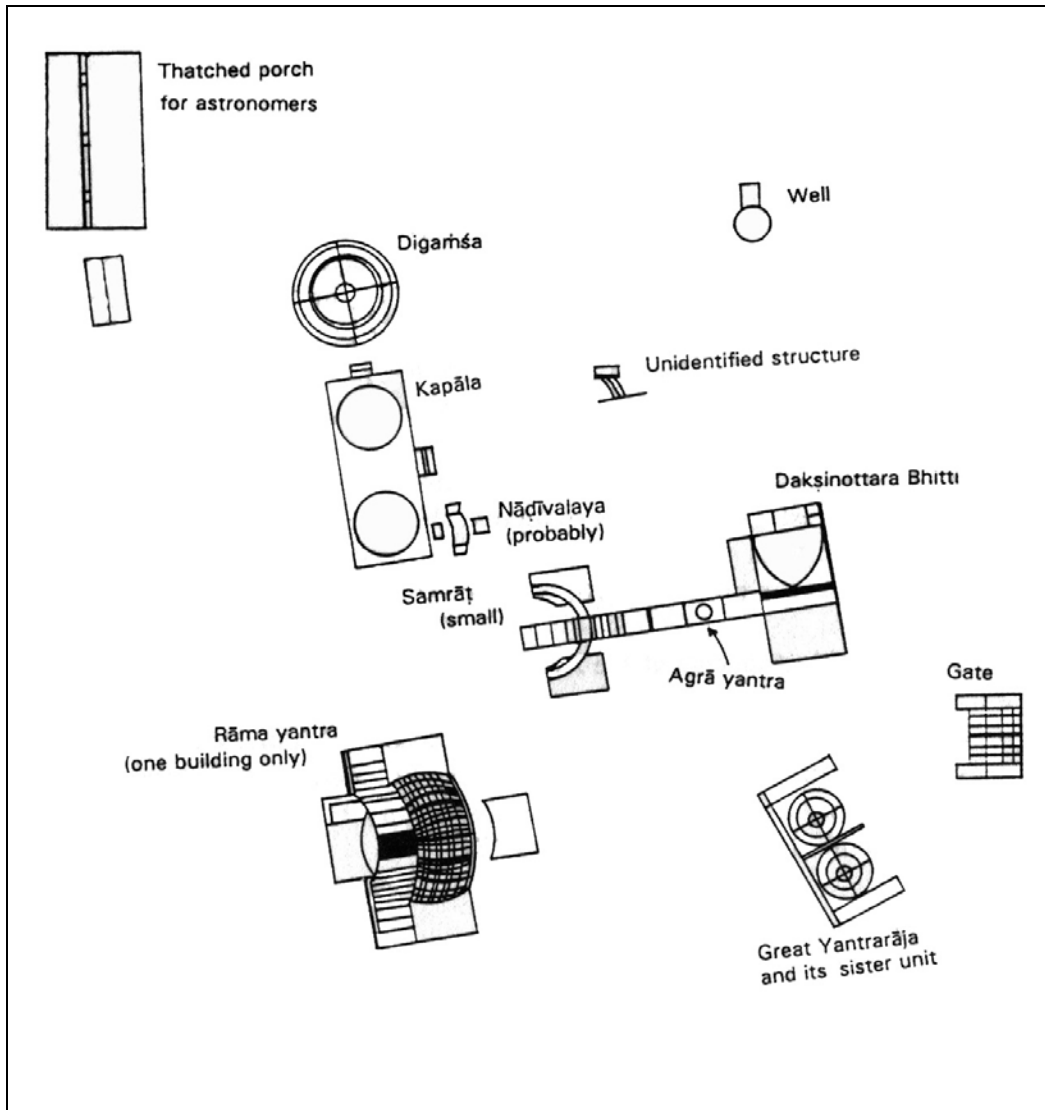
3.7 Maps



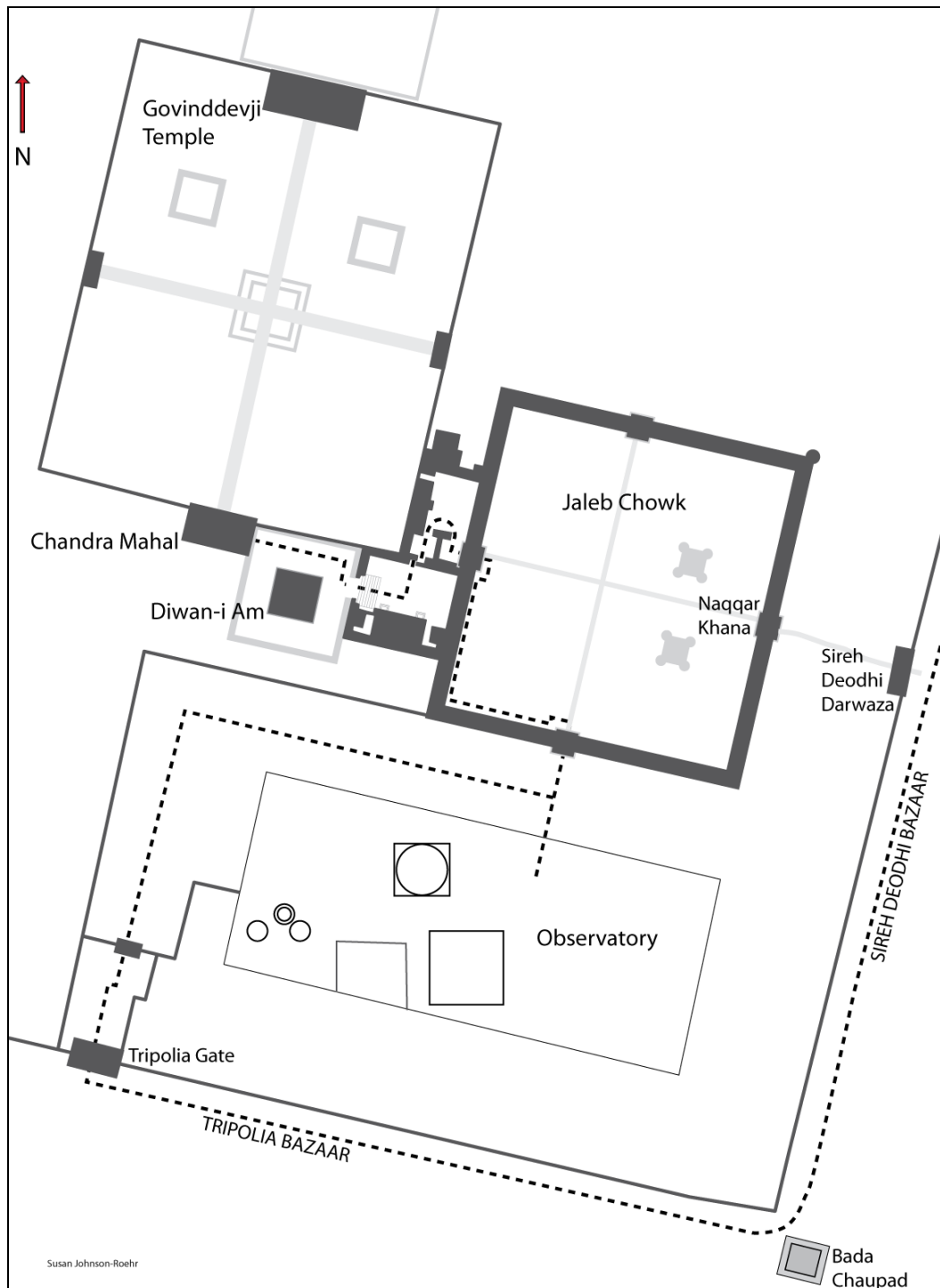
Map 3.1. Gates of Jaipur: Chand Pol, Dhruv Pol, Suraj Pol, Kishan Pol, Shiv Pol, Ghat Darwaza.



Map 3.2. Ceremonial route (dashed line) between Amer and City Palace.



Map 3.3. Site plan of observatory (Jaya Prakāśa Yantra mislabeled as Rāma Yantra), Jaipur, c. 1728 CE. Courtesy Sharma, *Sawai Jai Singh and His Astronomy*, 123.



Map 3.4. Site Plan of City Palace, Jaipur, showing relationship between Jaleb Chowk and Observatory, with common routes of travel marked.

3.8 Figures



Figure 3.1. Miśra Yantra at Delhi Observatory, March 2009 CE.



Figure 3.2. Thomas and William Daniell, Samrāt Yantra, with Rāma Yantra in background. From *Antiquities of India. Twelve [or rather, twenty-four] Views of India from the drawings of Thomas Daniell*. London: Thomas Daniell, 1799-1800. Courtesy of the British Library, London.



Figure 3.3. Thomas and William Daniell, Samrāt Yantra, with Miśra Yantra in background. From *Antiquities of India. Twelve [or rather, twenty-four] Views of India from the drawings of Thomas Daniell*. London: Thomas Daniell, 1799-1800. Courtesy of the British Library.

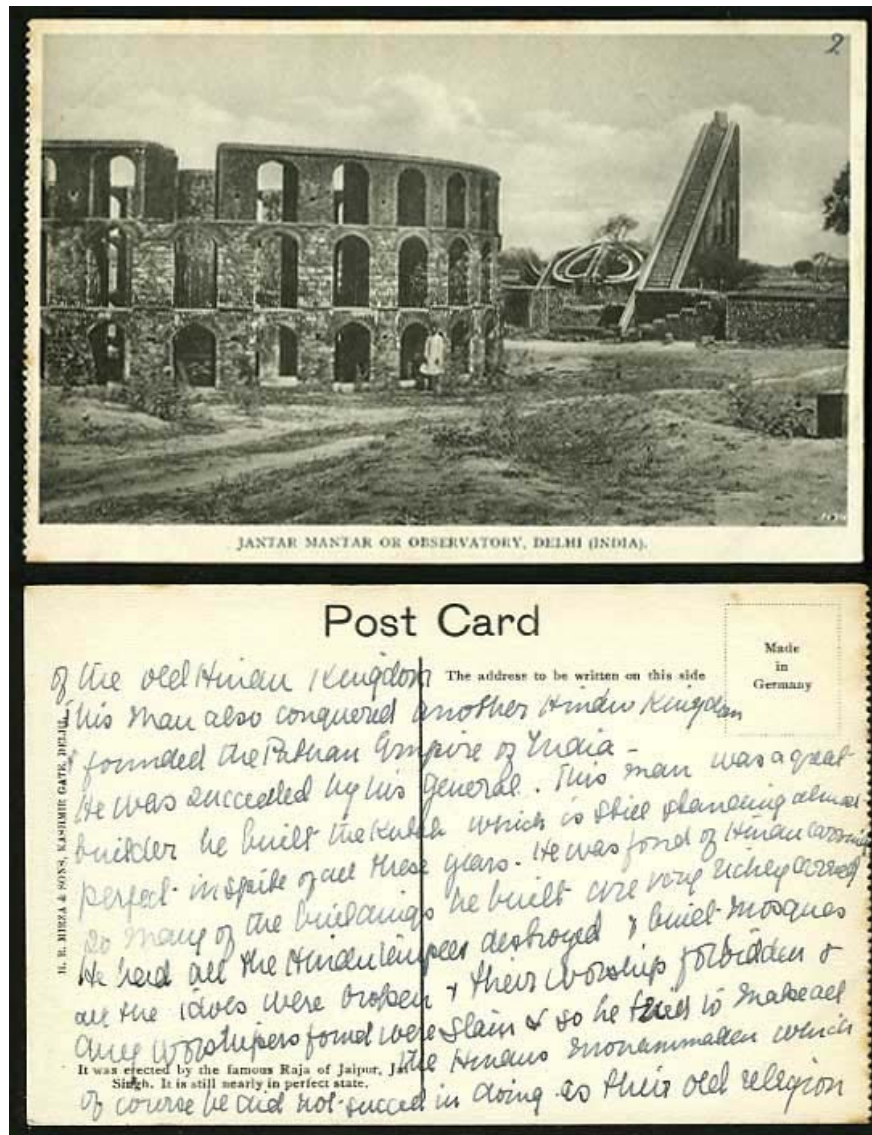


Figure 3.4. Tourist postcard published in Germany, showing ubiquitous view of Rāma Yantra.



Figure 3.5. Ajmeri Gate, Jaipur, December 2010 CE. Courtesy of Jiwon Youn.

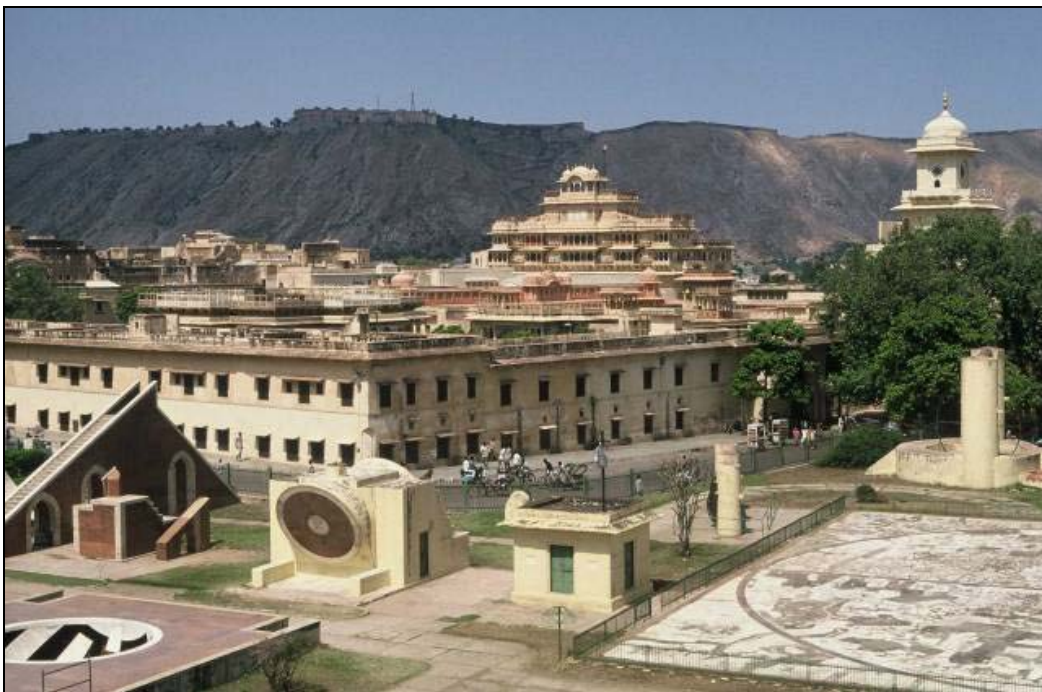


Figure 3.6. Spatial relationship between Chandra Mahal (center) and observatory (foreground), Jaipur, 1989 CE. Courtesy of David Clarke.

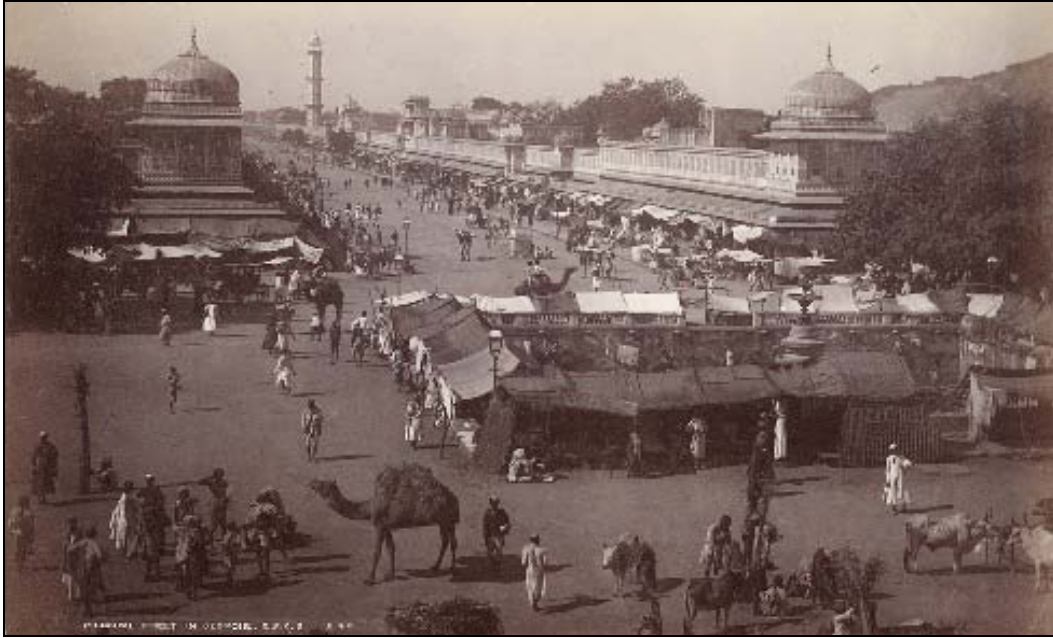


Figure 3.7. Samuel Bourne & Charles Shepherd, c. 1880 CE. *Baḍi Chaupaḍ* with step well, looking west along Tripolia Bazaar. Courtesy of the British Library, London.



Figure 3.8. Silver gelatin print, c. 1890 CE. Nahargarh Fort overlooking the city of Jaipur, *Baḍi Chaupaḍ* in foreground. Courtesy of British Library, London.

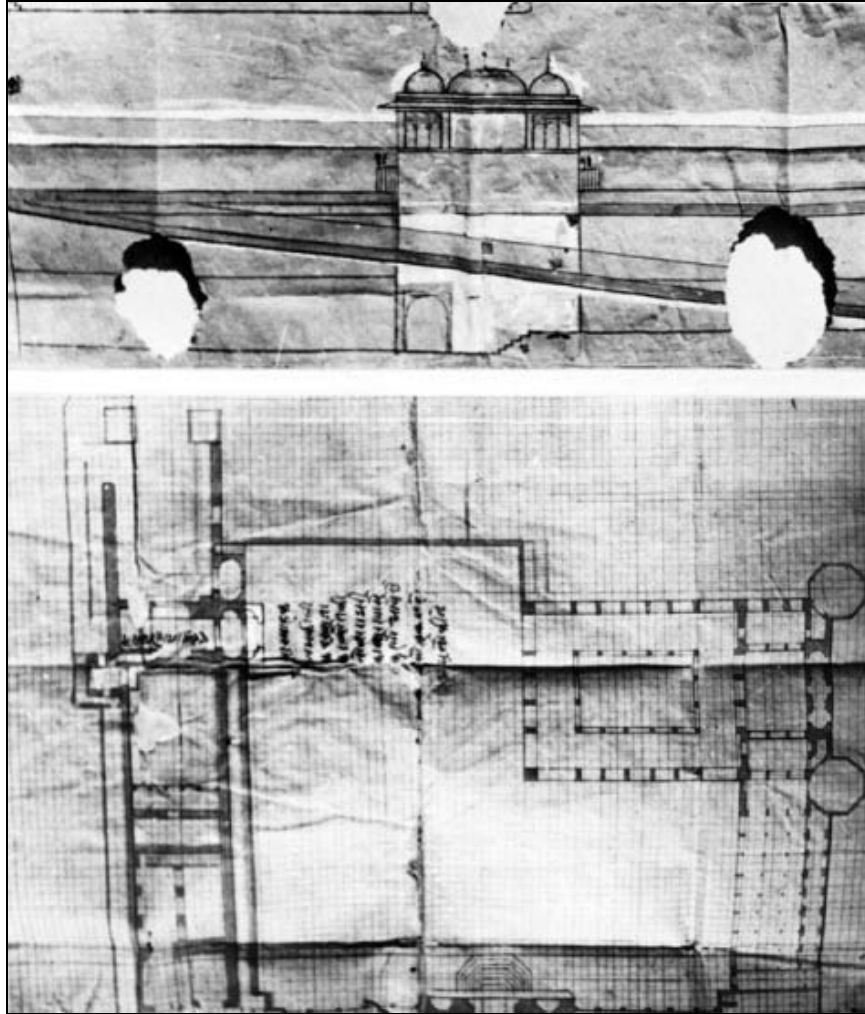


Figure 3.9. Section of the Ganesh Pol; Plan of *Diwān-i Ām* Chowk with Singh Pol (top left) and Ganesh Pol (bottom center). From Tillotson, 104.



Figure 3.10. Ganesh Pol, Amer Palace.

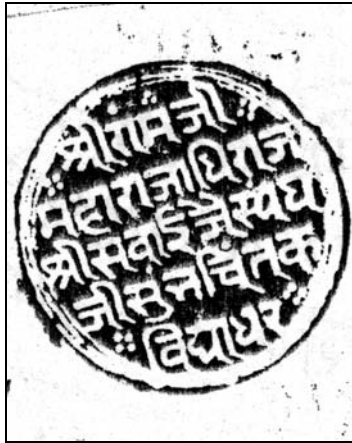


Figure 3.11. Vidyādhār's Seal, from the Expenditure (*karc*) accounts from the *Roznāma Imāratī* for Pausa Sūdi 10 VS 1790 (January 14, 1734 CE). Transliteration: "Shri Rimji Maharaja Dhiraja Shri Sawai Jai Singhji Subhchitak Vidyādhār."



Figure 3.12. Samrāt Yantra, water channels for leveling surface, Jaipur, 2006 CE.

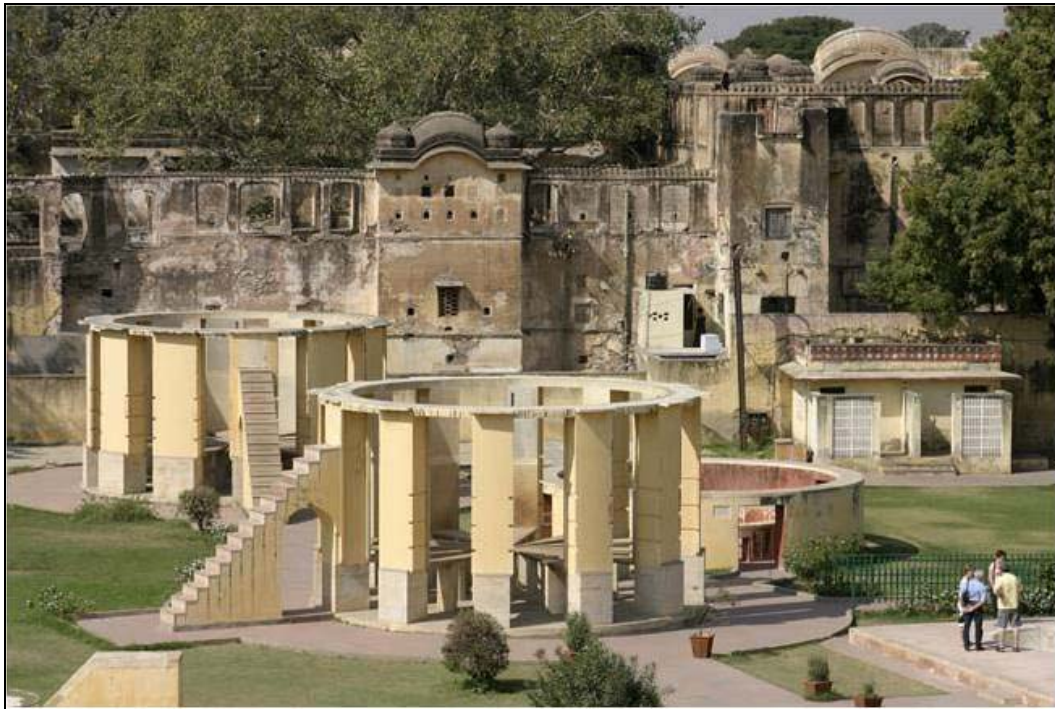


Figure 3.13. Rāma Yantra, with Digamṣa Yantra at right, Jaipur, 2006 CE.

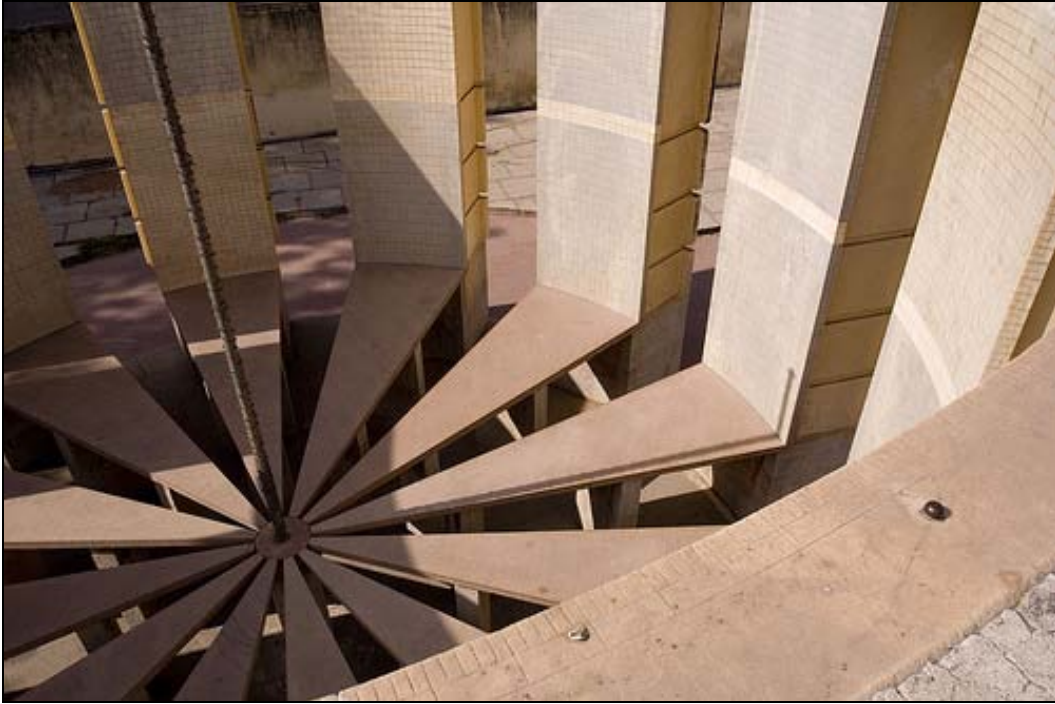


Figure 3.14. Renovated Rāma Yantra scales in stone, Jaipur, January 2007 CE. Courtesy of Lian Chang.

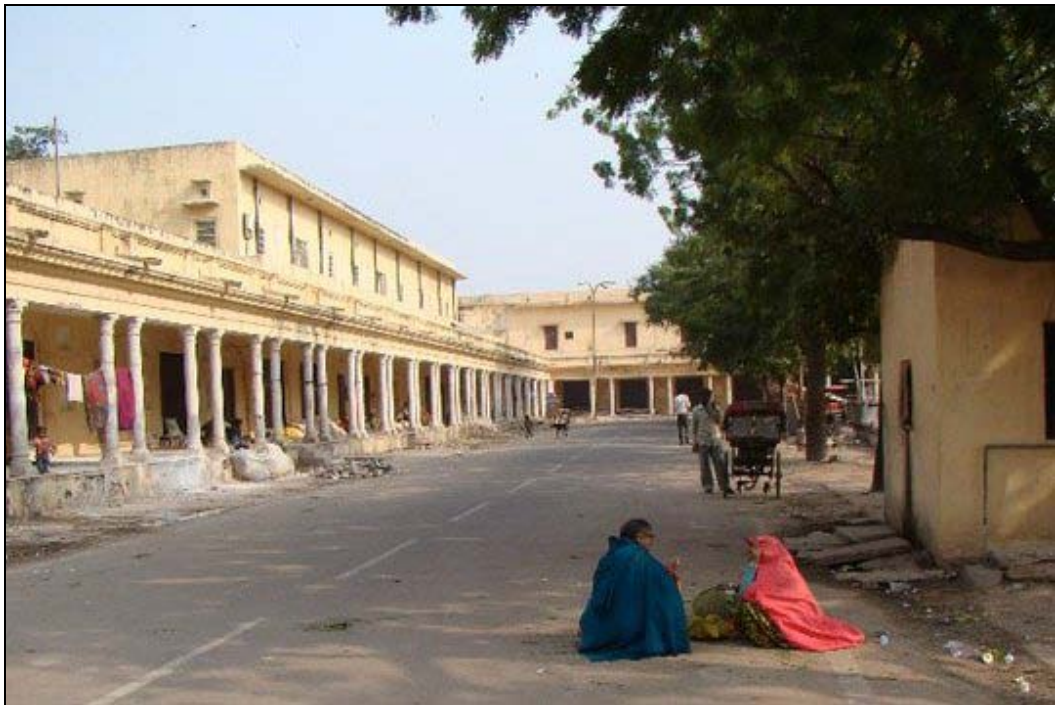


Figure 3.15. Office range and colonnade of Jaleb Chowk (left), Jaipur, December 2010 CE. Courtesy of Julia Kowalski.

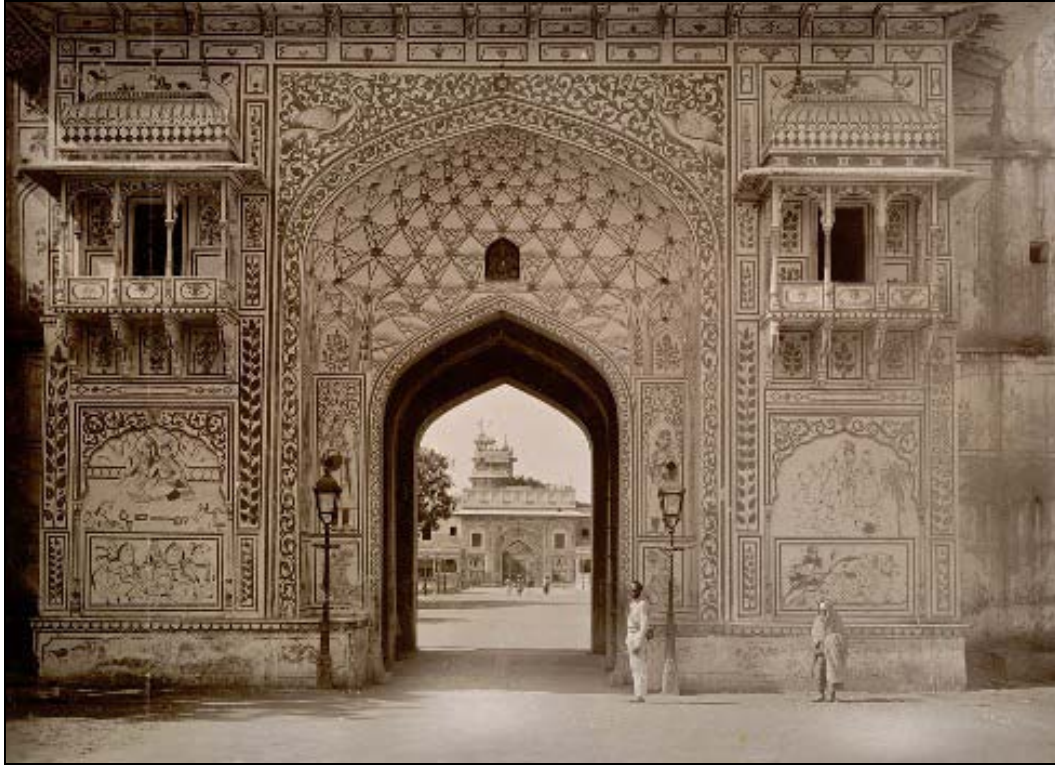


Figure 3.16. Lala Deen Dayal, c. 1890 CE. View of *Naqqar Khāna* as viewed through the *Sireh Deodi Darwaza*, Udaipur in background. Courtesy of the British Library.



Figure 3.17. New stone wall between observatory and City Palace, March 2008 CE.
Courtesy of Sourav Das.

CHAPTER FOUR

EXTRAMURAL SPACE

Although the observatories built under the patronage of Sawai Jai Singh II were responsive to the particularities of the local landscape, they also participated in an extramural landscape of scientific enquiry in the second quarter of the eighteenth century. Using the observatories as a lure, Sawai Jai Singh positioned himself as a knowledge metropole, drawing in multiple types of resources from peripheral positions to come to rest inside the walls of his new capital city. Without traveling more than one hundred miles from his court in Amer and Jaipur, the Maharaja Dhiraja manipulated pre-existing long distance networks of knowledge exchange, not to insinuate himself into an intercontinental discussion assumed to be dominated by European science, but rather to facilitate the accumulation of knowledge at a site within easy reach of his authority. Exploiting the extra-national corporation of the Society of Jesus to secure corridors of communication within a fragmented regional landscape, Sawai Jai Singh asserted his authority beyond the conventional boundaries of his kingdom to settle European scholars permanently as part of a team of intellectuals based at the observatories. By examining European interaction with the observatories, we can see how the particularities of the South Asian landscape and weather constantly worked against Sawai Jai Singh's desire to bring a global science home to rest. Despite his repeated efforts to add a European voice to the conversations at his court, the global continually slipped out of the astronomer-king's grasp, forcing him to search for alternatives to meet his political and scientific needs. Moreover, the particularities of the Jesuit rule conspired with the vagaries of the extramural landscape to prevent him from reaching his goals. Though the Maharaja Dhiraja was able to appropriate and manipulate the strengths of the Society of Jesus in order to gather resources from abroad, the

fragilities inherited from that same organization foiled his attempts to deposit those resources safely in his own city. Sawai Jai Singh's interactions with the scientific community outside the boundaries of his kingdom thus present an intriguing mixture of fragility and boldness, as he repeatedly worked his way through multiple obstacles in order to establish a multi-faceted scientific community in debt to his patronage.

4.1 Settling Knowledge

Judging from the collection of astronomical manuscripts produced and gathered in Jaipur during the second quarter of the eighteenth century, the Maharaja Dhiraja intended more than an ostentatious display of power in mind when he ordered the construction of the observatories in Shahjahanabad and Jaipur. The sheer quantity of treatises, deriving from the interrelated traditions of Greek, Islamic, European, and Hindu astronomy, contained in the stores of the *Pothī Khāna* in Jaipur reveals the serious scholarly endeavor behind the observatories demonstrates that Sawai Jai Singh intended the masonry instruments to be useful and well-used scientific tools. On the other hand, to ignore the political ramifications of these sites is to elide the cultural work with which they were charged by this same ruler. The observatories at Shahjahanabad and Jaipur, as extensive and original built environments, made a fairly emphatic statement as to the power and wealth of the Rajput king and his political superior, the Mughal emperor, Muhammad Shah. At least one European visitor to the observatories in these two cities read them as such, asserting that the Maharaja Dhiraja was “extremely hungry for glory,” and subsequently built the observatories as a dramatic act of self-promotion.¹ Indeed, few people in northern India could accumulate the resources and the labor to complete such a project, so as a symbol of economic strength, the construction details of the observatories alone announced the Rajput king as an

¹ Claude Boudier, Letter to Étienne Souciet, 18 January 1736, fol. 143v, GBro 088, Fonds Brotier, Les Archives des Jésuites de Paris, Vanves.

exceptionally capable ruler. However, for that symbolic strength to extend into the future, for Sawai Jai Singh's reputation to solidify and then expand across time and territory, the observatories needed to operate as not just as a conglomerate of exotic building projects, but as scientific spaces comparable to those patronized by the Timurid prince Ulugh Beg. In his own words, Sawai Jai Singh claimed a commitment to the science of astronomy equal to that of any of his antecedent astronomers, and in the same manner that "the geometers and astronomers of antiquity dedicated many years to the practice of observation, so too, for the establishment of a certain method, the places of the stars were observed daily [by him] after having constructed these instruments."² But before he could elevate himself to a position equal to that of these ancients, he had to prove his instruments produced results at least as reliable as those calculated from already existing astronomical tables. While the Maharaja Dhiraja could claim control of land, labor, and even specialized construction techniques simply by erecting the Samrāt Yantra at Shahjahanabad, he could not profess perfect knowledge of the heavens in the manner modeled

² *Zīj-i Muḥammad Shāhī*, Add. 14373, fol. 4v, Asia, Pacific and Africa Collections, British Library, London. While evidence proving the veracity of this claim of dedicated productivity remains elusive, an attentive reading of the astronomical treatises written by Jagannātha Samrāt reveals that not only did the astronomers employ the instruments as claimed by their patron, they later used the resultant observations in meaningful ways. For example, for an explication of solar parameters included in the *Samrāt Siddhānta*, Jagannātha observed two vernal equinoxes from Shahjahanabad, using the Ṣaṣṭāmsa Yantra, a darkened room within which stood a sixty-degree meridian dial (mural quadrant). In this same manuscript, Jagannātha mentioned three specific lunar observations, on Sāvna Sūdi 15 VS 1785 (August 19, 1728 CE), Māgh Sūdi 15 VS 1785 (February 13, 1729 CE), and Sāvna Sūdi 15 VS 1787 (July 29, 1730 CE), from which he calculated the mean motion (average speed of a celestial object moving in orbit) of both the moon and sun. In the second half of the *Yantraprakāra*, which provided computational methods based on data harvested from both observation and astronomical tables, Jagannātha based many of the worked examples on observations made in Delhi. The explication of the method for computing the nonagesimal (*vitribha*, the point of the ecliptic at 90° above the horizon) relied on an extensive list of observations made on Caitra Sūdi 11VS 1786 (March 31, 1729 CE), including the times of rising for the zodiacal constellations as measured in *palas*; the sun's longitude and declination at sunrise, midday, and sunset; the right ascension of the culminating point in *ghaṭis*; the moon's longitude at that same time; the duration of the night elapsed at the time of nonagesimal; and the moon's zenith distance at the specified time, amongst other observations. Jagannātha also employed the position of Jupiter as measured with the Samrāt Yantra on Baisākh Vadi 5 VS 1786 (May 7, 1729 CE) to demonstrate the method used to compute the true longitude (right ascension, or *ṣaṣṭagraha*) of a planet. See Ramasvarupa Sharma, ed. *Samrāt-Siddhāntah Avāntara Paṭhabhedasamanvitah Siddhāntasārakaustubhah*, 3 vols., vol. 3 (New Delhi: Indian Institute of Astronomical and Sanskrit Research, 1967), 1216-17, 40-41; Jagannātha Samrāt, "Yantraprakara of Sawai Jai Singh," in *Supplement to Studies in History of Medicine and Science*, ed. Sreeramula Rajeswara Sarma (New Delhi: Department of History of Medicine and Science, Jamia Hamdard, 1987), 33-34, 89-90.

for him by his predecessors unless the instrument then functioned properly. One way of proving the success of this enterprise was to create a manuscript comparable to Ulugh Beg's *Zīj-i Jadīd Sulṭānī* or the *Zīj-i Shāhjahānī*. This manuscript would be long-lasting evidence of his capabilities as both astronomer and king.

The production of a *zīj* based on observational data required a great collaborative effort, relying on the talents of numerous astronomers, mathematicians, translators, and scribes. Traditionally, the *azyāj* prepared during the reigns of the Mughals in India were based on calculation, not new observations. For example, Farīd Uddīn, the author of the *Zīj-i Shāhjahānī*, derived his new tables from the *Zīj-i Ulugh Beg*, updating and expanding the books and tables of the earlier *zīj* to correspond with the epoch date of Shah Jahan's ascension to the imperial throne.³ Sawai Jai Singh, on the other hand, intended to issue an entirely new set of tables, the *Zīj-i Muḥammad Shāhī*, to be built upon the work completed at his quintet of observatories. In accordance with long-standing conventions of publication and patronage followed from western Europe to eastern Asia, the Maharaja Dhiraja dedicated the *Zīj-i Muḥammad Shāhī* to the emperor Muhammad Shah in Shahjahanabad, effectively declaring his own ascendancy over the heavens while sharing the glory of this victory with the Mughal ruler. In the preface to the *Zīj-i Muḥammad Shāhī*, Sawai Jai Singh asserted that the manuscript was the direct product of his own tireless work and claimed to have used the masonry instruments at all his observatories productively for several years in order to complete the tables in the name of the emperor.⁴ After several years of labor, however, he learned that,

³ S. A. Khan Ghori, "Development of Zīj Literature in India," in *History of Astronomy in India*, ed. S. N. Sen and K. S. Shukla (New Delhi: Indian National Science Academy, 1985), 34-35.

⁴ The general consensus amongst historians of astronomy is that Sawai Jai Singh did not meet his expressed goal. While sections of the *Zīj-i Muḥammad Shāhī* certainly reflect recent innovations in astronomy, the tables appear to be based on those included in the second edition of Philippe de la Hire's *Tabulae Astronomicae*. For a deeper description of the composition of the *Zīj-i Muḥammad Shāhī*, see *Ibid.*, 36-41. For various opinions on Sawai Jai Singh's reliance on observation vs. previously-issued tables, see Raymond Mercier, "The Astronomical Tables of

at about this same time, observatories had been constructed in a foreign country, and that the learned of that country were employed in the perfection of this important work, that the business of the observatory was still carrying on there, and that they were constantly working to determine the subtleties of this science.⁵

Intrigued by the news of parallel scientific developments, the Maharaja Dhiraja proposed to send an ambassador to Europe to gather information about the foreign instruments and observational results, a decision that marked his first foray into the ongoing global discussions of the science of astronomy.

It is typically assumed that this ambassadorial gesture was prompted by a desire to correct errors in his own observations, but nothing indicates that Sawai Jai Singh believed his masonry instruments produced false positional data.⁶ In fact, his goal was not to locate a corrective measure for his own inaccurate observations and calculations, but to obtain a second viewpoint on a science in which he believed himself already to be an expert. Moreover, he intended his access to that alternative viewpoint to be permanent, in that he wished to expand his already diverse company of resident astronomers by adding a European representative to the mix. The account records of the *Imārat Khāna* and the *Pothī Khāna* show that Sawai Jai Singh employed a heterogeneous conglomerate of workers at the observatory and its associated workshops in Jaipur; the members of the group represented a number of different astronomical

Rajah Jai Singh Sawa'i," *Indian Journal of History of Science* 19(April 1984): 143-71; Virendra Nath Sharma, "Zij-i Muhammad Shahi and the Tables of de La Hire," *Indian Journal of History of Science* 25 (1990): 34-44; Benno van Dalen, "The Origin of the Mean Motion Tables of Jai Singh," *Indian Journal of History of Science* 35, no. 1 (2000): 41-66.

⁵ *Zij-i Muḥammad Shāhī*, fol. 4v.

⁶ And, in fact, during seven years between the groundbreaking at the observatory in Shahjahanabad and the departure of his ambassador to Europe, he probably had not yet acquired enough data to judge the accuracy of the instruments. If the construction of the observatory in Shahjahanabad began in 1719/20 CE, we can postulate from the description in the *Zij-i Muḥammad Shāhī* that the news of the European astronomers reached the Maharaja Dhiraja's ears only in 1726 or 1727 CE. Judging by dates mentioned in the *Samrāt Siddhānta* and the *Yantraprakāra*, the Maharaja Dhiraja pressed the observatory at Shahjahanabad into regular use only in 1728/29 CE. This means that the decision to send an ambassador to Europe must have come well before the collection of data had reached the point at which numbers could be compared for accuracy across multiple years of observations. The resolution certainly occurred before the founding of Sawai Jaipur.

traditions, and communicated in a number of different languages, including Persian, *bhāṣa*, and Sanskrit. As patron, the Maharaja Dhiraja would have been responsible not just for the monetary recompense of the highest ranking of the participants in this project, but for most of their material concerns, including their housing and wages. In this, Sawai Jai Singh followed a long-standing practice of Indian kings to invite scholars from various parts of the subcontinent to relocate to their courts for ease of consultation. As part of the invitation, the intellectuals were favored with a home and arable land in a city quarter or village established specifically for their support.⁷ The reasoning behind the establishment of scholars' villages was at least tri-fold: settling the intellectuals in close proximity to one another ensured the king easy access to diverse viewpoints without delay; it promised a certain amount of cross-fertilization among various traditions of learning and teaching; and it offered a visual and spatial display of the courts' intellectual strengths, turning the scholars into something of an ornament. Sawai Jai Singh was no exception to this general rule of intellectual assemblage. Even before the formal founding of Jaipur, the Maharaja Dhiraja established the scholars' village of Brahmapurī in what would become the northwest sector of the city. Standing at the foot of Gaḍh Ganesh, "the lofty edifice of the God Gaṇapati that towered over the hill close by," and fronted by the Rājamalla Lake, the *purā* housed many of Sawai Jai Singh's most significant advisors, most of who were born in villages in north India and Maharashtra.⁸ Included in these numbers was Sawai Jai Singh's astronomer royal, *jyotiṣa rai* Kevelarāma, an Audumbara Brahmin from Gujarat.⁹

⁷ K. V. Sarma, "Brahmapuri, the Scholar's Village Established by Maharaja Sawai Jai Singh," *Indologica Jaipurensia* 2 (1988-1995): 45.

⁸ Kṛṣṇa Bhaṭṭ, *Īśvaravilāsa Mahākāvyaṃ*, trans. Madhuranatha Shastri (Jaipur: Oriental Research Institute, 1958), 54-57. Gaḍh Ganesh stands almost due north of present-day Tal Katora, just below the Charan Mandīr in the Nahagaḍh Hills. The area once covered by Rājmalla Lake, northwest of Tal Katora, has been reclaimed and developed as a residential area.

⁹ Sarma, 48, 51.

Brahmapurī adhered to the model with which Sawai Jai Singh was most familiar, and around which the entire *karkhāna* system operated: expertise that drew on multiple and divergent traditions was to be kept close at hand. As we shall see, this belief could only have been reinforced by the Maharaja Dhiraja's attempts to bring European scientists and the results of their scholarship to his court. From his point of view, the work at the observatory may have presented an ideal opportunity to expand his knowledge by bringing manuscripts and scientists to Jaipur, but in order to do so, he first needed to conquer the problems presented by stepping outside the conventional boundaries of the kingdom of Jaipur and Amer to meet his needs. He needed the ability to flex his physical and figurative muscle across a landscape much larger than the one over which he had been granted control by the ruling Mughal empire in Shahjahanabad. At least at the outset of this experiment, he had to assume that his own gravitational pull was strong enough to collapse the space standing between Jaipur and Europe.

4.2 Enclaves and Imperial Fragmentation

Although Sawai Jai Singh used the imprecise term *firenga* (foreign) to describe the distant land in which astronomical research was being conducted by unfamiliar persons, the region to which he ultimately referred was the European subcontinent. Precisely when and how he was informed of these activities is unknown, but given that Europeans had been present at the Mughal court from the time of Akbar, it is not surprising that such news reached his ears. On the other hand, Europe as a specific locale was an unknown for both the seated Mughal emperor and the Maharaja Dhiraja. Even though the Mughals followed a tradition of associating themselves with the Persianate dynasty of the Timurids, and so believed themselves to be closely connected with the culture of west Asia, since the era of Akbar no emperor had ranged farther west than

present-day Afghanistan.¹⁰ As the head of a hereditary state, Sawai Jai Singh possessed some mobility, moving around northwestern and central India at the will of the Mughal emperor, but in reality his explorations were somewhat limited in range, and his own landscape of control was constrained to a loosely-defined triangle of power, consisting of a geographical region pinned at the corners by the cities of Jaipur, Shahjahanabad, and Agra (Akbarabad).¹¹ Fortunately, it was a relatively simple task to locate Europe within the royal circuit connecting the imperial courts at Shahjahanabad and Agra and his own capital of Jaipur, and his initial foray into intercontinental communications did not require him to deviate even a single step from his regular trajectory of ritual motion.

Reportedly, Sawai Jai Singh sent multiple astronomers out into the world to make observations, but in terms of contacting Europeans directly, his first effort was made via a delegated representative, the Portuguese Jesuit priest Manuel de Figueredo.¹² Padre Manuel de Figueredo, or “Padri Manuel,” born in Coimbra in 1688 CE and admitted into the brotherhood of

¹⁰ Judging from a late eighteenth-century copy of a Mughal map, the topography and roads west of the well-known Kabul-Kandahar route were still largely unexplored during Sawai Jai Singh’s era. See MUGHAL Map of North-West India and Kabul, c. 1650-1730, Maps 188.i.2.(4.), British Library, London.

¹¹ Like his predecessors, Sawai Jai Singh spent much of his reign taking care of military matters for the currently seated emperor. While his father, Bishan Singh, traveled as far north as Kabul as a result of being punished by Aurangzeb for his “proclivity for pleasure,” Sawai Jai Singh’s travels took him in a south-easterly direction. Most of his military activity took place fairly close to home, in the Rajasthan kingdoms of Kota and Bundi, or the city of Thun near Mathura. However, in 1714 CE, and again in 1729 CE, he ventured as far south as Ujjain and greater Malwa. V. S. Bhatnagar, *Life and Times of Sawai Jai Singh, 1688-1743* (Delhi: Impex India, 1974), 19, 218; Jadunath Sarkar, *A History of Jaipur c. 1503-1938* (Jaipur: Maharaja Sawai Man Singh II Museum, 1984), 163-65, 178.

¹² At an unknown date, Sawai Jai Singh sent emissaries to “every country on the globe” to make observations. This included sending one “Muhammad Sarīf” to the Island of Mahaila at the latitude of 4° 12’. V. N. Sharma has proposed that Muhammad Sarīf and Sheik Muhammad Saḥī might be the same individual. Muhammad Saḥī received three separate awards of 500r-0a-0p from Sawai Jai Singh: on Baisākh Sūdi 5 VS 1786 (May 3, 1729 CE), Pausa Sūdi 5 VS 1786 (December 24, 1729 CE), and Mangsira Sūdi 11 VS 1786 (December 1, 1729 CE). It is possible this extravagant sum was a reimbursement or a gift on departure for an overseas trip. However, unlike other Muslim astronomers listed in the *Dastūr Kaumwār*, Sheik Muhammad Saḥī was not identified as a *najūmī*. See Sheik Muhammad Shaḥī, VS 1786, 604, Vol. 20, DK, RSA, Bikaner; Baisākh Sūdi 5 VS 1786, n.p., Bundle No. 46, DNP, RSA, Bikaner; Mangsira Sūdi 11 VS 1786, n.p., Bundle No. 46, DNP, RSA, Bikaner; Ramasvarupa Sharma, ed. *Samrāt-Siddhāntah Avāntara Paṭhabhedasamanvitah Siddhāntasārakaustubhah*, 3 vols., vol. 2 (New Delhi: Indian Institute of Astronomical and Sanskrit Research, 1967), 1164-65; Virendra Nath Sharma, *Sawai Jai Singh and his Astronomy* (Delhi: Motilal Banarsidass Publishers, 1995), 287.

the Society of Jesus in 1703 CE, was serving as the Rector of the Jesuit College at Agra during the second quarter of the eighteenth century.¹³ It has long been assumed—perhaps not without reason—that Sawai Jai Singh’s choice of representatives had something to do with the fact that Portugal was the strongest European power in close proximity to his kingdom of Amer and Jaipur, but as a matter of fact, Portugal’s political dominance was noticeably on the wane during this period. By the second quarter of the eighteenth century, Portugal’s political and military strength was under attack on multiple fronts: its European and Arabian competitors challenged its thalassocracy, and on land, the Maratha Confederacy made constant and successful incursions into the isolated territories that comprised Portugal’s empire in India. Though the illusion of political and military strength might have seduced the Rajput king into thinking that Portugal would be a useful ally, given the kingdom’s actual decline in influence in the region, he had good reason to look elsewhere for a representative. In fact, we might ask why he needed a representative at all—had Sawai Jai Singh wished to do so, he could have negotiated with the Portuguese Viceroy in Goa directly, or at least sent an emissary from his own court at Amer to discuss an exchange of information. Instead, he contacted Padre Figueredo and arranged for him to head a fact-finding mission to Europe.

One explanation for his reliance on an emissary lies in the very nature of imperial sovereignty in eighteenth-century India, where power and territory were not inseparable companions. In political and economic terms, the Portuguese presence in India grew rapidly in

¹³ Because orthographic reforms in Portuguese did not occur until 1911 CE, the spelling of Portuguese names varies from document to document, and even within a single document. “Emmanuel de Figueredo” is also written as “Manuel Figueiredo” in many sources. In records from the courts of Amer and Jaipur, Figueredo is referred to fairly consistently as “Padri Manvel.” Figueredo later served as *cure* at Salsette Island, and as administrator of the royal hospital at Goa. In 1756 CE, he was named *procureur* of the province. *Lettres Édifiantes et curieuses, écrites des missions étrangères*, Nouvelle ed., 26 vols., vol. 15 (Paris: J. Merigot je Jeune, 1781), 337; Augustin Backer and Aloys Backer, *Bibliothèque de la Compagnie de Jésus*, ed. Carlos Sommervogel, vol. 9, 1 ptie. (Bruxelles: O. Schepens, 1890-1900), col. 337; Raymond Mercier, “Account by Joseph Dubois of Astronomical Work under Jai Singh Sawa’i,” *Indian Journal of History of Science* 28, no. 2 (1993): 159, 162.

the two centuries following Vasco de Gama's approach to Calicut on the coast of Kerala in 1498 CE. In 1503 CE, the Portuguese state displaced the reigning ruler of Cochin and built their first fort in the city, an act that set the precedent for further invasion by European trading companies and their armies. Two years later, the Portuguese crown appointed a Viceroy to manage its *Estado da Índia Portuguesa* (Portuguese State of India), after which it was only a matter of a few years before the cities of Goa, Vasai (Baçaim/Bassein) and Diu were seized and annexed to the State. The imperial arm of the kingdom of Portugal reached deep into the subcontinent by the middle of the sixteenth century. However, even at the height of its power, the *Estado da Índia* consisted not of a bounded and unified stretch of territory, but of the multiple enclaves of Goa, the islands of Daman (Damão), Diu, and Dadra, and Nagar Haveli (located between Maharashtra and Goa), connected only by often tenuous corridors of security.¹⁴

This lack of territorial integrity meant that Sawai Jai Singh could not appeal to a single political power if he wanted to reach Europe from his seat in Rajasthan. Sawai Jai Singh, or his ambassador, had to come to terms with multiple ruling parties before they even left the subcontinent. Any individual traveling from Jaipur to Europe had to negotiate passage with the Mughals at Ajmer, Ahmadabad, and Surat, the Sisodia Mewars at Udaipur, the Rathore Marwars at Jodhpur, and the Maratha Confederacy, in addition to the *Estado da Índia*, not to mention the random groups of bandits that plied the roads of Rajasthan and Gujarat.¹⁵ By reaching out to Padre Manuel, a priest associated with the Society of Jesus, Sawai Jai Singh forged a bond with an organization that offered access to the political mechanism of Portugal without actually committing to a diplomatic relationship with that kingdom, establishing instead a long-standing

¹⁴ For an astute analysis of the long-standing depiction of empire as an inevitable rationalization of space in pursuit of territorial unity, see the discussion of enclaves and corridors in Lauren A. Benton, *A Search for Sovereignty: Law and Geography in European Empires, 1400-1900* (Cambridge: Cambridge University Press, 2010), 10-23.

¹⁵ This is ignoring completely, of course, the sea leg of the trip, which in Figueredo's case would have come under the control of the Portuguese empire.

partnership with the Jesuits. As an extra-national body, dependent on its own organization strategy for success in their mission, the Society of Jesus seemed capable of moving information and people across both state and imperial boundaries. As Sawai Jai Singh set in motion his plans to bring Europeans and their work back to his home in Jaipur, the apparent strength of the Jesuit organization must have made the organization looked like the best choice of all possible collaborators.

4.3 The Society of Jesus as an Extra-National Corporation

Iñigo López de Recaldo (b. 1491-d. 1556 CE), more popularly known as St. Ignatius of Loyola, founded the Society of Jesus in 1534 CE as an apostolic ministry. He considered his clergy to be “latter-day apostles,” charged with the subsequent spread of Catholicism by preaching and the salvation of souls through conversion. The Society consisted of recruited clerks regular who, through the joint institutions of propaganda, moral policing, and education, drew close the unsaved of the world with the express purpose of inculcating them in the confessional values of the Catholic Church.¹⁶ The work of the Society was driven by what has been described as “confession building” or the desire to develop “a confessional hierarchy who, through a coherent system of doctrines, rituals, and social norms, seek to inculcate confessional values among the masses.”¹⁷ In turn, confession-building relied on the Jesuit “ministries among the learned,” an “up-scale strategy of proselytization (i.e., ministering to all but targeting elites for conversion and confirmation)” that put the clergy in regular contact with the educated and

¹⁶ “Clerks regular” are a body of priests organized for apostolic work. Like monks, they follow a religious rule and rely on alms. However, they work and live as clerics “in the world,” rather than as part of an enclosed monastic order.

¹⁷ Steven J. Harris, “Confession-Building, Long-Distance Networks, and the Organization of Jesuit Science,” *Early Science and Medicine* 1, no. 3 (1996): 291.

governing classes wherever they went in the world.¹⁸ By the beginning of the seventeenth century, Jesuits had become the principal confessors of the Catholic royalty and lesser nobles of Europe, forging a particularly strong relationship with the court of Portugal.¹⁹ As Jesuit clerics spread out into the world as participants of various missions (such as the Tibetan Mission, the Mogor Mission, the China Mission) ideologically supported from the seat of central authority in Rome, and politically supported from the royal courts of Europe, they operated not only as “educators of the rising elites, but also as *Kulturträger* among the learned generally,” shaping the local spiritual values through the inculcation of Christian values in the masses via the political and cultural leaders.²⁰ The goal of the Jesuits on mission, whether in Europe or in South America, was to “ingratiate themselves with the culturally powerful and at the same time engage in a measure of ‘cognitive disciplining,’” a practice that simultaneously accomplished the political task of currying favor with local elites, and the religious task of proselytizing to a group of people considered cultural exemplars to the greater mass of heathens.²¹

A significant component in the success of the confession-building strategy of the Jesuits was the perceived strength of the Society’s communication network, augmented by the mobility of its missionaries. The Jesuit cycle of recruitment and concentration followed a typical pattern: the Society recruited resources (novices, material resources, objects, knowledge), and deployed them into the field of missions, always under control of the authority of the rule of their order

¹⁸ Ibid., 292.

¹⁹ Dauril Alden, *The Making of an Enterprise: the Society of Jesus in Portugal, its Empire, and Beyond, 1540-1750* (Stanford: Stanford University Press, 1996), 14.

²⁰ Harris, 292. A “mission” was an apostolic task carried out by a group of missionaries in a designated missionary space. This concept differs somewhat from that of a Jesuit “residence,” a term that refers to a specific geographical location. See Ines G. Županov, *Disputed Mission: Jesuit Experiments and Brahmanical Knowledge in Seventeenth-century India* (Oxford: Oxford University Press, 1999), 5, n. 17.

²¹ Harris, 292. In India, this ideal was put into practice as early as 1573 CE, when Portuguese Jesuits traveled north from Goa to visit the emperor Akbar while he was besieging the port city of Surat. This early attempt at diplomacy was followed by the first mission to Fatehpur Sikri in November 1579 CE. Although this mission originated in the Estado da Índia, none of the members of the delegation were Portuguese, effectively distinguishing the Jesuit interests from those of the State of Portugal. See Alden, 51.

seated in Rome. In turn, missionaries were expected to collect knowledge from their overseas stations, and send it to the central authority in the form of written correspondence and physical specimens. The Society in Rome, with support from ancillary centers such as Lisbon, Seville, and Coimbra, used whatever knowledge the missionaries accumulated via the network to strengthen those same networks and recruitment capabilities.²² In addition, information gathered in one locale was fed to those at other locations in the hopes that the missionaries would be “edified” by the words and parallel experiences of their compatriots. These endless feedback loops allowed the Jesuits to operate a particularly robust system of communication that encircled the globe during the eighteenth century, and in India both the structure (strong connection to a central authority) and the purpose (missions of ministry) of that network coincided nicely with Sawai Jai Singh’s goals to acquire what he could of European astronomical knowledge. The evangelical goals of the Jesuits led the Church to Sawai Jai Singh; subsequently, the organization of Mogor Mission gave the Maharaja Dhiraja the tools he needed to navigate the challenging and largely unfamiliar landscape looming between him and Europe. Manipulating the Jesuit cause and using Figueredo’s own confessional relationship with the royal court of Portugal, Sawai Jai Singh was able to reach into the intellectual core of Europe, dislodge a specific type of knowledge, and order it brought to him, without once leaving the seat of his own power in Amer. The Jesuit mission enabled him to navigate by proxy the many challenges and hardships imposed by the extramural landscape and natural elements on the participants in this endeavor, leaving him free to concentrate his resources on the construction of his new city and other political matters.

²² Harris expands on Bruno Latour’s work on long-distance networks, recasting Latour’s “cycles of accumulation” and “centres of calculation” as “cycles of recruitment” and “centers of concentration.” Harris, 298.

4.4 Extramural Motion

Conventionally, Hindus have been understood as physically and intellectually isolated, reluctant to travel “across the ocean” for fear of ritual pollution.²³ But in the eighteenth century, Indians enjoyed a range of motion in which repose was quite often the prerogative of the powerful. A large section of the subcontinental population was on the move for a variety of reasons, traveling long distances for marriage, pilgrimage, and trade.²⁴ While the landed and the privileged could remain stationary and expect that people and information would head toward their location, the poor and the hungry were always in motion, in search of employment or spiritual sustenance.²⁵ Indian merchants—including both Hindus and Muslims—were an integral component of the Indian Ocean trade, traveling not only along the western coast of the South Asian peninsula, but across the ocean to ports in east and south Africa as well. On land, Mughal military camps epitomized an itinerant form of living.²⁶ And even though stillness was a privilege of power, all of the Mughal emperors from Babur to Aurangzeb ruled while on the move, dragging the entire Mughal body politic with them on their never-ending migrations.²⁷ This is not to say that travel, or communication in its many forms, was a simple matter in

²³ This is the precise explanation offered by V. N. Sharma for Sawai Jai Singh’s decision to send a representative to Portugal rather than undertake the journey himself. See Sharma, *Sawai Jai Singh and his Astronomy*, 298.

²⁴ C. A. Bayly, “Knowing the Country: Empire and Information in India,” *Modern Asian Studies* 27, no. 1 (1993): 7.

²⁵ This is the logic that governed the construction of the *Diwān-i Ām* at the court of the Mughal emperors and Rajput kings. While the Maharaja Dhiraja of Amer did make significant ceremonial passages through the streets of his capital city, the local population came to the public audience hall of his court rather than addressing him on the streets. See George Michell and Antonio Martinelli, *The Royal Palaces of India* (London: Thames and Hudson, 1994), 33-37.

²⁶ For a comparative study of Indian merchants working along the Coromandel, Gujarat, and Bengal coastlines, see Om Prakash, “The Indian Maritime Merchant, 1500-1800,” *Journal of the Economic and Social History of the Orient* 47, no. 3 (2004): 435-57.

²⁷ This was true of all Mughal emperors, as well as Sher Shah Suri, but was particularly so of Aurangzeb, who advised that “an emperor should never allow himself to be fond of ease and inclined to retirement, because the most fatal cause of the decline of kingdoms and the destruction of royal power is this undesirable habit. Always be moving about, as much as possible: it is bad for both emperors and water to remain at the same place...” Hamid al-Din Khan Bahadur, *Anecdotes of Aurangzib*, trans. Jadunath Sarkar, 3rd ed. (Calcutta: M. C. Sarkar & Sons, Ltd., 1949), 53. For a description of Mughal dependency on encampments, see Jos J. L. Gommans, *Mughal Warfare: Indian Frontiers and Highroads to Empire, 1500-1700*, Warfare and History (London: Routledge, 2002), 100-11.

eighteenth-century India. As C. A. Bayly points out in his study of empire and intelligence gathering, “flows of information and news were unevenly distributed in space, in time, and among different social groups,” a phenomenon he attributes at least in part to the disruptive forces of nature.²⁸ Monsoon, for instance, threatened communication and transport systems for a full four months of every year, depending on the location.²⁹ These four months (the *cāturmāsa*, or the four month period from Asāḍh Sūdi 11 to Kāti Sūdi 11, popularly styled as the time of Vishnu’s retreat to sleep at the bottom of the ocean) marked the slow progression of the monsoon from the southwest coast toward the central regions of the South Asian subcontinent. As the ancient Marwari ballad *Dūhā de Ḍholā Mārū* describes,

This is the season where the crane itself does not set foot on the inundated land.
In this season, who then leaves his dear wife to depart on a trip?
The mountains are made green again; in the groves the peacocks throw their cry,
In this season, nobody ventures out, only the beggars, the *cātak*, and the thieves.
Rivers, streams and waterfalls are swollen with rainwater,
The camel's foot slip in the mud: O Voyager! Pūgal is far!³⁰

The turn of the seasons governed travel across the Gangetic Plain—from the Gulf of Cambay (Khambhāt) in the west to the Bay of Bengal in the east—as much the perceived political or economic necessity of any given trip. During the rainy season, both trade and politics followed a different rhythm, one so quiet as to be almost imperceptible to the ears of outsiders.³¹ Upon the advent of monsoon, the emperor retreated into his palace, and public displays of power and politics reached a temporary stopping point.

²⁸ Bayly, 8.

²⁹ In fact, the lacunae in the construction records for the city of Jaipur suggest that most work on new buildings paused during *Sāvna* and *Bhāḍva*, the season (*ritu*) of rain on the Gangetic Plain.

³⁰ Charlotte Vaudeville, *Les Duhā de Ḍhola-Mārū: Une Ancienne Ballade du Rājasthān* (Pondicherry: Institut Français d'Indologie, 1962), 76. The *cātak*, or pied cuckoo, is believed to live on raindrops, particularly those of the autumnal lunar asterism of *Svāti* (roughly, October). The town of Pūgal is 85 kilometers northwest of Bikaner, Rajasthan.

³¹ Bayly, 9; Jean Deloche, *Transport and Communications in India Prior to Steam Locomotion*, trans. James Walker (Delhi: Oxford University Press, 1993), 276.

During monsoon, the roads were mean, the rivers deadly. Any individual intent on moving through a monsoon region between June and October planned carefully, or did not live to tell the journey's tale.³² Few permanent bridges existed in Rajasthan or Gujarat in the Mughal era; during military campaigns, pontoon bridges were built on the fly, taking from one to four days to construct.³³ Independent travelers, lacking the resources to command a new bridge built at every river, relied instead on local informants to locate the safest place to ford a river.³⁴ When winter rains fell, few of those safest places existed, even near major metropolitan areas. For example, the Sābarmatī River, which flows through Ahmadabad, Gujarat, made the capital city almost unreachable during the *cāturmāsa*. As one European traveler described,

during the rainy season, which lasts in India three or four months, [the Sābarmatī] becomes very wide and rapid, and does great injury every year. It is the same with all the rivers of India, and when the rains have ceased, you must generally wait six weeks or two months before it is possible to ford the river at Ahmadabad, as there is no bridge. There are two or three boats, but one cannot make use of them, save when the river falls, and it takes much time to cross.³⁵

In the season of rain, it was almost impossible to complete an uninterrupted trip within the boundaries of a major city or principality, much less more than halfway across the subcontinent.

In addition to the very real dangers and delays introduced by the weather, travelers faced challenges when attempting to navigate the roadways of the northern region. Good roads were scarce, as even the most-frequently used routes were not surfaced with macadam or even metalled; most roads were not emplaced deliberately, but rather worn into the ground by habitual

³² During the seventeenth century, European trading companies were usually unable to find carriers during the *cāturmāsa*, as few were willing to risk breaking the legs of their pack animals or the axels of their carts. Deloche, 75.

³³ Abdul Khair Muhammad Farooque, *Roads and Communications in Mughal India* (Delhi: Idarah-i Adabiyat-i Delli, 1977), 41-44.

³⁴ *Ibid.*, 45-51.

³⁵ Jean-Baptiste Tavernier, *Travels in India*, trans. Ball V, 2 vols. (London: Macmillan and Co., 1889), 59.

use.³⁶ Although Mughal maps tended to represent the direction and duration of movement in schematic simplicity, in fact, the roads were twisted and tortuous, skirting areas made dangerous by bandits, topography, and weather. Well into the nineteenth century,

the Indian network formed an immense web, spun by generations of travelers...the route thus formed was here a confused tangle of tracks, there a well-laid out roadway; elsewhere it lost itself in rice fields to re-appear only at a forest's edge; at times it led to a forgotten temple and terminated there; a badly provided track at the approach to a city, it could have been a beautiful straight avenue in a modest village: its condition was dependent upon the attention it received from the local authorities.³⁷

Maintenance and safety of even major byways typically was charged to individuals, not the state. The imperial government attempted to improve both transport and communication infrastructure after Babur's invasion in 1526 CE, including his opposition, Sher Shah Suri (r. 1539-1545 CE), who did more than any one ruler in the Mughal era to shape the landscape of travel in India when he ordered the construction of what is now called the Grand Trunk Road from Attock to Delhi.³⁸ However, much still depended on local initiative. For instance, when Emperor Jahangir (r. 1605-1627 CE) expressed concern for the welfare of travelers, including him, during the hot season, he ordered local zamindārs to plant shade trees along the imperial highway between Agra and Attock, as well as between Agra and Bengal.³⁹ When he further took heed of the dangers introduced by marauding bandits, he declared that wherever roads were frequented by thieves

³⁶ Typically, larger cities had at least a few streets paved streets, often with brick. In the imperial city of Fatehpur Sikri, the market road was paved with flint stone. The streets of Cambay were paved, and the large trading city of Sirhind also had a paved road. However, the major highways, even when used emperor on a regular basis, were neither paved nor metalled. See Farooque, 38-40.

³⁷ Deloche, 141.

³⁸ This road became the dominant route for north-south travel and communications under the later Mughals, and when it was extended to the city of Sonargaon, it became the safest and quickest route to the Bay of Bengal. Under Mughal patronage, the Grand Trunk Road continued to serve as the spine, supporting an ever-expanding body of roads, most of which led to the imperial city of Agra. C. E. A. W. Oldham, "Routes, Old and New, from Lower Bengal 'Up the Country': Part II--The 'New Military Road' and the Grand Trunk Road," *Bengal, Past & Present; Journal of the Calcutta Historical Society* 30(July-Dec 1925): 18-34.

³⁹ Jahangir, *The Jahangirnāma: Memoirs of Jahangir, Emperor of India*, trans. Wheeler M. Thackston (New York: Oxford University Press, 1999), 310; Farooque, 13.

and highway robbers, and wherever roads were distant from population centers (and thus easy protection), “the jagirdars of that region were to construct a caravansaray and mosque and dig a well to encourage habitation in the caravansaray.”⁴⁰ Even the most basic support systems along the highway were cared for by individuals, not the central government: in 1619/20 CE, Jahangir again directed the zamindārs responsible for land fronting the imperial highway to erect a milestone (*kos minar*) at every *kos*, and to dig a well every three *kos* in order “that wayfarers could travel easily and comfortably and not suffer from thirst or the heat of the sun.”⁴¹ This type of caretaking meant that the traveler relied on local fortunes and local priorities when making a trip that extended across country, even if ultimately the central authority claimed credit for the improvements.

This dependence on local resources imperiled the traveler when the roads were not maintained and bandits were not suppressed, but by employing a Jesuit to travel in his stead, Sawai Jai Singh relieved himself of any need to worry about the dangers lurking outside the city walls. In addition, he avoided making unnecessary demands on limited financial resources and minimized the expenditures made in support of the military camp that would have been required should he have chosen to travel with his ordinary manner. By sponsoring a delegate, he could still penetrate the landscape and reach those distant destinations, while risking little but money and time. Moreover, because he chose Father Manuel Figueredo, a well-placed Jesuit priest, to act as his voice, he could easily appropriate the already-extant Jesuit long-distance networks and exploit them for his own benefit. At the end of the day, whatever money or manpower he expended to ensure that Figueredo would return to Jaipur with the necessary information and

⁴⁰ Jahangir, 26. If, upon an individual’s death, no heir could be located, the local government would absorb the money and spend it on “licit expenditures such as constructing mosques and caravansarais, repairs to broken bridges, and the creation of tanks and wells...” ———, 26.

⁴¹ Jahangir, 310; Farooque, 14.

advisors would have been well spent even had the mission failed completely, particularly when compared to what he would have lost had he put himself up to the test of traveling to the European subcontinent.

4.5 First Attempt

Initial contact between the Jesuit College in Agra and the Kacchawāhā court in Amer has been attributed to a “chance encounter.”⁴² From the *Zīj-i Muḥammad Shāhī*, we know that Sawai Jai Singh called for “several skilful persons with Manuel Padri,” otherwise known as Padre Manuel de Figueredo, to travel abroad, in order to procure “the new tables which had been constructed there thirty years earlier and published under the name la Hire, as well as the European tables previous to those.”⁴³ Reading between the lines of account ledgers, we can see that, for whatever reason, Sawai Jai Singh and Figueredo conferred at least twice while the Maharaja Dhiraja still resided in his palace at Amer. On August 23, 1727 CE (Bhādva Sūdi 7 VS 1784), or approximately three months before the formal founding of the city of Jaipur, Sawai Jai Singh awarded 200r-0a-0p to Padre Figueredo, presumably while the Jesuit was in attendance at court.⁴⁴ The king had ordered this cash gift to be given to the priest more than a year earlier, on August 2, 1726 CE (Sāvna Sūdi 5 VS 1783), which means that negotiations with the Jesuit

⁴² J. B. Amâncio Gracias, “Uma Embaixada Científica Portuguesa à Corte do Rei Indiano no século XVIII,” *O Oriente Português* 19 (1938): 192. Many sources assume that the source of Sawai Jai Singh’s knowledge about the astronomical work being undertaken in Europe was Father Manuel, but according to the *Dastūr Kaumwār*, the Maharaja Dhiraja was in contact with another “Foreign Father” (*Pādri Firengī*) as early as Jeth Vadi 8 VS 1781 (May 16, 1724 CE). While it is tempting to assume that this unnamed individual was Father Manuel, many of the entries included in the list of gifts of protocol fall on dates when Father Manuel was known to be in Portugal. Pādri Firengī, VS 1781, 849, Vol. 19, DK, RSA, Bikaner; Pādri Firengī, VS 1783, 849-50, Vol. 19, DK, RSA, Bikaner; Pādri Firengī, VS 1785, 850, Vol. 19, DK, RSA, Bikaner; Pādri Firengī, VS 1786, 850, Vol. 19, DK, RSA, Bikaner; Pādri Firengī, VS 1790, 851, Vol. 19, DK, RSA, Bikaner; Pādri Firengī, VS 1796, 851, Vol. 19, DK, RSA, Bikaner.

⁴³ *Zīj-i Muḥammad Shāhī*, fol. 4v.

⁴⁴ The records do not indicate that the cash was delivered “by means of” (*ke vāste*) any other individual in the city of Akbarabad, as was typical when the money was delivered to a location distant from the capital. Pādri Mānvel Fīrjāzādā Firengī ke Pātsyaha ka, Bhādva Sūdi 7 VS 1784, 199-200, Vol. 20, DK, RSA, Bikaner.

must have commenced at a relatively early point in the life of the Shahjahanabad observatory, and well before the founding of the Jaipur observatory.

The delegation sent to Portugal under the Padre's leadership was small, and the "several skillful persons" mentioned in the *Zīj-i Muḥammad Shāhī* remain shadowy figures in the history of astronomy. Upon Figueredo's arrival in Goa in January 1728 CE, the public press noted him to have been accompanied only by an unnamed "Moor sent by the House of Mogol."⁴⁵ A published account describing Figueredo's appearance before King João V of Portugal the next year noted that two "fidalgos," or gentlemen of the court, both of whom were Indian, accompanied the Jesuit, a situation that indicated a third party must have joined Figueredo and "the Moor" before their departure from Goa.⁴⁶ Further reports clarified the members of the delegation as "Pedroji, a Catholic and Mughal by birth," and "Sheikji, [a] Muslim."⁴⁷ The composition of the group was diverse, then, consisting of two Catholics, one born in Europe, the other probably of European descent, and one Muslim, possibly hailing from Jaipur. As an ensemble, the three represented the best of all possible combinations in terms of ambassadorial

⁴⁵ "Letter to King João V," in *Arquivo Portugues Oriental*, ed. A. B. de Braganca Pereira (Bastora: Rangel, 1936-40), 85. The 200r-0a-0p presented to Figueredo in November 1727 CE likely coincided with the departure of his delegation from Jaipur, since by January 17, 1728 CE, the priest, as representative of the "House of the Mogol," had arrived in Goa.

⁴⁶ "PORTUGAL. Lisboa. 20 de Janeiro," *Gazeta de Lisboa Occidental*, January 20, 1729, 24.

⁴⁷ *Ibid.*, March 10, 1729, 80. "Pedroji" was undoubtedly the same Pedro da Silva Leitão who settled in the city of Jaipur after arriving from Goa in 1730/31 CE. M. F. Soonawala equates Pedro da Silva Leitão with the physician popularly known in Jaipur as "Hakim Martin" ("Doctor Martin"); however, Sawai Jai Singh constructed a haveli for "Hakimji" as part of his new city, approximately three years before Pedro da Silva appeared in Jaipur. V. N. Sharma has tentatively identified "Sheikji" as Sheik Asadulā Najūmī, based on a payment of 100r-0a-0p made on Baisākh Vadi 14 VS 1783 (May 1, 1726 CE), perhaps as many as fifteen months before the departure of Figueredo's group from Jaipur. This is certainly possible, as based on our knowledge of other gifts-in-kind presented to Sheik Asadulā, he seemed to be a valuable member of Sawai Jai Singh's stable of astronomers. Unquestionably, Sawai Jai Singh would have wished to send one of his more knowledgeable astronomers to assess the value of the science performed in Europe. However, this identification is quite tentative, and is not borne out by any other archival records. See M. F. Soonawala, "Maharaja Sawai Jai Singh II, (1686-1743)," *Science and Culture* 9, no. 10 (April 1944): 414. For du Bois' autobiography, see Mercier, "Account by Joseph Dubois of Astronomical Work under Jai Singh Sawa'i," 158, 161. For the accounts covering the construction of Hakimji's haveli, see Bhādvā Sūdi 3 VS 1785 to Bhādvā Sūdi 2 VS 1786, fol. 49, Bundle 1, AI, RSA, Bikaner; Bhādvā Sūdi 3 VS 1786 to Bhādvā Sūdi 2 VS 1787, fol. 49, Bundle No. 2, AI, RSA, Bikaner; Bhādvā Sūdi 3 VS 1787 to Bhādvā Sūdi 2 VS 1788, fol. 90, Bundle No. 3, AI, RSA, Bikaner; Jeth Sūdi 15 VS 1791, fol. 7v, Bundle No. 3, RI, RSA, Bikaner.

potential. Two of the members were undoubtedly conversant in Portuguese, and while Figueredo was bound most closely to the Catholic hierarchy in Portugal, Pedroji probably possessed the most insight into the local conditions in Goa. In addition, as a “Mughal by birth,” Pedroji probably read or spoke a form of Persian and could mediate between the Islamic astronomer, Sheikji, and the mathematicians in Portugal. The linguistic, religious, and intellectual resources of the three combined in such a way that they would undoubtedly be able to communicate with anyone who stood between them and their next destination.

The delegation required the typical span of three months to travel from Amer to Goa via Surat, the point at which the journey switched from overland to overseas transport methods.⁴⁸ Within the context of Mughal transportation and travel, the routes between Jaipur and Surat were well-known and well-traveled. The most popular road running from the imperial center of northern India and the Gulf of Cambay in the west ran south from Agra to Surat via Burhanpur, and had Figueredo departed on his European mission from the Jesuit College in Agra, this would have been the only practical choice of routes (map 4.1). Certainly, Mughal rulers preferred this route, as did the military and other agents appointed by the imperial court, and as an agent of Sawai Jai Singh, who was himself an agent of the Emperor, Padre Figueredo probably considered traveling along it as well.⁴⁹ However, since preparations for the journey were undoubtedly finalized in Amer, it is much more likely that the group started for Surat from that

⁴⁸ Tavernier noted that it required forty days to travel from Surat to Agra (Akbarabad), but in reality, it often required many more due to weather, banditry, and illness. For example, William Finch departed Surat on January 18, 1610 CE, and reached Agra via Burhanpur only on April 4, 1610 CE. From Surat, the final leg to Goa would have been covered by ship in a few days. Considering the overland and oversea distances together, three months represented a very efficient traveling experience on the part of Figueredo and his companions. Jean Baptiste Tavernier, *Les six voyages de Monsieur Jean-Baptiste Tavernier...en Turquie, en Perse, et aux Indes, pendant l'espace de quarante ans & par toutes les routes que l'on peut tenir: accompagnez d'observations particulières sur la qualité, la religion, le gouvernement, les coùtumes & le commerce de chaque païs*, Nouvelle ed. (Rouen: Eustache Herault, 1713), 36; William Finch, “1608-1611 William Finch,” in *Early Travels in India*, ed. William Foster (London: 1921), 133-46.

⁴⁹ Deloche, 53.

royal palace and therefore followed the road that ran from Agra to the Gulf of Cambay through the desert kingdoms of Rajasthan and Gujarat (map 4.2). At the proper time of year, this course was considered the better choice.⁵⁰ In terms of mileage, the trip through the sandy wilderness was shorter, and although the main road bypassed Jaipur, it was connected to Sawai Jai Singh's capital by a relatively short spur branching to the northeast from Ajmer. However, timing was crucial for anyone choosing to follow this route, as the road made for an unpleasant and possibly lethal companion for at least eight months out of the year. No one willingly plied the scorching paths of Rajasthan between the months of March to May, preferring to avoid the deadly burn of the spring heat. Nor was travel in monsoon ever recommended as an intelligent choice. And, as one eighteenth-century traveler described, even in the best of weather, the route was wearying, as "truthfully, the path is smooth, to the point that not the smallest stone can be found under your feet, but so sandy, that it really tires the feet of the travelers & animals."⁵¹ Both of these byways were well-established in the sixteenth and seventeenth centuries, and it is unlikely that Figueredo would have reached Surat safely had he strayed from either one. Regardless of his choice of itineraries, it is easy to see that even following an "easy" route, the trip from Jaipur or Agra to Surat would have been challenging in any weather and at any time of year.

From Surat, it was a quick and reasonably safe boat trip to Goa, under the protection of the *Estado da Índia*. We do not know how long the party dallied in Goa before their departure for Europe—presumably long enough to locate Pedroji and arrange for his services—but Figueredo, in the company of the "Catholico" and the "Mohametano," was noted to have disembarked at the port of Lisbon in January 1729 CE, approximately one year after the Viceroy

⁵⁰ Ibid.

⁵¹ Joseph Tieffenthaler, Anquetil du Perron, and James Rennell, *Description Historique et Géographique de l'Inde*, trans. Jean Bernoulli, 1 ed., 3 vols., vol. 1 (Berlin: Chrétien Sigismond Spencer, 1786), 332.

of Goa first noted his presence in that coastal state.⁵² Soon after Figueredo's arrival in Lisbon, the Jesuit was awarded a private audience with João V, King of Portugal, and allowed to confer with the court mathematicians in matters of astronomy.⁵³ Other than these few details, the record of his time in Europe is non-existent, although it would be safe to assume that he consulted at length with his superiors of the Society of Jesus in Lisbon or possibly his hometown of Coimbra. Almost two years passed between the embassy's arrival in Lisbon and its return to the Indian subcontinent at some date before November 1730 CE. Figueredo did not communicate with the court of Jaipur during this extended absence, a silence that clearly worried his patron. In April 1730 CE, the Maharaja Dhiraja sent a missive to Goa demanding an explanation for the priest's tardiness and requesting that he be sent back to Jaipur as soon as possible.⁵⁴ By the time Sawai Jai Singh's letter reached the Viceroy, Figueredo had already returned to Goa, and he must have departed immediately for Jaipur, because by March 20, 1731 CE (Phālguna Sūdi 12 VS 1787), he was in Surat and in the position to receive a draft of 500r-0a-0p sent by Sawai Jai Singh to cover his expenses.⁵⁵

The journey home from Surat to Jaipur once more remained undocumented, so we cannot be certain how many days passed between Figueredo's departure from the first city and his arrival in the second, but in the summer of that same year, he was awarded a daily allowance of 2r-8a-0p by the Maharaja Dhiraja, presumably for maintenance while he lingered in Jaipur for his debriefing.⁵⁶ In addition, in the autumn of 1731 CE, the Jesuit, together with his *chelo* (disciple/student), accepted several additional cash payments, including the extremely large sum

⁵² "PORTUGAL. Lisboa. 20 de Janeiro," 24; *Gazeta de Lisboa Occidental*, March 10, 1729, 80.

⁵³ Ibid.

⁵⁴ "Outra ao mesmo," in *Arquivo Portugues Oriental*, ed. A. B. de Braganca Pereira (Bastora: Rangel, 1936-40), 180-81.

⁵⁵ Pādri Mānvel Fīrjāzādā Firengi ke Pātsyaha ka, Jeth Vadi 14 VS 1788, 200, Vol. 20, DK, RSA, Bikaner.

⁵⁶ Asādh Sūdi 13 VS 1789, n.p., Bundle No. 46, DNP, RSA, Bikaner.

of 1000r-0a-0p.⁵⁷ While the amount and frequency of these raise a number of interesting questions about the court economy, they also tell us a great deal about the timeline of communication between Jaipur and distant interests in Europe. The treasury at Jaipur distributed these final cash payments a full five years after Sawai Jai Singh's first contact with Figueredo, and a full four years after the ambassadorial party departed for Europe. Without a doubt, the rate of construction at the observatories far outpaced the rate of communication between the courts of Lisbon and Jaipur via Figueredo. When the court disbursed the last of Figueredo's rewards, the observatory at Jaipur had been under construction for at least four years, and the Maharaja Dhiraja stood on the verge of investing a tremendous sum of money on a Samrāt Yantra more massive than the one already built outside Shahjahanabad.⁵⁸

As an initial attempt to fold European astronomical holdings into his own, the Maharaja Dhiraja achieved a certain level of success. Figueredo returned with a set of tables, but at the same time, this experiment demonstrated the validity of the scholar's village model as established at Brahmapurī. It certainly would have been more efficient for the king to consult with an expert in European astronomy had that individual lived in close proximity to the court. And indeed, it would seem that Sawai Jai Singh concluded as much as he made some effort to retain the services of both Figueredo and Pedroji, otherwise known as Pedro da Silva, over the long term. Figueredo resided in Jaipur for at least two years after his return from Lisbon—Sawai Jai Singh gifted him with a ceremonial *sirapão* of a customary value of 92r-0a-0p in 1734 CE (VS 1790)—and Pedro da Silva settled in the city for the duration of his life.⁵⁹ However, even

⁵⁷ This payment was listed in two different sets of accounts, the Gifts of Religious Protocol and the Gifts of (Political) Protocol. Pādrī Mānvel Fīrjāzādā Firengi ke Pātsyaha ka, 201; Bhādvā Sūdi 7 VS 1788, n.p., Bundle No. 46, DNP, RSA, Bikaner. For additional, less substantial, disbursements, see also Pādrī Mānvel Fīrjāzādā Firengi ke Pātsyaha ka, 200.

⁵⁸ Mercier, "Account by Joseph Dubois of Astronomical Work under Jai Singh Sawa'i," 159, 162.

⁵⁹ Pādrī Mānvel Fīrjāzādā Firengi ke Pātsyaha ka, Asoj Sūdi 2 VS 1790, 201, Vol. 20, DK, RSA, Bikaner. In addition to monetary gifts given to Pedro in 1733 CE, the accounts include several mentions of payment rendered to

though the Maharaja Dhiraja managed to resettle Pedro da Silva in his town, there were several obvious weak points in the mission to Portugal. To begin with, it is apparent that the Maharaja Dhiraja fell sway to the growing reputation of the Society of Jesus and overestimated the capabilities of Figueredo and what he could deliver to him in Jaipur. Today, the typical description of Jesuit networks tends to emphasize the Jesuits' abilities to communicate globally, an assertion borne out in the eighteenth century not only by Figueredo's safety during the overland and overseas journey, but by the voluminous publications of Jesuit letters and commentaries throughout the seventeenth and eighteenth centuries (until the year of the Suppression of the Society in 1767 CE). All too frequently, however, these popular conceptions of the Jesuits do not take into account "the difficulties, inefficiencies, and outright failures of the Jesuit system in practice. As the detailed studies...demonstrate, the struggles to establish the order and efficiency for which the old Society is famous were great."⁶⁰ Once Sawai Jai Singh began to rely on the Jesuits, he also had to deal with struggles that were not readily visible to the outsider. Figueredo's five-year expedition suggests that though the system may have been robust, it was far from efficient. Accustomed to the rapidity of Mughal communication systems, and perhaps ignorant of the distances and protocols involved in Jesuit relations, Sawai Jai Singh was surely shocked by the time it took to get his astronomical tables back from Portugal. As the head of a hereditary state serving at the pleasure of Muhammad Shah, he was in large part integrated into this imperial communications system.⁶¹ Typically, message delivery between

Pedro's apprentice in 1732 and 1737 CE. See Bhādvā Sūdi 7 VS 1788, n.p.; Māgh Sūdi 7 VS 1789, n.p., Bundle No. 46, DNP, RSA, Bikaner; Jēṭh Sūdi 4 VS 1794, n.p., Bundle No. 46, DNP, RSA, Bikaner; Asoj Sūdi 3 VS 1794, n.p., Bundle No. 46, DNP, RSA, Bikaner. William Hunter, who allegedly met Kevelrāma's grandson in 1796 CE, claimed that Pedroji's son still resided in Jaipur, and that the father had died only five or six years earlier. William Hunter, "Some Account of the Astronomical Labours of Jayasinha, Rajah of Ambhere, or Jayanagar," *Asiatick Researches* 5 (1799): 211.

⁶⁰ Harris, 297, n. 27.

⁶¹ The *farmāns*, *vakīl* reports, and *arzdāsts* now housed in the Rajasthan State Archives suggest that Sawai Jai Singh had the ability to dispatch and collect intelligence across the Mughal dominion. For a catalogue and descriptive

major metropolitan areas in northern India was speedy. For example, the relay from Agra to Ahmadabad, manned by foot couriers, covered the 854 kilometers between the two cities in just five days.⁶² These same relay couriers took only seven to twelve days to run the 976 kilometers between Delhi and Ahmadabad. A single express courier, traveling at a much slower speed than a relay courier, still could traverse the 1,209 kilometers between Delhi to Surat in fifteen to twenty days. The road from Agra to Surat was slightly shorter than that from Delhi, but required more time for the express courier to make the journey.⁶³ Soldiers traveled at a much slower pace, ranging from approximately 25 to 35 kilometers, and merchants more slowly still, at 20 kilometers per day. Individual travelers, however, could move much more quickly, averaging 35 to 40 kilometers a day.⁶⁴ If Sawai Jai Singh calculated the expected length of Figueredo's absence based on any one of the familiar means of transportation—courier, merchant caravan, military march, palanquin, or saddled mount—his letter to the Viceroy of Goa demanding an explanation for his missing emissary should have come as no surprise to its recipient. The extended time lapse between Figueredo's departure and his return left both the scientist and politician in Sawai Jai Singh with several difficult questions. Should he continue to follow his building agenda as planned, or should he wait for the results of Figueredo's consultation with

summary of extant *vakīl* reports and *arzdāsts*, see Rajasthan State Archives, *A Descriptive List of the Vakil Reports Addressed to the Rulers of Jaipur (Persian)*, vol. 1 (Bikaner: Government Press, 1967); ———, *A Descriptive List of the Vakil Reports Addressed to the Rulers of Jaipur (Persian)*, vol. 2 (Bikaner: Government Press, 1972); ———, *A Descriptive List of the Vakil Reports Addressed to the Rulers of Jaipur (Rajasthani)*, vol. 3 (Bikaner: Government Press, 1974); ———, *A Descriptive List of the Arzdashts (Persian) Addressed by the Various Officials to the Rulers of Jaipur, 1658-1707* (Bikaner: Rajasthan State Archives, 1981); ———, *A Descriptive List of the Arzdashts (Persian) Addressed by the Various Officials to the Rulers of Jaipur, 1707 to 1720 A.D* (Bikaner: Rajasthan State Archives, 1986).

⁶² The Mughal court often relied on messengers riding horses or camels to deliver urgent correspondence, but their normal system of communication was manned by foot couriers. The lengths of the stages covered on foot by relay couriers varied under different emperors (two *kos* under Sher Shah Suri and Aurangzeb, five *kos* under Akbar), but during times of great need, relay couriers could exceed 100 kilometers per day. For more detail, see Deloche, 218-24.

⁶³ With a length of 1,088 kilometers, this route took twenty-five to thirty days, with an average distance covered of 36.2 to 43.5 kilometers per day. Ibid., 281.

⁶⁴ Ibid., 283-86.

European mathematicians and astronomers before committing more resources to the project? Was it worth the financial and political risk to continue operating under the assumption that he understood the science of Ptolemaic astronomy perfectly well?

While Sawai Jai Singh might have initially basked in the glow of victory when his Jesuit emissary stepped into the *Diwān-i Ām* of his new palace of Jaipur, eventually, he would have realized that his triumph was almost pyrrhic: whatever else he gained in the way of scientific knowledge by this maneuver, he lost several years during which he could have been working at his observatories. Once he had Pedro da Silva settled into his new home, he might have felt more comfortable moving forward with further construction at the observatory, but soon he hit a new stumbling block. Neither Figueredo nor da Silva was capable of explaining the astronomical manuscripts that had accompanied them on their return voyage from Portugal. Fortunately, Sawai Jai Singh was intelligent and a quick learner. Just as the changes made in the instruments constructed in Jaipur demonstrated his ability to adapt to solve a design problem that had appeared in Shahjahanabad, so too did his later dealings with Europeans indicate he was capable of adjusting his approach when met with failure. He clearly learned from his experience with Figueredo and Pedroji, and subsequently, when faced with a new need for expertise in European astronomy, he adapted his approach based on the lessons learned during from his first encounter with the Society of Jesus and its missionaries.

4.6 From West Bengal to Jaipur

As chronicled in the preface to the *Zīj-i Muḥammad Shāhī*, Figueredo's party made its way back to Jaipur with several astronomical manuscripts and treatises in hand, most notably, the

Tabulae Astronomicae of Philippe de la Hire (figure 4.1).⁶⁵ Perhaps because he needed to share the information between two different groups of astronomers, the first working in Persian, the second working in Sanskrit, Sawai Jai Singh arranged for at least one additional transcription to be made of de la Hire's treatise.⁶⁶ The Maharaja Dhiraja may have blundered at this point, as he hired the completely inadequate Joseph du Bois for the task. Du Bois, a self-described "wandering" French man who would be considered something of a charlatan today, parlayed a limited exposure to astronomy into a lucrative position at the court of Jaipur. According to a brief autobiographical statement written in Latin and pre-pended to his translation of de la Hire's *Tabulae*, du Bois received a small amount of training in "astronomy and Euclid's Elements in the Arabic idiom and in French" courtesy of Alexandre Martin and Theodore Forest while residing with the Martin brothers in Shahjahanabad.⁶⁷ From the Martin household, du Bois moved to a position of "physician" for Said Farash Khan, after which point, "God, by ways unknown," led him

to the service of a certain great native Ruler by name Sawai Yassang [Sawai Jai Singh], Prince of Astronomers who, just as Alphonso of Castille in Asturiae spent 400,000 thousand gold pieces for the provision of astronomers, so also this man gives the same stipend each month, for six years now, 4,000 rupees, which equals 1000 gold pieces of Venice, Holland or Hungary.⁶⁸

⁶⁵ There is some dispute as to which edition of de la Hire's tables first arrived at Jaipur. V.N. Sharma suggests that Sawai Jai Singh received the first edition, printed in 1687 CE, from the party that returned from Portugal in 1731 CE, and the second edition a year later. However, David Pingree asserts that Sawai Jai Singh only received a 1727 CE reprint of de la Hire's second edition, originally published in 1702 CE. Certainly, it was the reprint of the second edition that was translated by Joseph du Bois in 1732 CE. Sharma, *Sawai Jai Singh and his Astronomy*, 245; David Pingree, "Philippe de La Hire at the Court of Jayasimha," in *History of Oriental Astronomy*, ed. S. M. Razaullah Ansari (Dordrecht: Kluwer Academic Publishers, 2002), 123.

⁶⁶ Pingree, 123.

⁶⁷ The dates of du Bois' travels remain somewhat vague in his autobiography, as he noted only that he wandered for fifteen years before arriving in India. After landing on the subcontinent, he traveled for an indefinite amount of time, eventually stopping in Shahjahanabad, where he took up with the Martin brothers. Mercier, "Account by Joseph Dubois of Astronomical Work under Jai Singh Sawai," 158, 161.

⁶⁸ Ibid., 159, 161. Many thanks to Professor Thomas H. Watkins for his assistance with du Bois' text.

Presumably because of du Bois' professed familiarity with mathematics and astronomy, Sawai Jai Singh placed the French physician on stipend with his astronomers and delegated to him the task of translating the *Tabulae Astronomicae* from Latin to Sanskrit, in addition to translating Shah Jahan's version of Ulugh Beg's New Tables (*Zīj-i Shāh Jahānī*) from Persian "into the language of the Indians."⁶⁹ Although no concrete dates were provided, implicit in du Bois' work was a claim that he resided for an extended period of time at Jaipur, since he mentioned that he had the opportunity to serve as an eyewitness to the Maharaja Dhiraja's work at the observatory "not once or twice," but multiple times.⁷⁰ In fact, he may have passed multiple years as a member of the king's intellectual retinue, as his name appears in the *Dastūr Kaumwār* as late as January 28, 1735 CE (Māgh Sūdi 4 VS 1791).⁷¹ It would appear, then, that in the space of a year or two, Sawai Jai Singh managed to expand his advisory council by at least two brains, those of da Silva and du Bois, and three, if we count the two years Figueredo loitered in the city. This seems like a tremendous wealth of personnel, but evidently, none of these individuals was well-versed in de la Hire's methods.

Further study of de la Hire's work by the Maharaja Dhiraja only emphasized the lack of training of da Silva and du Bois in these matters, and it soon became apparent that the calculations based on observations made in Shahjahanabad did not correspond with those dependent on the values included in either the *Tabulae Astronomicae* or in the New Tables. Comparing de la Hire's calculations with his own observations, it appeared to Sawai Jai Singh that "there was an error in the former of half a degree in assigning the moon's place: although

⁶⁹ David Pingree has attributed a *nāgarī* version of the lunar tables from the *Zīj-i Jadīd*, catalogued as Khasmohor 5484 in the Maharaja Man Singh II Museum in Jaipur, to the hand of du Bois. Pingree, 123.

⁷⁰ Mercier, "Account by Joseph Dubois of Astronomical Work under Jai Singh Sawa'i," 159-62.

⁷¹ The entries for "Padrī Bodyā" in the *Dastūr Kaumwār* have been interpreted as meaning many different individuals, but I suggest that Joseph du Bois, even though not a Jesuit "padre" remains the most likely candidate. The total sum awarded Padrī Bodyā is relatively large (2095r-0a-0p), and includes a reference to du Bois' previous patron Farās Khān. See Padrī Bodyā, VS 1791, 38-39, Vol. 20, DK, RSA, Bikaner.

the error in the other planets was not so great, yet the times of solar and lunar eclipses...come out later or earlier than the truth, by the fourth part of a *ghatika* or fifteen *palas*.”⁷² As David Pingree has demonstrated, du Bois was clearly not a mathematician, so the fact that Sawai Jai Singh’s calculations did not correspond with de la Hire’s initially may have been attributed to de Bois’ shortcomings as an intellectual. De la Hire’s text involved a variety of geometric models that depended on heliocentric assumptions, as well as on logarithms of ordinary numbers and of trigonometric functions, none of which were familiar to Sawai Jai Singh.⁷³ Since none of the other astronomers at the Jaipur court, including the Astronomer Royal Kevelrāma, understood de la Hire’s calculations, either, the astronomer-king was left with a dilemma.⁷⁴

We can only imagine the scientific—and political—debate that ensued from the perpetual disagreement between what the eye observed in the sky and what it read in the European tables. Sawai Jai Singh had contracted with Figueredo, and consulted with Pedroji and du Bois, and yet, he still was left with uncertainties about the state of astronomy in Europe. Much was at stake with respect to the Maharaja Dhiraja’s reputation: he was powerful enough to unilaterally send a delegation to Europe through a dangerous and unpredictable landscape, but his massive expenditures on masonry instruments were beginning to look futile in terms of achieving acceptable results. Sawai Jai Singh clearly did not blame his instruments for the contradiction between the observed locations and the calculations of de la Hire; instead, he repeatedly displaced the errors onto Europe, insisting that his observations were made with the most precise of instruments and the utmost care. In fact, he concluded that, “since in Europe, astronomical instruments must not have been built of such a size, and with such large diameters, the motions

⁷² *Zīj-i Muḥammad Shāhī*, fol. 5r.

⁷³ Kim Plofker, *Mathematics in India* (Princeton: Princeton University Press, 2009), 287.

⁷⁴ Pingree uses Kevelrāma’s inaccurate rendering of de la Hire’s method of computing the longitudes of the Sun, Moon, and planets in the form of the Sanskrit poem *Dr̥kpaḥsasāriṇī* as evidence of the astronomer’s misunderstanding. Pingree, 124.

which have been observed with them may have deviated a little from the truth.”⁷⁵ However, the Maharaja Dhiraja was nothing if not persistent, and having done so once with a reasonable amount of success, he proceeded to exploit yet another Jesuit network, changing his approach slightly to overcome the challenges thrown up during his first experience with the Christian organization. Instead of contacting Figueredo, or the Viceroy of the *Estado da Índia*, he wrote to a pair of Jesuit priests residing at the French mission in Chandernagore (Chandannagar), West Bengal, asking for advice in interpreting de la Hire’s numbers.⁷⁶ While this move appears similar to the one he made in contacting Padre Manuel de Figueredo at the Jesuit College in Agra, by reaching out to the priests directly, he more determinedly circumvented the French national and colonial governments, including their French proxy in the form of *la Compagnie des Indes Occidentales* (the French East India Company). Ignoring whatever alliance the Jesuits might have had with a European state, he freed himself from the need to establish any sort of diplomatic relationship with France in Europe and its political enclaves in India. In addition, in seeking the answers from the Jesuits themselves, instead of simply naming one as an ambassador to a foreign land, he eliminated—in theory—the delays imposed by long-distance travel between India and Europe.

Similar to the situation in the Portuguese *Estado da Índia*, the territories claimed by France in West Bengal were attended to by competing orders of the Catholic Church. In the

⁷⁵ *Zīj-i Muḥammad Shāhī*, fol. 5r. In fact, although Sawai Jai Singh’s observations contained their own errors, the tables of Philippe de la Hire were almost obsolete because of observational errors made by the astronomer by the time the Maharaja Dhiraja acquired his copy. E.G. Forbes, “The European Astronomical Tradition: its Transmission into India, and its Reception by Sawai Jai Singh II,” *Indian Journal of History of Science* 17, no. 2 (November 1982): 236.

⁷⁶ The French agent Duplessis established the French colony of Chandernagore, a trading post thirty kilometers north of Calcutta in 1673 CE, with permission of the Governor of Bengal, Shaista Khan (r. 1664-1688 CE). Duplessis’ trading post soon foundered, but in 1688 CE, a permanent French factory was built nearby under the grant of a Mughal *farmān*. From this point, the town continued to prosper as a center for merchant trade, and within a decade, France established a garrison at Fort d’Orleans under the supervision of Deslande. As the French increased their involvement in the opium trade, using Bengal as a base for their attempts to expand activity in Southeast Asia, Chandernagore developed into a significant commercial city. By the era of Sawai Jai Singh, Joseph Francis Dupleix (b. 1697-d. 1763), governed the city as the Superintendent of French affairs.

French factory of Chandernagore on the Hooghly River, Jesuits comprised the primary group of clergy, although the city also served as a base for the Tibetan Mission run by the Capuchins.⁷⁷ In the second quarter of the eighteenth century, the local Jesuits were represented by the Fathers Jean François Pons (d. 1752 CE), Superior of the Mission in Bengal from 1728 to 1733 CE, and Claude Stanislaus Boudier (b. 1686-d. 1757 CE).⁷⁸ The two priests were assigned to the same residence as directed by Part VII of the Constitutions of the Society of Jesus, in which it was indicated that “it would be wise when possible not to send one person by himself [on mission], but instead at least two persons, so that they may be of greater aid to one another in spiritual and bodily matters.”⁷⁹ If two individuals were to serve together, care should be taken that they complemented one another emotionally, intellectually, and physically: if one priest was inexperienced, the other should be someone “whom he can imitate, consult, and get advice from in matters where he is uncertain.”⁸⁰ If one was practical, the other should be of a more spiritual bent; if one was young, the other should be old; and so on. While Boudier and Pons were not so far from each other in age, their annual reports, redacted versions of which were later published for European readers, show that their intellectual foci were quite different. Father Pons was a dedicated linguist who, when forced to retire due to old age and exhaustion to the seat of the Mission in Pondicherry, dedicated the remainder of his life to revising his commentaries on

⁷⁷ As a result of an agreement between the French Company of the Indies and Dom Jose Pinheiro, the Bishop of San Thomé, the missions in French India were divided between the Capuchin and Jesuit orders, with the former charged with ministering to European populations, and the later to potential and actual converts among the native population. A branch of the Capuchin Tibetan mission under the Vicar Apostolic at Agra also maintained a foundling hospital in “la loge,” the present-day Quai Dupleix in Chandannagar. A. Lehuraux, “Echoes from Old Chandernagore,” *Bengal, Past & Present; Journal of the Calcutta Historical Society* 2 (1908): 345; Steven Neill, *A History of Christianity in India, 1707-1858* (Cambridge: Cambridge University Press, 2002), 81-82.

⁷⁸ Boudier was born in Sens, France, and left his homeland for Chandernagore in 1718 CE. R.K. Kochhar, “Secondary Tools of Empire: Jesuit Men of science in India,” in *Discoveries, Missionary Expansion and Asian Cultures.*, ed. T.R. de Souza (New Delhi: Concept Publishers, 1994), 179.

⁷⁹ John W. Padberg, ed. *The Constitution of the Society of Jesus and Their Complementary Norms* (St. Louis: The Institute of Jesuit Sources, 1996), 290.

⁸⁰ Ibid.

Sanskrit texts.⁸¹ Father Boudier, on the other hand, preferred to spend as much time with the sciences of the heavens as he did with the lost flocks of India. Even the most cursory examination of Boudier's journals and annual reports suggests that while he might have studied astronomy within the spiritual boundaries of his position as a missionary, he came perilously close to privileging discussions of lunar eclipses over those centered on the redemption of the heathen soul. Descriptions of stellar and planetary observations dominated the letters he addressed to the governing authorities in the French capital at Pondicherry and in Paris, and the bulk of every loose leaf was dedicated to pleas for assistance in acquiring the latest astronomical and geographical texts from Europe.

Du Bois dated his transcription of de la Hire's tables September 10, 1732 CE, but the Maharaja Dhiraja must have taken note of the discrepancies between his observations and the values in the tables long before du Bois had fully completed his translation, because his missive requesting assistance from the priests in Chandernagore arrived in that city some time in 1731 CE. In a letter written to Étienne Souciet (b. 1671-d. 1744 CE),⁸² dated January 19, 1732 CE, Boudier mentioned that he had written previously to Père Jean-Baptiste du Halde (b. 1674-d. 1743 CE) in Paris regarding an invitation extended to him by the King of Amer to visit the Jaipur observatory.⁸³ In addition to the invitation, the Maharaja Dhiraja had included a list of his worries regarding de la Hire's models with the hope that Boudier could clarify a few issues for

⁸¹ Ludo Rocher, *Ezourvedam: A French Veda of the Eighteenth Century* (Amsterdam: John Benjamins Publishing Company, 1984), 76.

⁸² The son of an advocate, Souciet entered the novitiate of the Society of Jesus in Paris in 1690 CE, and was ordained a priest in 1701. From 1702, he was a scribe at Louis-le-Grand, and then served as Professor of Positive Theology from 1716 to 1725. He was responsible for the main library of the college from 1725 to 1740, during which time he collaborated on the *Mémoires de Trevoux*. For a more complete biography, see Carlos Sommervogel, *Bibliothèque de la Compagnie de Jésus*, vol. 7 (Bruxelles: Oscar Schepens, 1896), 1397-404.

⁸³ Claude Boudier, Letter to Étienne Souciet, 19 January 1732, fol. 125v, GBro 088, Fonds Brotier, Les Archives des Jésuites de Paris, Vanves. Jean-Baptiste du Halde entered the Society of Jesus in 1692 CE, and from 1711 to 1743 CE, edited and published the *Lettres Edifiantes*. Although he corresponded with Jesuits working in various parts of the world, he was particularly close to those stationed in China, and was most noted for his publications on Chinese history such as *Description géographique, historique, chronologique, politique, et physique de l'empire de la Chine et de la Tartarie chinoise* (1736 CE).

him.⁸⁴ Reading the list of Sawai Jai Singh's concerns, it is easy to see that he was not interested in re-fashioning his instruments, which in any case would have been impossible, but in discovering the reasoning behind several of de la Hire's conclusions. According to Boudier, Sawai Jai Singh wished to know

- 1st. From where does the difference come that he finds between the longitude of the moon as observed, and the calculation made with the tables of Monsieur de la Hire, which he has translated? This difference is nearly one degree; however, the instruments with which he made his observations are large and exact, and the observations were made with all the necessary care. Does this difference also exist for the meridian line of Paris?
- 2nd. Are there tables that give the motion of the moon perfectly in conformity with observations? If there are, who is the author; and what astronomical assumptions does he follow?
- 3rd. What are the assumptions that Monsieur de la Hire followed, & by which geometrical model did he make his tables of the movements of the moon?
- 4th. In Europe, how is the longitude of the moon observed when it is not on the meridian line, and with what instruments?
- 5th. On what basis did Monsieur de la Hire establish his third equation of the movements of the moon, and how could one reduce this to a hypothesis & calculate it geometrically?⁸⁵

The Maharaja Dhiraja's questions landed in the hands of precisely the right individual, since Boudier was also in the process of constructing a set of astronomical tables based on his observations made in Chandernagore. The priest concurred with Sawai Jai Singh as to the fallibility of de la Hire and attempted to address his worries from a place of mutual understanding. He believed that he had answered the questions as best he could, but confessed to Souciet that

⁸⁴ Boudier forwarded the questions to Father Calmette at the Jesuit mission in Vencatiguiry in the Carnatic, who then forwarded them to Mr. de Cartigny, *intendant général des Armées navales de France*, for his consideration.

⁸⁵ Père Calmette, "Lettre du Père Calmette, Missionnaire de la Compagnie de Jésus, à Monsieur de Cartigny, intendant général des Armées navales de France," in *Lettres Édifiantes et Curieuses, Écrites des Missions Étrangères*, ed. Charles le Gobien, et al. (Paris: J. Merigot je Jeune, 1781), 391-92.

there are some on which I am not well-informed; as it is, in France there are currently better astronomical tables than those of Monsieur de la Hire, and one can find that in Paris, as well as quite often at Amer, the location of the moon based on the tables of Monsieur de la Hire is 45 minutes of a degree different from the location given in these observations.⁸⁶

Boudier did not elaborate on the reasons behind his eagerness to answer the Maharaja Dhiraja's letter, noting only that he wanted to be better informed on such matters, and that he wished Souciet could put him in a position to answer the questions.⁸⁷ Since Boudier's own journals reflect his dedication to observational astronomy, we can probably conclude that there was at least a small amount of self-interest behind his question. He, too, hoped to possess the same level of knowledge exhibited by the ruler of Amer. Other Jesuits, on the other hand, saw in the Maharaja Dhiraja's curiosity an opening to proselytize and conquer yet another kingdom in the name of the Christendom. The opportunity to set up a new mission in Jaipur would help create a dominant Jesuit presence in India. As Father Jean Calmette (b. 1693-d. 1749 CE), who often served as intermediary between Boudier and other Jesuits in Europe, indicated,

Father Boudier, accompanied by another missionary [Pons] who is obliged to leave this Mission because of his foible health, will go to find the Raja, and that after having satisfied him on the subject of astronomy, will examine what advantage religion can draw from the protection of this Raja, and the disposition of his people: because science can be here as it is in China, one of the principal instruments of which serves God in the edification of his church... If this opening gave a place for the establishment of a Mission, we would have to some extent blockaded India since, if while we advance towards north from the Cape of Comorin, the Missionaries of Bengal gaining the south come to join us, we would form a Mission of five hundred leagues in extent. Such is the vine that God gives us to cultivate.⁸⁸

In Boudier's correspondence, there was no suggestion that his relocation to Jaipur was anything but temporary. He seemed eager to meet another individual that he considered "more clever" in

⁸⁶ Boudier, Letter to Étienne Souciet, fol. 125v.

⁸⁷ Ibid.

⁸⁸ Calmette, 393-94.

the field of astronomy than he, particularly since his repeated pleas to receive more manuscripts and observations from his European contacts seemed to fall on deaf ears, but he made no explicit statement about leaving the mission of Chandernagore for good.⁸⁹ Père Calmette's proposal, however, makes quite clear that he hoped to establish a permanent mission in Jaipur to advance the Christian cause in general, and the Jesuit cause in specific. His words make apparent that Father Pons, at the very least, would not be returning to Chandernagore because of his poor health. This willingness on the part of the Society of Jesus to place missionaries in the city for the duration aligned perfectly with Sawai Jai Singh's understanding of the form an intellectual community should take, and should Boudier or Pons choose to reside in Jaipur, even with the primary goal of proselytizing, the Maharaja Dhiraja probably would have been happy to receive them and assist them in establishing a more permanent situation in his capital city.

If Sawai Jai Singh thought that restricting his queries to several questions, or asking Boudier and Pons to travel only within the subcontinent rather than to France to discuss the matter in person, would speed things up in comparison to what he experienced with Figueredo's overseas voyage to Lisbon, he was sorely mistaken. To begin with, even more than his negotiations with Figueredo, his communications with the priests at Chandernagore were affected by the Jesuit rule and its guidelines for appropriate letter writing. The parameters and conventions of acceptable correspondence had been determined long before Boudier and Pons arrived in India, having been laid down by the central authority of the Society in the second-half

⁸⁹ Claude Boudier, Letter to Étienne Souciet, 1734, fol. 133r, GBro 088, Fonds Brotier, Les Archives des Jésuites de Paris, Vanves. Boudier repeatedly begged Souciet to confer with the Masters of the Academy, and to send to him select transcriptions from the Memoirs of the Academy relevant to the topic at hand. He wished to obtain a copy of Manfredi's method for projecting solar eclipses, as well as Delisle's brief on the use of the gnomon. When eventually he did receive information about the recent work of Cassini and Godin, it was too late to help in his discussions with Sawai Jai Singh, arriving late to Boudier's hands because of travel delays and sickness. See Boudier, Letter to Étienne Souciet, fol. 143.

of the sixteenth century.⁹⁰ Although missionaries were free to write more frequently, the Society operated on the assumption that full reportage by the priests would occur only once a year, a situation that necessarily slowed the speed of intercontinental communications. Additionally, a significant portion of the letters were meant to be “edifying,” either to other Jesuits on mission, or to the layperson when the letters were printed for public consumption in collections such as *Lettres Édifiantes et Curieuses, écrites des Missions Étrangères par quelques Missionnaires de la Compagnie de Jesus* or the *Journal de Trevoux*. Delays and losses were apparently expected by the Jesuits, but it is obvious from the tone used by some of the letter writers that these occurrences frustrated for the missionaries. This is particularly true of those priests trying to hold intercontinental discussions on the topic of astronomy and mathematics. Restricted to the rhythm of annual exchanges of information, scientific information could not travel rapidly from center to periphery, particularly if a third party was involved in the transaction.⁹¹ While the subjects of astronomy and mathematics might seem eternal, in fact, both were time sensitive; if observations and calculations exchanged among multiple people contained errors, those same errors were carried through an entire year’s work if corrections were not made in a timely

⁹⁰ John Correia-Afonso, *Jesuit Letters and Indian History: A Study of the Nature of the Jesuit Letters from India (1542-1773) and of their Value for Indian Historiography* (Bombay: Indian Historical Research Institute, 1955); Županov, 9-16.

⁹¹ This struggle is nowhere more evident than the discussions Boudier and Antoine Gaubil (b. 1689-d. 1759 CE), a Jesuit priest on mission to China, attempted to hold on astronomy via their central contacts in Paris. Father Antoine Gaubil arrived in China in June 1722 CE. Although charged with heading the school of Latin in the city, he spent the better part of his years making geographical and astronomical observations, and carrying on extensive correspondence with scholars in France, included Féret, Delisle, and du Halde. During the same time period in which Sawai Jai Singh was soliciting advice from Boudier, the astronomer-priest was also soliciting advice from Gaubil. As early as 1731 CE, Boudier sent transcriptions of his observations to Souciet in Paris and Gaubil in Beijing. In a letter written to Delisle in July 1734 CE, Gaubil mentioned that he had “good friends” on mission in French East India, many of whom “work in their spare time to observe.” He made special note of Boudier at Chandernagore, mentioning his attempts to determine the diameter of the sun and the obliquity of the ecliptic, amongst other astronomical tasks. He had already received many of Boudier’s observations, sent directly from India by ship rather than via Souciet. A year later, Gaubil was lamenting the fact that although he had received Boudier’s observations, and had amply responded to them, he had received no further aid from Europe on the subject. Like Boudier, he was quite afflicted to not have received further assistance from his European counterparts. See Antoine Gaubil and Renée Simon, *Correspondance de Pékin 1722-1759* (Genève: Librairie Droz, 1970), 372, 427.

fashion. This truth could have had particularly bad consequences for someone in Sawai Jai Singh's situation. Holding a flawed data set, with no hope of receiving reliable corrections any time soon, he had a choice between waiting for advice or pressing on with the risk that the *Zīj-i Muḥammad Shāhī* would be worthless. The periods of waiting for information to travel from abroad also contradicted his personal experience of having a hand-chosen group of individuals on hand for immediate consultation. The repeated interruptions and the long passages of time between questions and answers must have been nearly incomprehensible to someone in the Maharaja Dhiraja's position.

In addition to the constraints imposed by the mode of letter writing employed by the Jesuits, the lethargic rate of travel endured by Fathers Pons and Boudier further frustrated Sawai Jai Singh's attempts to quickly resolve his issues. From the arrival of the questions in Chandernagore to the departure of Boudier and Pons from that city for Jaipur took at least two years, hardly a time savings when compared to the journey to Portugal undertaken by Figueredo.⁹² The trip from west Bengal to the Mughal capital of Shahjahanabad, where the Fathers paused for several weeks before backtracking to Jaipur, required a passage of some five months. The journey was arduous, and even life-threatening for the priests. During their travels,

⁹² Boudier, who had been planning a trip to Pondicherry, left for Amer in a rush, scarcely taking the time to inform Étienne Souciet of his departure. He originally intended to start for Jaipur at the end of March of the previous year (1733 CE), but was delayed for some unspecified reason. It is quite possible that he dallied in Chandernagore hoping to receive an answer to the Sawai Jai Singh's questions from Father Calmette or Souciet. The departure of the priests from Chandernagore has been attributed to a local dispute between the Council of Chandernagore and the local Jesuits in 1731 CE. The Council favored a new appointment for French Capuchins under their own Prefect Apostolic at Pondicherry, while the Jesuits already residing in Chandernagore felt the authority should be remain in the hands of the Provisieur (Superior General) of the Diocese of San Thomé at Golgotha (Hooghly). They refused to follow the Council's directive to designate the Chapel of Fort d'Orleans as the parish church, and as a result of this resistance, the Jesuit Fathers Boudier and Pons were dismissed from their posts (*chassés de la loge*). A Capuchin priest by name of Dom Albert Saldeim temporarily replaced them as Almoner. It would appear that the Jesuits were quickly reinstated in their posts, as Boudier fails to mention the controversy in his letters to Etienne Souciet. While the disagreement may have made the Fathers Boudier and Pons wish they could pack up and leave town, since they remained in residence until 1734 CE, it seems unlikely the tensions between the Capuchins and Jesuit orders had much to do with their eventual departure for Jaipur. See Lehuraux, 345; Boudier, Letter to Étienne Souciet, fol. 125r-26v; Claude Boudier, Letter to Étienne Souciet, 1733, fol. 133r, GBro 088, Fonds Brotier, Les Archives des Jésuites de Paris, Vanves.

the priests made certain “geographical observations” that were later deemed inadequate by colleagues, but as it was reported in the *Lettres Édifiantes*, “this is all that they [Fathers Boudier and Pons] were permitted to do on this type of uncomfortable trip in this country, especially when one needed to make it by land, and with their poor health, both had thought that before returning they would die of disease caused by the hardships and the bad water that one is forced to drink along the way.”⁹³

That Boudier and Pons were willing to undertake such a hazardous expedition at all demonstrates something of the high regard in which they held the Maharaja Dhiraja of Jaipur at the time. The Jesuits assigned a certain amount of power to Sawai Jai Singh, believing at the outset of their journey that the Rajput

is the most powerful, or at least one of the most powerful, Rajas of India, and one who has no other dependencies of the great Mogol than to provide a number of troops each year, in addition to the quite large lands of which he is the king, of whose capital is roughly about one degree further south than Dely and 3 or 4 degrees to the west. He has a great deal of authority throughout the Mogol Empire, and is much more part of the government than the Great Mogol himself.⁹⁴

Not only did they consider him powerful enough to sustain his own position within the government and strong enough to secure the boundaries of his own kingdom, they believed his name and reputation to be great enough to protect them on the precarious journey west. In fact, they faithfully relied on his reputation to keep them safe, reporting that

the passport we have, which is absolutely necessary in this country, otherwise we would be stopped almost at every step by the customs here called “chowkis,” is in the name of the Raja, otherwise we have about 300 leagues of country to cross which are dependent

⁹³ Claude Boudier, “Observations Géographiques faites en 1734 par des Peres Jésuites, pendant leur voyage de Chandernagor à Dely & à Jaëpour,” in *Lettres Édifiantes et curieuses, écrites des missions étrangères*, ed. Charles le Gobien, et al. (Paris: J. Merigot je Jeune, 1781), 338.

⁹⁴ Boudier, Letter to Étienne Souciet, fol. 133r.

on the Mogol. And if I am not mistaken, the passport will be more respected than if it was issued by the emperor himself.⁹⁵

They attributed the security of their transportation corridors to Sawai Jai Singh, not to Muhammad Shah, so it would seem that the entire trip could be styled as a large-scale demonstration of the Maharaja Dhiraja's ability to govern from afar in the manner of an imperial power.

Boudier and Pons departed Chandernagore on January 6, 1734 CE, traveling up the Hooghly as far as Cassimbazar (Cossimbazar) by water (map 4.3, table 4.1).⁹⁶ At that point, the Fathers largely abandoned boat travel and proceeded to Shahjahanabad overland by oxen cart.⁹⁷ They followed a riverine route, cleaving tightly to the south (left) bank of the Ganges, since straying far from the river to the north or south would have doomed them to a struggle against the worst of nature and humanity.⁹⁸ Between Cassimbazar and Patna, the Fathers seldom strayed more than a few leagues in south of the Ganges.⁹⁹ From Patna, the group diverted south to follow the route established by Sher Shah Suri, temporarily leaving the alluvial plain of the Ganges for that of the Son River.¹⁰⁰ Three weeks after leaving Patna, the Fathers arrived in

⁹⁵ Ibid., fol. 133v.

⁹⁶ Boudier was not able to measure the latitude and longitude of any of the towns between Chandernagore and Cassimbazar as the journey was taken by boat and "the winding path of the Ganges would demand that one use a great deal of time to make a correct estimation; then, too, we traveled several times by night." ———, "Observations Géographiques faites en 1734 par des Peres Jésuites, pendant leur voyage de Chandernagor à Dely & à Jaëpour," 342; Claude Boudier, *Quelques observations qu'on a faites pendant la voyage d'Amber*, 2 Feb 1734, fol. 31r-32r, GBro 078, Fonds Brotier, Les Archives des Jésuites de Paris Vanves.

⁹⁷ Deloche, 241.

⁹⁸ Ibid., 39. To the south of the Gangetic plain ranged the backbone of the Choṭā Nāgpur, a wilderness mountain chain populated by independent and allegedly hostile tribes. The continual interruption of the northern (right) bank of the river by effluvial drainage systems made necessary constant detours in search of fords for anyone attempting to travel west by that path. All things considered, a route that cleaved closely to the left bank was the most efficient and most secure.

⁹⁹ This was the route preferred by the Mughals until the middle of the eighteenth century. In 1757 CE, the East India Company initiated a survey of the Choṭā Nāgpur jungles to establish a more direct route between Bengal and Bihar. This "New Military Road," on which construction began in 1781 CE, followed a course that seldom overlapped with previously established roads. The present route of the Grand Trunk Road between the Hooghly ports and Varanasi was proposed in 1831 CE under Lord Bentinck, and completed in 1838. Ibid., 43-44.

¹⁰⁰ Ibid., 38.

Benares (Varanasi), and seventeen days later, they reached Agra. Not surprisingly, the priests made an extended stop in Agra, the home of the Jesuit College, before proceeding up the Yamuna River to the palace of the Mughal emperor in Shahjahanabad. The priests remained in Delhi for approximately six weeks, during which time Boudier took advantage of the proximity of Sawai Jai Singh's observatory to the city walls, using the *Ṣaṣṭamśa Yantra* to continue observations of the sun and the several stars he had been tracking since Cassimbasar.¹⁰¹

After retiring from Delhi, Pons and Boudier retraced their steps as far south as Mathura before veering to the west to travel to Jaipur via Dig. Seven months after they took leave of their residence in Chandernagore, the pair arrived in Jaipur during the first fortnight of July 1734 CE. Upon their arrival, the priests were unable to speak with the Maharaja Dhiraja as he was not then in residence, but at an encampment outside the city where he was discussing military strategy with other Rajput rulers.¹⁰² When Sawai Jai Singh did return to his palace, the priests were forced to wait an additional fifteen days before obtaining a proper audience with him, as the king had taken a three-week vow of silence as part of his preparation for the performance of the *Aśvamdeh Yajana*, or Horse Sacrifice.¹⁰³ Neither Boudier nor Pons provided a full accounting of their conversations with the Maharaja Dhiraja, but it would appear that they failed to engage him

¹⁰¹ Boudier, *Quelques observations qu'on a faites pendant la voyage d'Amber*, fol. 32r; Claude Boudier, *Les observations faites en 1733, 1734, et 1735*, fol. 24v, GBro 078, Fonds Brotier, Les Archives des Jésuites de Paris Vanves; Boudier, "Observations Géographiques faites en 1734 par des Peres Jésuites, pendant leur voyage de Chandernagor à Dely & à Jaëpour," 350-54.

¹⁰² Boudier, Letter to Étienne Souciet, fol. 143v. Sawai Jai Singh was probably attending the Hurda (Hurra) conference, which took place on July 16, 1734 CE about 36 miles SSE of Ajmer. Several Rajput rulers, including the Maharana Jagat Singh, Maharaja Abhai Singh, Maharao Durjansal of Kota, and Rajadhiraja Bakht Singh, gathered soon after the fall of Malwa to the Marathas to discuss possible ways to keep Rajputana from suffering the same fate. See Bhatnagar, 222-24.

¹⁰³ Boudier, Letter to Étienne Souciet, fol. 143v. Revivified under Sawai Jai Singh, the horse sacrifice was meant to symbolize and ensure the dominant position of a king over his own kingdom as well as over neighboring kingdoms. The rituals associated with the horse sacrifice were numerous and complicated. In essence, the sacrificial horse was prepared by priests, and then released from captivity for a year. Throughout the year, certain offerings were made to the appropriate deities, oblations were performed, and ballads were spoken before the king. At the end of a full year, the horse was recaptured, prepared in accordance with the rules of the sacrifice, and sacrificed in the presence of the king's wives. For a more detailed description of the elements of the sacrifice, see G. P. Pilania, *Enlightened Government in Modern India: Heritage of Sawai Jai Singh* (Jaipur: Aalekh Publishers, 2002), 247-52.

in an extended discussion about observatories or ephemerides, even though they took advantage of the instruments in the observatory to add to their chart of observations.¹⁰⁴

If we take Claude Boudier at his word, he contributed little to, and gained little from, the work being conducted at the observatory in Jaipur and Delhi.¹⁰⁵ Boudier indicated that the Maharaja Dhiraja “kept many astronomers who observed day and night without interruption, at different observatories beautifully built at his expense, especially in Delhi, a large suburb dependent on him, called ‘Jaisinghpura’ for this reason.”¹⁰⁶ Yet, once arrived in Jaipur, they found little to discuss with the astronomer-king, a development they attributed to his superstitious adherence to Hindu tradition, but was more likely related to Sawai Jai Singh’s understandable distraction by the Maratha-Mughal conflict in Malwa. Where Boudier and Pons saw the performance of the *Āśvamdeh Yajana* as a pointless performance of a shallow superstition, other Rajput leaders read it as a symbol of power produced in the face of a potential invasion of the desert kingdoms by the Maratha confederacy. Sawai Jai Singh’s duties to the Mughal emperor and his Rajput allies necessarily eclipsed his interest in astronomy at the time of the Jesuits’ visit. From the point of view of the priests, the king’s indifference to their mission pre-empted any attempt to set up a permanent residence in the city. Moreover, they believed that “the commitment that this prince [Sawai Jai Singh] has to paganism does not allow us to have any hope for religion,” so in terms of conversion to Christianity, there was no reason to let dust gather on their feet in Jaipur.¹⁰⁷ Boudier merely noted that, since the Maharaja Dhiraja apparently cared more for the arrangements for the *Āśvamdeh Yajana* than he did in meeting

¹⁰⁴ Boudier, “Observations Géographiques faites en 1734 par des Peres Jésuites, pendant leur voyage de Chandernagor à Dely & à Jaëpour,” 352.

¹⁰⁵ Although Fathers Boudier and Pons passed through both Mathura and Benares (and, in fact, paused two nights in Benares), there is no evidence that they visited the observatories in these towns.

¹⁰⁶ Boudier, “Observations Géographiques faites en 1734 par des Peres Jésuites, pendant leur voyage de Chandernagor à Dely & à Jaëpour,” 337.

¹⁰⁷ ———, Letter to Étienne Souciet, fol. 143v.

with the travelers from Chandernagore, they departed the city on September 17, 1734 CE, despite the fact that Father Pons had a fever.¹⁰⁸

Boudier seems confident in his assessment of Sawai Jai Singh's character and intellectual interests. He was dismayed and even disgusted by Sawai Jai Singh's loyalty to heathen superstitions and saw no reason to linger at the court, even though his superiors had hoped to establish a Mission in the city. In Boudier's mind, Jaipur was no longer considered fertile ground for astronomy or Christianity, so there was little need for the Society of Jesus to prolong diplomatic communications with the Maharaja Dhiraja. However, this dismissive attitude is difficult to reconcile with the favorable reception with which Sawai Jai Singh's next proposal was met by the Society of Jesus, suggesting that not all of his colleagues agreed with his opinion. Once freed from the obligations of mediating the Mughal-Maratha conflict over Malwa, the Maharaja Dhiraja returned to the task of deciphering the mysteries of de la Hire's logarithmic tables, and by March 1737 CE, he was once again in contact with the Society of Jesus.

4.7 The Mathematical Fathers of Bavaria

From 1737 until the year of his death, 1743 CE, Sawai Jai Singh lived mostly in Jaipur, traveling only infrequently to address a few lingering issues in his government of Agra and Malwa.¹⁰⁹ Withdrawing from the politics of the court of Muhammad Shah in the post-Nadir Shah era, the Maharaja Dhiraja was apparently free to return to the problem of producing a new *zīj*. In spite of Boudier's assertion that Sawai Jai Singh had little interest in the sciences, the king

¹⁰⁸ Ibid; Calmette, 394. Boudier traveled as far as Agra before falling desperately ill with the bloody flux for three months, interrupting his communications with his fellow Jesuits for two years. He also indicated that while he was absent from Chandernagore for a total of fifteen months, he spent only two months plus several additional days in Sawai Jaipur.

¹⁰⁹ The Mughals ceded Malwa to the Marathas in 1737 CE, and Sawai Jai Singh was relieved of the governorship of Malwa and Agra in August of that same year. Bhatnagar, 256.

renewed his efforts in the last years of his life to relocate permanently a European astronomer to his court. Using Pedro da Silva as a go-between, he convinced the Viceroy of the Portuguese State of India, the Conde de Sandomil, to help procure a mathematician.¹¹⁰ Specifically, he requested Figueredo to make a second trip to Jaipur in the company of a Jesuit mathematician. However, despite his repeated requests, Figueredo remained in Goa; in his place, the Conde de Sandomil proposed another Jesuit, Father Anton Gabelsperger (d. March 9, 1741 CE), a missionary originally from Bavaria.¹¹¹ Already resident in Goa, Gabelsperger agreed to travel to Jaipur and establish a Christian mission in the new capital city of the “heathen king.”¹¹²

The tale of Gabelsperger’s attempts to move house to Jaipur should sound somewhat familiar by this point. Despite the Jesuit’s readiness to undertake a new assignment, he was unable to depart Goa as quickly as Sawai Jai Singh would have liked. For one thing, the timing of the Maharaja Dhiraja’s request put him in direct conflict with the *cāturamāsa*. On May 20, 1737 CE, the Conde de Sandomil informed Sawai Jai Singh and Pedro de Silva under separate cover that the “Padre Mathematico” had been delayed in Goa because of the winter, but once the weather improved at the end of October, he would resume his trip to Surat.¹¹³ In addition to this difficulty, which surely should have been expected by Sawai Jai Singh, the departure was hindered by the same Society rule of companionship that had governed the French priests in Chandernagore. Gabelsperger was forced to linger in Goa while waiting for arrival of his partner

¹¹⁰ “Para o Raja Savae Iae Singa,” in *Arquivo Portugues Oriental*, ed. A. B. de Braganca Pereira (Bastora: Rangel, 1936-40), 38; “Padre Pedro da Silua assistente ao Raja Savae Iae Singa,” in *Arquivo Portugues Oriental*, ed. A. B. de Braganca Pereira (Bastora: Rangel, 1936-40), 38-39.

¹¹¹ “Para o Raja Savae Iae Singa,” 38; “Padre Pedro da Silua assistente ao Raja Savae Iae Singa,” 38-39; “Ao muito Illustre Rajá,” in *Arquivo Portugues Oriental*, ed. A. B. de Braganca Pereira (Bastora: Rangel, 1936-40), 123-24; “Para o Visitador da Companhia Brolhas Antonio Brandolini,” in *Arquivo Portugues Oriental*, ed. A. B. de Braganca Pereira (Bastora: Rangel, 1936-40), 217. The Viceroy viewed a possible journey by Manuel Figueredo favorably, but a lingering illness prevented Figueredo from making a second trip to Jaipur.

¹¹² Andreas Strobl, “Letter No. 643,” in *Der Neue Weltbott mit allerhand Nachrichten dern Missionariorum Societatis Jesu*, ed. Joseph Stocklein (Augsburg: 1726), 9.

¹¹³ “Para o Raja Savae Iae Singa,” 38; “Padre Pedro da Silua assistente ao Raja Savae Iae Singa,” 38-39.

and junior, Father Andreas Strobl (d. 1758 CE), so that they could travel and live as a duo, in accordance with the Constitutions.¹¹⁴ Father Strobl did not disembark in Goa until September 30, 1737 CE, so regardless of any promises made by the Viceroy, the trip north could not have commenced until the end of that same year, simply because Strobl had yet to reach India.¹¹⁵ In truth, even had Strobl's ship made port a few months earlier, the Jesuits would have failed to progress in their push toward Jaipur.¹¹⁶ In July 1737 CE, the Conde de Sandomil sent a second letter to the Maharaja Dhiraja, blaming further delays on the continuing war between the Portuguese government in Goa with the Marathas. What once had been a fairly secure sailing route between Goa and Surat resembled a shooting gallery during the four-year conflict, as the Marathas claimed one island enclave after another, and the Viceroy, dangling the Jesuits in front of him as an incentive, wished Sawai Jai Singh would be so generous as to mediate the conflict.¹¹⁷ The Maharaja Dhiraja declined. The end result of the disagreement between the Maratha Confederacy and the *Estado da Índia* was that Strobl and Gabelsperger did not depart Goa for Jaipur for a full thirteen months, making time elapsed between request and fulfillment comparable to that which Sawai Jai Singh had endured during his relations with Fathers Figueredo and Boudier.¹¹⁸

In August 1738 CE, the Conde de Sandomil sent a notice to Pedro da Silva that he had received word that the Brahmin, who had been dispatched by Sawai Jai Singh to meet the Mathematical Fathers in Surat, was waiting for them in the city, but that they had not yet departed Goa. The Brahmin was demanding recompense, but since it was impossible for the

¹¹⁴ Strobl, 9.

¹¹⁵ P. S. Pissurlencar, *Antigualhas: Estudos e Documentos sobre a Historia dos Portugueses na India*, vol. I, Fasc. I (Bastora: Tipographia Rangel, 1941), 43.

¹¹⁶ Strobl, 10.

¹¹⁷ "Ao muito Illustre Rajá," 123-24.

¹¹⁸ Strobl, 10.

entourage to depart for Surat before October, there was no way for the Jesuits to meet his needs.¹¹⁹ The implication was that the priests needed to wait until the end of monsoon, but in fact, the journey northward was put on hold for yet another reason: financing. The unexpectedly long residence of the priests in Goa due to the Maratha conflict had put a strain on their budget, and the Viceroy was not willing to commit state resources to fund an expedition that fell under the governance of the Society of Jesus.¹²⁰ In September 1738 CE the Conde de Sandomil contacted the Visitor of the Jesuits, Father Brolhas Antonio Brandolini, requesting he make provisions for Gabelsperger and Strobl.¹²¹ The Visitor agreed that the group should not be allowed to leave until the matter of their expenses for the trip from Goa to Jaipur, as well as their account due for their extended stay at the Viceregal court in Goa, had been settled.¹²² Finally, on October 24, 1738 CE, the Conde de Sandomil informed Moizes Tobias, the Director of the Portuguese State in Surat, that Strobl and Gabelsperger were on their way to his city and would be bunking with the French Jesuits at that location.¹²³

Not surprisingly, given the on-going state of the war between Portugal and the Maratha Confederacy, the passage taken by Strobl and Gabelsperger from Goa to Surat was disrupted by “pagan enemies,” forcing their small fleet to put in at Chaul for a few days before unsuccessfully seeking refuge at Damon. Under constant threat of attack, the ship arrived at Surat on December

¹¹⁹ “Para Pedro la Silva Leitão em Jaepor corte do Raja Sawai Iaceng,” in *Arquivo Portugues Oriental*, ed. A. B. de Braganca Pereira (Bastora: Rangel, 1936-40), 213.

¹²⁰ While relations between the Viceregal court in Goa and the Jesuits were generally cordial, as the eighteenth century progressed, Jesuit prosperity was viewed with more and more suspicion. In the 1740s, the province of Goa experienced its first true shortfall in revenue, a development that occurred in marked contrast to the continued state of affluence of the Society of Jesus. Alden, 582-83.

¹²¹ The Visitor was appointed by the Superior General of the Society of Jesus as an attempt to mitigate the influence of the Portuguese crown on Jesuit missionaries residing in Portuguese enclaves. He was charged with visiting each college and residence in India and reporting on its material and spiritual well-being. *Ibid.*, 247; Charles J. Borges, *The Economics of the Goa Jesuits, 1542-1759: An Explanation of their Rise and Fall* (New Delhi: Concept Publishing, 1994), 156.

¹²² “Para o Visitador da Companhia Brolhas Antonio Brandolini,” 217-18.

¹²³ “Para Moizes Tobias Director da nação Portugueza em Surrate,” in *Arquivo Portugues Oriental*, ed. A. B. de Braganca Pereira (Bastora: Rangel, 1936-40), 236. According to Father Strobl, they stayed with French Capuchins who received them with “incredible love.” Strobl, 10.

5, 1738 CE.¹²⁴ After this, the team experienced an additional six month delay in Surat, waiting out the devastating effects of Nadir Shah's invasion of northern India.¹²⁵ Sawai Jai Singh's Brahmin messenger reappeared in Surat with a gift of a thousand rupees to support the fathers during the last leg of their journey, but even with these funds at the ready, Strobl and Gabelsperger were able to leave Surat only on November 19, 1739 CE.¹²⁶ The trip to the northwest was more hazardous than the one Pons and Boudier's journey from Chandernagore to Jaipur: while the French priests had complained of contaminated water, the Bavarians found their ox carts harassed by highway robbers armed with arrows.¹²⁷ In addition, the Bavarians were treated poorly by customs officials whereas Boudier and Pons were awarded free passage based on the passports that had been issued by Sawai Jai Singh.¹²⁸

At long last, on March 4, 1740 CE, the Mathematical Fathers met with the Maharaja Dhiraja of Jaipur, a good three years after the invitation to Figueredo had been issued by the king. Immediately upon their arrival, semi-permanent lodgings were arranged for the priests in Jaipur. Father Strobl found Sawai Jai Singh to be pleasant and generous, welcoming the pair into a well-furnished apartment complete with European-style chairs and access to ice.¹²⁹ The Maharaja Dhiraja set them up with a cart and a string of two oxen, managed by a coachman appointed from the court's staff. He provided them with five rupees per day and ensured that goats were regularly slaughtered for their meals, a practice which was otherwise prohibited in the city.¹³⁰ When Father Gabelsperger fell ill with a cough, the king regularly sent a court servant to

¹²⁴ Strobl, 10.

¹²⁵ Ibid., 11.

¹²⁶ Ibid., 10. Strobl believed that the Brahmin sent by Sawai Jai Singh to escort them to Jaipur deliberately dallied in Surat so they would be delayed further by the monsoon season.

¹²⁷ Ibid., 12.

¹²⁸ Ibid., 11.

¹²⁹ Ibid., 12.

¹³⁰ Ibid.

check on his welfare, even in the deep of night.¹³¹ Overall, Sawai Jai Singh seemed quite pleased to have arranged for the Jesuits' presence in his court. Strobl considered the Maharaja Dhiraja to be a particular lover of mathematical objects and a generous benefactor who had no qualms about spending tremendous sums of money in his scientific pursuit. While the priest noted that Sawai Jai Singh gave away a lot of money to questionable charitable causes—more than twenty-five thousand rupees went toward a wedding feast, two million silver coins sponsored a ritual slaughter of animals, a hundred thousand rupees was delivered to local “idol-priests”—he also reported the Maharaja Dhiraja's investment in the construction of a perpetual motion machine, a total of some fifty thousand guilders.¹³² On his part, the Maharaja Dhiraja hoarded Strobl's talents, refusing to let him travel to the court of Muhammad Shah in spite of the emperor's repeated requests that he do so.¹³³

It must have seemed to Sawai Jai Singh that he had finally found a solution to his problems. He had enticed a pair of Europeans who were educated in mathematics to visit his city, and unlike Claude Boudier, who saw no point in establishing a Mission in Jaipur, these priests appeared willing to be folded into the his own collection of scholars, at least initially. While Strobl described the Maharaja Dhiraja as an intellectual to be respected, he simultaneously considered him a very unlikely candidate for conversion to Catholicism and much too comfortable with superstition. Much to the priest's dismay, the king

hangs entirely on the word of the people, and he dwells in almost servile subjection to the same, and they pull and lead him wherever they like. If God does not illuminate this otherwise well-mannered prince with an extraordinary ray of heavenly light, I fear that he will remain in darkness of his idolatry to the end of life.¹³⁴

¹³¹ Ibid.

¹³² Ibid., 14; Andreas Strobl, “Letter No. 644,” in *Der Neue Weltbott mit allerhand Nachrichten dern Missionariorum Societatis Jesu*, ed. Joseph Stocklein (Augsburg: 1726), 15.

¹³³ Strobl, “Letter No. 643,” 14.

¹³⁴ Ibid.

Even worse, Sawai Jai Singh's astronomers (*Sternsehers*) appeared to be as superstitious and corrupt as any other individual the priests had met in India. These astronomers took advantage of "the credulous people through their feigned Repentance-work, worship, and hypocrisy to build a grand reputation."¹³⁵ Strobl gave the example of a dishonest Brahmin astronomer who worked and resided in the one of the instruments at the observatory (*Stern-Seh-Thurm*, probably the Samrāt Yantra). This particular astronomer claimed he could demonstrate his spiritual purity by fasting while hanging by his feet from a gallows. The Brahmin appeared to endure this torture for a full nine days in the *Stern-Seh-Thurm*, at which point it was discovered he had been sleeping comfortably on his blanket instead of dangling above the ground.¹³⁶ Strobl's letters to his Jesuit brothers were filled with such examples, demonstrating that "among those astonishing penitence-works of pagan penitents often lies hidden a fraud and hypocrite."¹³⁷ That Sawai Jai Singh tolerated this behavior in his kingdom both puzzled and relieved the priests. On the one hand, the Maharaja Dhiraja was "a zealous servant of the Idols," and set a poor example for his subjects in his worship by following the spiritual advice of the deceitful *pandits* in their temples. On the other hand, the king was a man who would "worship with profound reverence, also publicly, the image of our Saviour," and leave five gold coins on the altar while paying his respects during the Feast of the Ascension.¹³⁸ He expressed no prejudices against Christianity, and in fact, encouraged the priests to worship as they wished, offering no interference. In the end, however, Father Strobl was forced to admit that for all of the Maharaja Dhiraja's financial support, attempts at conversion would always come to nothing. Ultimately, the priests concluded

¹³⁵ Ibid., 13.

¹³⁶ Ibid.

¹³⁷ Ibid.

¹³⁸ Ibid., 14.

that “all his affection for us and our teaching is just a sign of appreciation of other things, not a desire for those same things, and it is after, as before our arrival, entirely for his idols, to whose service he wastes incredible sums of money.”¹³⁹

Despite reaching this disappointing conclusion, Father Strobl seemed willing to remain in Jaipur for an extended period of time, even after his companion, Father Gabelsperger, died of his cough March 9, 1741 CE, leaving him alone with the mission.¹⁴⁰ Allegedly, Gabelsperger’s death, along with a sudden breakout of war, prevented the Maharaja Dhiraja from taking a new step in his outreach program, that of sending the two Bavarian priests laden with gifts to Rome, “to establish friendship and to show them admiration.”¹⁴¹ By 1742 CE, Strobl could claim only forty conversions, a development he attributed at least in part to the demands made on him as a servant of the court of Jaipur. However, even though his carefully sewn seeds came to fruition “late and sparingly,” he made no gesture toward abandoning his post in Jaipur.¹⁴² In fact, he remained in the city long enough to witness the drama of Sawai Jai Singh’s funeral pyre after his death on October 2, 1743 CE (Asoj Sūdi 14 VS 1800), and to assess the intellectual qualities of his successor, Ishvari Singh.¹⁴³ Altogether, Strobl dedicated three years of his life to the Maharaja Dhiraja of Jaipur, remaining in Jaipur long enough to participate fully in the intellectual life of the court and observatory.

¹³⁹ Ibid.

¹⁴⁰ Ibid.

¹⁴¹ Ibid.

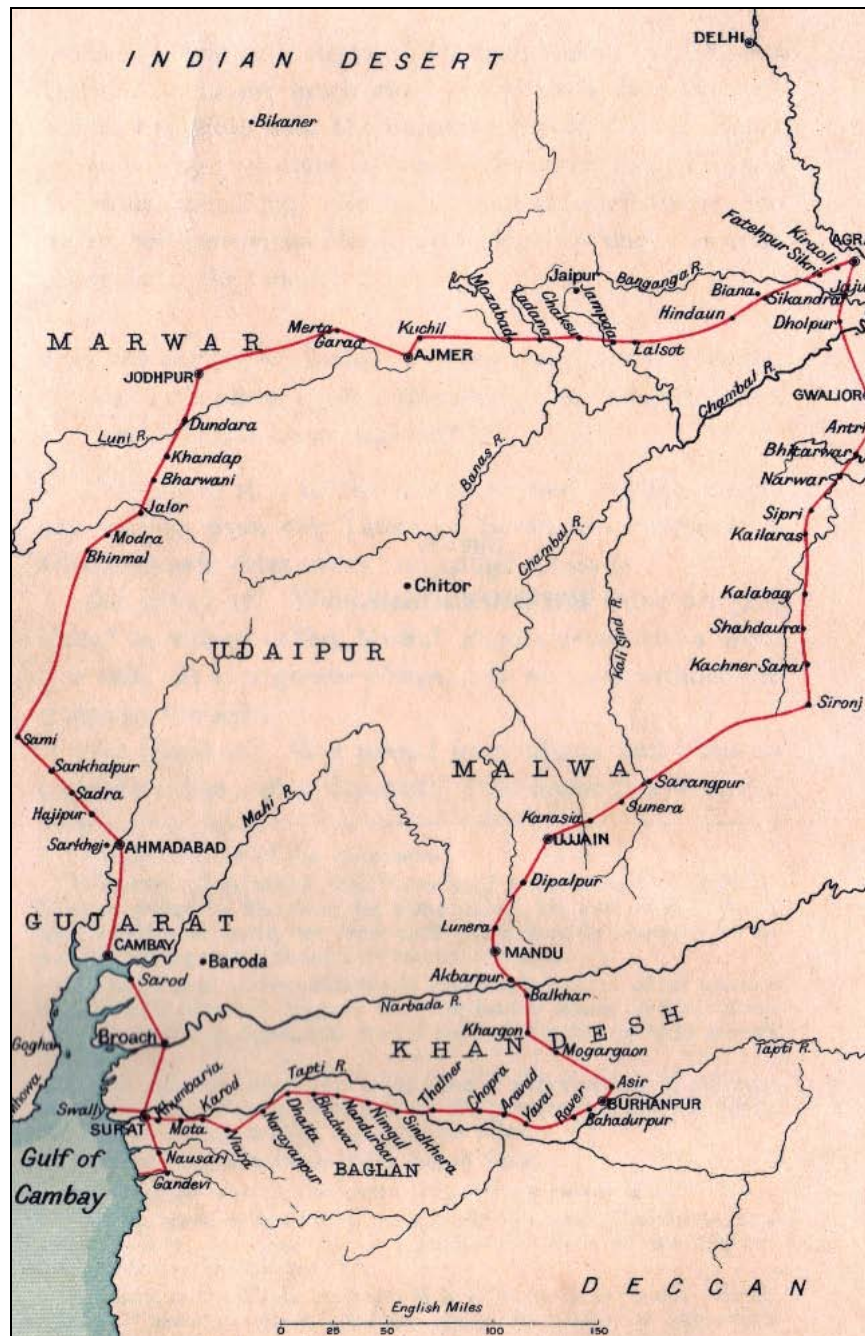
¹⁴² Ibid.

¹⁴³ Strobl’s first audience with the new Maharaja left him in doubt as to his future in Jaipur, but during his second audience, twelve days later, Ishvari Singh showed him great mercy, and promised that the Treasury would take care of his needs, as well as the needs of his church, in accordance with the custom established by the recently passed Sawai Jai Singh. ———, “Letter No. 644,” 15-17.

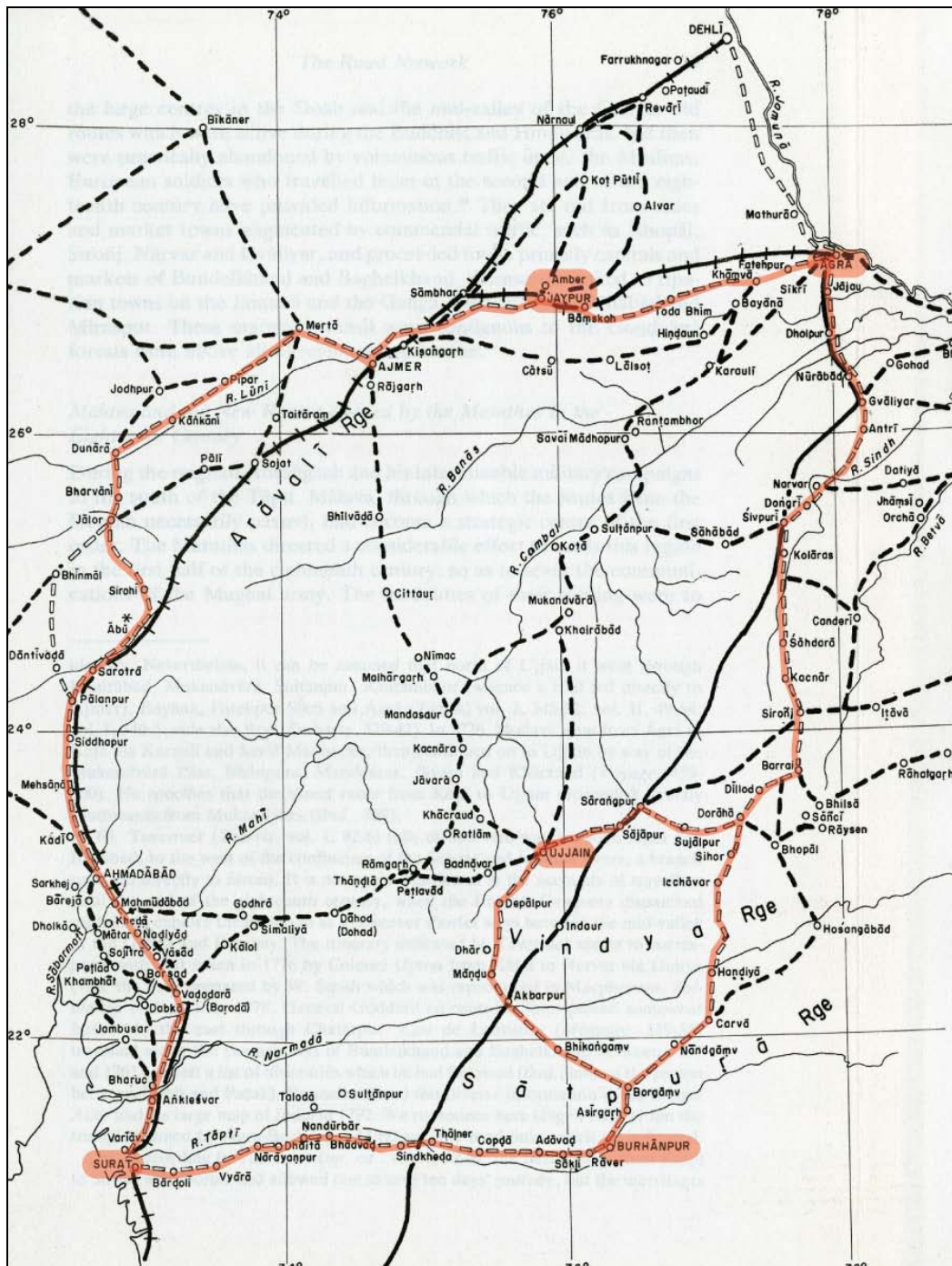
4.8 Conclusion

Not surprisingly, the contributions of the intramural and extramural geographies in the production and movement of astronomical knowledge in northern India were significantly different. As we saw in our discussion of the observatory at Jaipur in the previous chapter, the intramural landscape participated in a display of power through spectacle, and facilitated the exchange of knowledge among the multiple institutions that operated in support of the observatory. In contrast, extramural space served only as an impediment to Sawai Jai Singh's success. When we look at the records produced during the Maharaja Dhiraja's multiple conversations with representative of the Society of Jesus, we can see that the king was always striving toward the intramural, attempting to position knowledge in a more convenient and controllable location. Sawai Jai Singh experienced limited success in his efforts to draw the extramural inward, in that he forced the intellectual processes shaping European astronomy to conform to his own ideas of how an intellectual community should function. At the same time, he was unable to overcome the host of problems introduced by the natural and designed landscapes of northern India, the institutional peculiarities of the Jesuit order, and ongoing political unrest that consumed multiple types of resources in his region of the world.

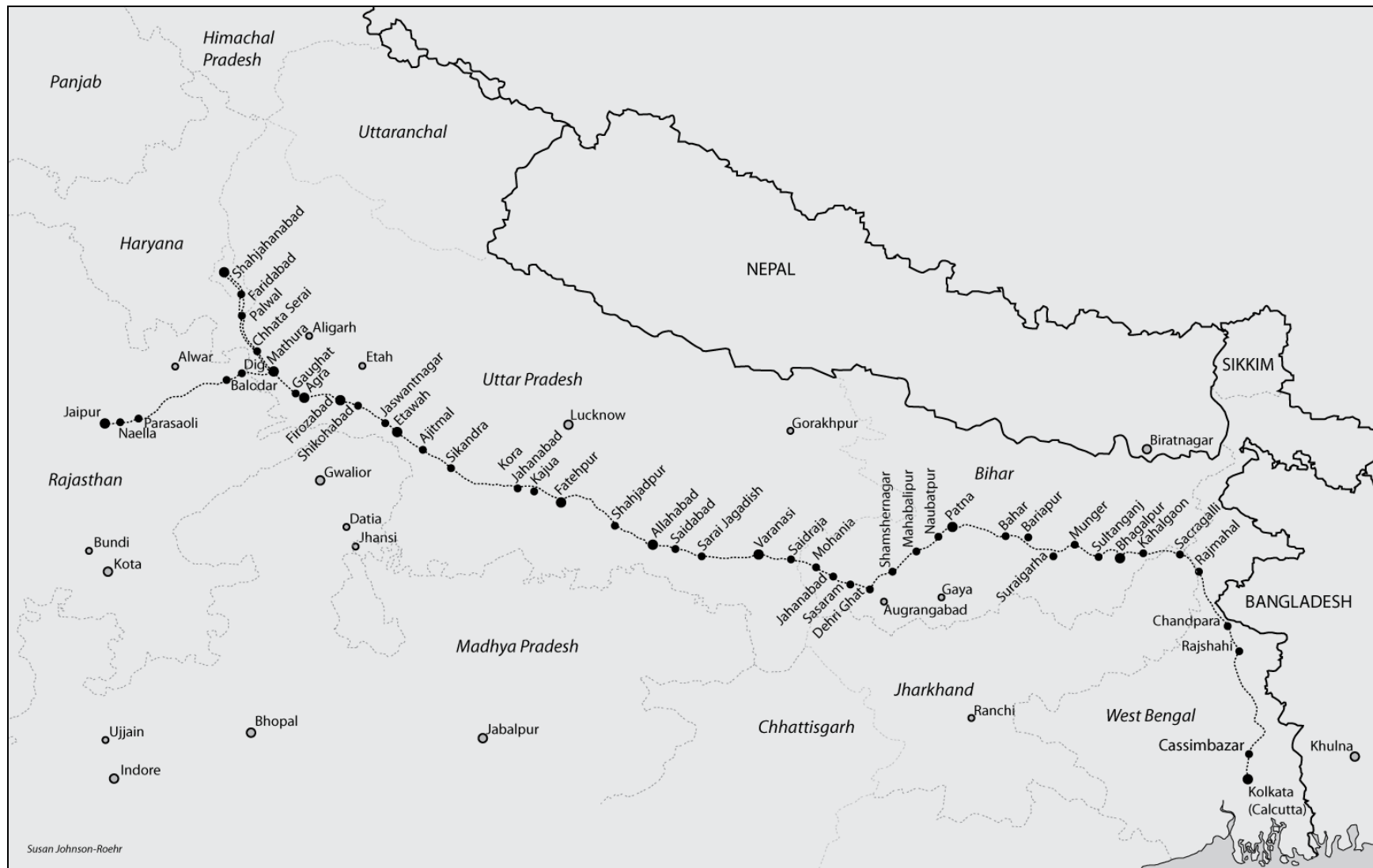
4.9 Maps



Map 4.1. John Jourdain's Routes from Surat to Agra via Burhanpur and Gujarat, c. 1608-1617. From Foster, following p. 140.



Map 4.2. Highlighted routes from Gulf of Cambay to northern urban centers. Adapted from Deloche, Map VIII.



Map 4.3. Route of Fathers Boudier and Pons, with boundaries of contemporary states shown for clarity.

4.10 Figures

Tabula I. Conversio partium Aequatoris in tempus medium.

G.	H.	M.	G.	H.	M.
M.	M.	S.	M.	M.	S.
1.	2.	3.	4.	5.	6.
1	0	4	31	1	4
2	0	8	32	1	8
3	0	12	33	1	12
4	0	16	34	1	16
5	0	20	35	1	20
6	0	24	36	1	24
7	0	28	37	1	28
8	0	32	38	1	32
9	0	36	39	1	36
10	0	40	40	1	40
11	0	44	41	1	44
12	0	48	42	1	48
13	0	52	43	2	0
14	0	56	44	2	4
15	1	0	45	2	8
16	1	4	46	2	12
17	1	8	47	2	16
18	1	12	48	2	20
19	1	16	49	2	24
20	1	20	50	2	28
21	1	24	51	2	32
22	1	28	52	2	36
23	1	32	53	2	40
24	1	36	54	2	44
25	1	40	55	2	48
26	1	44	56	2	52
27	1	48	57	2	56
28	1	52	58	2	0
29	1	56	59	2	4
30	1	0	60	2	8

Ufus
Quaeritur gradus, minuta & secunda in 1. & 3. columna, & e regione in 4. & 6. columna horae, minuta, secunda & tertia aequivalentia reperietur.

Tabula II. Conversio temporis medi in partes Aequatoris.

M.	G.	M.	M.	G.	M.	H.	G.
1.	M.	S.	1.	M.	S.	1.	2.
1.	2.	3.	4.	5.	6.	7.	8.
1	0	15	31	7	45	3	45
2	0	30	32	8	0	4	60
3	0	45	33	8	15	5	75
4	1	0	34	8	30	6	90
5	1	15	35	8	45	7	105
6	1	30	36	9	0	8	120
7	1	45	37	9	15	9	135
8	2	0	38	9	30	10	150
9	2	15	39	9	45	11	165
10	2	30	40	10	0	12	180
11	2	45	41	10	15	13	195
12	3	0	42	10	30	14	210
13	3	15	43	10	45	15	225
14	3	30	44	11	0	16	240
15	3	45	45	11	15	17	255
16	4	0	46	11	30	18	270
17	4	15	47	11	45	19	285
18	4	30	48	12	0	20	300
19	4	45	49	12	15	21	315
20	5	0	50	12	30	22	330
21	5	15	51	12	45	23	345
22	5	30	52	13	0	24	360
23	5	45	53	13	15		
24	6	0	54	13	30		
25	6	15	55	13	45		
26	6	30	56	14	0		
27	6	45	57	14	15		
28	7	0	58	14	30		
29	7	15	59	14	45		
30	7	30	60	15	0		

Ufus
Quaeritur horae, minuta, secunda & tertia in 1. 2. & 3. columna, & e regione in 4. & 6. reperietur gradus, minuta, secunda & tertia aequivalentia.

Figure 4.1. Philippe de la Hire, *Tabulae Astronomicae*, 2nd edition, 1.

4.11 Tables

Table 4.1 Route Taken by Fathers Claude Boudier and Jean Pons from Chandanaggar to Jaipur, 1734 CE			
Location	Present-Day Name	Known Dates of Residence	Distance Traveled
Chandernagore	Chandanaggar	January 6	From Chandernagore to Benares, all stops on right bank of Ganges River
Cassimbasar	Cossimbazar	January 17-22	No latitudes/longitudes measured between Chandernagore and Cassimbasar because traveled by water; about six leagues away from Ganges River.
Caméra	Chandpara		To the left of a small arm of the Ganges River.
Bonapour			To the left of a small arm of the Ganges River.
Ragemol	Rajmahal	February 10	
Sacrigalli	Sahibganj (possibly)		It is here the kingdom of Bengal begins, separate from Bihar
Calégam	Kahalgaon		
Baguelpour	Bhagalpur		
Sultanegange	Sultanganj		
Monguère	Munger		
Surgégara	Suraigarha		
Dariapour	Dariapur		
Bahar			
Décantpour/Bec antpour			
Patna	Patna	Feb 23-March 6	Sone River empties into Ganges 3-4 miles above Patna, on right bank of Sone River; Kandoc River flows into Ganges north of Patna.

Table 4.1 (cont.)

Novotpour	Naubatpur	More than two miles from Sone River, on right bank of river; about four leagues from Ganges, on right bank.
Mahavélipour	Mahabalipur	On right bank of Sone River; about thirteen leagues from Ganges, on right bank.
Samsernagar	Shamshernagar	W/in quarter league of Sone River, on right bank of river; about fifteen leagues from Ganges, on right bank.
Gothaoli	Dehri-on-Ghat	A good half mile from Sone River, on right bank of river; about eighteen or twenty leagues from Ganges, on right bank.
Sasseram	Sasaram	About twelve or thirteen leagues from Ganges, on right bank.
Jehanabad	Jahanabad	About nine or ten leagues from Ganges, on right bank.
Mounia	Mohania	About six leagues from Ganges, on right bank; between Sedraja and Mounia, ford two small rivers that empty into Ganges; the river closest to Mounia is the Savot-Durgavedi.
Sedraja	Saidraja	About three leagues from Ganges, on right bank; between Sedraja and Mounia, ford two small rivers that empty into Ganges; the river closest to Sedraja is the Caramnassa.
Benarez	Varanasi	March 22-23
Babouki-Serai	Sarai Babu	
Jagdis	Jagdish	One mile from Ganges, on left bank;
Saïdabad	Saidabad	½ league from Ganges, on left bank of river.

Table 4.1 (cont.)

Helabas	Allahabad	March 28	Yamuna and Ganges join immediately above city; on left bank of Yamuna, right bank of Ganges.
Alemchand	Alam Chand		Yamuna River passes w/in 3-1/2 leagues, on left bank of river; ¾ league from Ganges, on right bank of river.
Chassadpour	Shahzadpur		Yamuna River passes w/in about six leagues, on left bank of river; 1/3 league from Ganges, on right bank of river.
Chobé	Chobe		Yamuna River passes w/in five leagues, on left bank of river; ¾ league from Ganges, on right bank of river.
Fatépour	Fatehpur	April 1-2	Ganges passes w/in two leagues; on right bank of river
Cajoua	Kajua		Yamuna River passes w/in three leagues; on left bank of river; Ganges passes w/in three leagues; on right bank of river
Corregianabad	Kor Jahanabad		Yamuna River passes w/in two leagues; on left bank of river
Drouguedas			
Sicandra	Sikandra		Yamuna River passes w/in 1-1/2 leagues; on left bank of river
Agitmal	Ajit Mal		Yamuna River passes w/in 1-1/2 leagues; on left bank of river
Etaya	Etawah		Yamuna River passes w/in one league; on left bank of river
Jassondnagar	Jaswantnagar	April 9	Yamuna River passes w/in two leagues; on left bank of river
Sacourabad	Shikohabad		Yamuna River passes w/in two leagues; on left bank of river
Férosabad	Firozabad		Yamuna River passes w/in two leagues; on left bank of river

Table 4.1 (cont.)

Agra	Agra	April 13-25	Compass not used from Patna to Agra because it was in cart; On right bank of Yamuna River
Gaugat	Gau Ghat		On right bank of Yamuna River
Matoura	Mathura		On right bank of Yamuna River
Chatéqui-Serai	Chhata Serai		
Ourel			Yamuna River passes w/in two leagues; on right bank of river
Parval	Palwal		Yamuna River passes w/in 2-1/2 leagues; on right bank of river
Faridabad	Faridabad		Yamuna River passes w/in five quarter leagues; on right bank of river
Dely	Delhi	May 3-June 21	
Dig	Dig		
Balodar	Tauradar (possibly)		
Parasaoli	Parasoli		
Naëlla	Nayla		
Jaëpour	Jaipur	August 7-Sept 10	

CHAPTER FIVE

NEW DEVELOPMENTS

Although Sawai Jai Singh was obliged to spend much of his reign away from his own kingdom, he passed most of his time in the three years preceding his death at age fifty-five within the confines of the palace complex in Jaipur.¹ During the final months and weeks of his life, he continued to apply himself to various scholarly projects, including his work in the observatory. In 1742 CE, Father Strobl reported that the Maharaja Dhiraja intended to send an emissary to Rome as a demonstration of admiration and friendship, but the scheme had been delayed by the unfortunate death of Father Gabelsperger and the ongoing conflict between the Mughals and the Maratha confederacy.² The plans to contact the Papacy were abandoned permanently with the death of Sawai Jai Singh on October 2, 1743 CE (Asoj Sūdi 14 VS 1800), and all work at the observatories came to an abrupt halt as a formal period of mourning began in Amer and Jaipur.³ The accession of Ishwari Singh, Sawai Jai Singh's eldest living son, marked the beginning of a new stage in the development of the observatories. On first glance, it appeared as if the observatories were about to be abandoned and left to wear away to piles of

¹ Although it is generally agreed that Sawai Jai Singh's sedentary state was caused by ill health, the underlying cause for the decline in his well-being has been attributed to various causes. According to the *Vamśa Bhaskar*, the final years of the Maharaja Dhiraja's life were devoted to sexual excess and drug abuse, resulting in his death from venereal disease. According to the *Īśvaravilāsa*, the king spent his final months studying religious matters and gazing upon the image of Govinddevji in his abode adjacent to the Chandra Mahal. See V. S. Bhatnagar, *Life and Times of Sawai Jai Singh, 1688-1743* (Delhi: Impex India, 1974), 267; Kṛṣṇa Bhaṭṭ, *Īśvaravilāsa Mahākāvya*, trans. Madhuranatha Shastri (Jaipur: Oriental Research Institute, 1958), 145; Ashim K. Roy, *History of the Jaipur City* (New Delhi: Manohar Publishers & Distributors, 1978), 8-9.

² Andreas Strobl, "Letter No. 643," in *Der Neue Weltbott mit allerhand Nachrichten dern Missionariorum Societatis Jesu*, ed. Joseph Stocklein (Augsburg: 1726), 14.

³ There is some dispute as to the date of Sawai Jai Singh's death according to the Gregorian calendar. The date is reported as Āśvin śukla caturdaśī VS 1800 (Asoj Sūdi 14 VS 1800) in the *Īśvaravilāsa*. Bhatnagar and Roy calculate this date to be the equivalent of September 21, 1743 CE. However, according to Father Andreas Strobl, the Maharaja Dhiraja passed away on October 2, 1743 CE. This later date concurs with my own calculations based on *Imārat Khāna* records. See Bhaṭṭ, 177; Bhatnagar, 268; Roy, 53; Andreas Strobl, "Letter No. 644," in *Der Neue Weltbott mit allerhand Nachrichten dern Missionariorum Societatis Jesu*, ed. Joseph Stocklein (Augsburg: 1726), 15. For a description of Sawai Jai Singh's funeral pyre, see Strobl, "Letter No. 644," 16.

rumble under the pressure of repeated monsoon storms. This impression is congruent with the history of the observatories as described by Robert Barker, John Williams, and William Hunter: the future of astronomy in India, too, was cast upon the flames of Sawai Jai Singh's funeral pyre.⁴ It is not, however, an accurate representation of the actual fate of any of the observatories. An examination of the built environment, shows second trajectory of development in the post-Sawai Jai Singh era, one that indicates that although the observatories may have ceased functioning as scientific institutions, the instruments and their surroundings were assigned new meanings and functions on both the global and local levels. The literature from the years immediately following Sawai Jai Singh's death, particularly the descriptions written by the Jesuits still connected to the observatories, reveals the beginning of the Orientalization of the observatories, and the stripping away of agency of the patron(s). The process of Orientalization slowly unfolds, and at the end of the eighteenth century the history of the observatories is fully entangled in the sinews of colonial power and prejudice. An analysis of the changes in the built environment that occurred during the same time period shows that the literary deadening of scientific potential at the observatories helped vacate the sites of meaning, and allowed the instruments to develop new connotations and social significance. A study of the architecture and landscape of the observatories after the death of Sawai Jai Singh proves that, contrary to the colonial dismissal of the sites as grubby useless ruins, the instruments maintained a visible and meaningful presence in their local and global environments.

⁴ While this sentiment was first expressed by Hunter, it was echoed and popularized in the work of James Tod. See William Hunter, "Some Account of the Astronomical Labours of Jayasinha, Rajah of Ambhere, or Jayanagar," *Asiatick Researches* 5 (1799): 210; James Tod, *Annals and Antiquities of Rajast'han: or, the Central and Western Rajpoot States of India in Two Volumes*, Popular edition ed., 2 vols., vol. 2 (London: George Routledge & Sons Limited, 1914), 298.

5.1 Father Joseph Tieffenthaler, S. J.

Father Joseph Tieffenthaler (b. July 27, 1710-d. July 5, 1785 CE) occupies an intermediate position between the active participation of Fathers Strobl and Gabelsperger in the production of knowledge at the observatories and the assignation of those same sites and processes to the deepest reaches of history by Sir Robert Barker.⁵ A native of Bolzano (Bozen) in the Austrian Tyrol (now part of Italy), Tieffenthaler spent forty-two years, or more than half his life, documenting the landscapes and cities of India. He left his home in Austria in 1740 CE, and after working two years for the Society of Spain, set sail from Lisbon to Daman via the Philippines in December 1743 CE with the annual Portuguese fleet.⁶ He reportedly was sent to India to take the place of the recently deceased Father Gabelsperger and to work at the observatory in Jaipur with Sawai Jai Singh, but upon his arrival in Daman, he received word of the Maharaja Dhiraja's death.⁷ He altered his plans accordingly and advanced instead to Agra, where he took up the position of teacher at the Jesuit College.⁸ He did not remain long at this post, however, embarking on his first journey through northern India within a few months of setting up residence in the city. His decision to leave Agra had much to do with the aspirations

⁵ Tieffenthaler's birth date is reported in various places as April 27, July 27, and August 27, with his year of birth alternately given as 1710 and 1715. Edward Maclagan, *The Jesuits and the Great Mogul* (London: Burns, Oates & Washbourne, 1932), 137; Reginald Henry Phillimore, *Historical Records of the Survey of India*, 4 vols., vol. 1 (Dehra Dun: Survey of India, 1945), 388; Surendra Nath Sen, "Joseph Tieffenthaler and his Geography of Hindustan," *Journal of the Asiatic Society* New Series 4, no. 3-4 (1962): 75; Agustin Udias, *Searching the Heavens and the Earth: The History of Jesuit Observatories*, vol. 286, Astrophysics and Space Science Library (Dordrecht: Kluwer Academic Publishers, 2003), 57.

⁶ Sen: 75; Joseph Tieffenthaler, Anquetil du Perron, and James Rennell, *Description Historique et Géographique de l'Inde*, trans. Jean Bernoulli, 1 ed., 3 vols., vol. 1 (Berlin: Chrétien Sigismond Spencer, 1786), 3.

⁷ Severin Noti, *Joseph Tieffentaller SJ: Missionar und Geograph in Grossmogulschen Reiche in Indien 1710-1785* (Aachen: Xaverius Verlag, 1920), 9. Noti provides no evidence to prove the assumption that Tieffenthaler was destined for the Jaipur observatory and, indeed, in his English summary of Tieffenthaler's work, he prefaces the claim with the phrase "for aught we can guess." Tieffenthaler makes no mention of his direct orders in any published source. See also ———, "Joseph Tieffentaller, S.J., A Forgotten Geographer of India," *East & West* 5 (1906): 146.

⁸ Noti, "Joseph Tieffentaller, S.J., A Forgotten Geographer of India," 145.

the Church had for him as a newly-arrived priest: Tieffenthaler was charged with the revivification of the all but moribund Mogol Mission. By 1740 CE, many of the Portuguese Jesuits in India had retired to Goa, and the few that remained within the bounds of the Mughal Empire were pressed to their limits in terms of resources and energy.⁹ As a relatively young and presumably healthy missionary, Tieffenthaler was assumed to possess the vigor and fortitude needed to make onerous overland journeys as a representative of the Jesuit order. As part of an effort to safeguard the practice of worship and the sacraments in these beleaguered regions, he was instructed to visit cities with established Christian communities. With this goal in mind, after Agra, he planned to pay calls on the missions at Ahmedabad, Cambay, Sambhar, Jaipur, and Lahore.¹⁰ His departure from Agra in January 1744 CE marked the beginning of a full calendar year away from the Jesuit College. By February 2, he was in Surat, and by March he had returned to Daman. He remained in this Portuguese city until the conclusion of the monsoon season in September, at which point he traveled north again to the port of Surat. From Surat, he traveled to Jaipur via Bharuch, Khambhāt, Ahmedabad, Rādhanpur, Jālor, Jodhpur, Merta, Ajmer, and Sambhar, reaching Jaipur by the end of the year.¹¹

Tieffenthaler's initial wanderings may have been prompted by religious concerns, but in outlook and attitude, he was similar to Father Claude Boudier in that he considered the world around him as worthy of his attention as the mission with which he was charged by his superiors.

⁹ By 1700 CE, Jesuit membership in the provinces of Goa and Malabar had shrunk by about 40% from its peak in 1627 CE. By 1734 CE, only three Jesuits resided along the entire east coast (Malabar/Coramandel) of the subcontinent. Goa's decline was not as dramatic, but there still existed a pattern of deaths outnumbering arrivals of replacement Jesuits. Between 1719-1722 CE, for example, thirty-six missionaries died, and fewer than twenty new recruits arrived in the province. Those that did risk the voyage to Goa were young (an average age of twenty-one) and untrained. This, combined with Goa's drop in revenue in the 1740s, put the Jesuit mission in India in some peril. Dauril Alden, *The Making of an Enterprise: the Society of Jesus in Portugal, its Empire, and Beyond, 1540-1750* (Stanford: Stanford University Press, 1996), 581-84; Noti, *Joseph Tieffentaller SJ: Missionar und Geograph in Grossmogulschen Reiche in Indien 1710-1785*, 10.

¹⁰ Noti, *Joseph Tieffentaller SJ: Missionar und Geograph in Grossmogulschen Reiche in Indien 1710-1785*, 10.

¹¹ Tieffenthaler, du Perron, and Rennell, 3, 221-23, 332.

In a letter to Anquetil du Perron, he noted that since his departure from Germany “nothing, after the gain of souls and the addition of the leaders of foreign nations to Christianity, was greater than the desire to observe the location of the countries through which we have gone, directions of the winds of the heavens, fertility [of the soil], and the customs of the local inhabitants.”¹² Also like Boudier, he traveled with a brass quadrant, telescope, and armillary astrolabe for measuring latitudes and longitudes.¹³ As he moved from place to place, he compiled an impressive list of geographic coordinates for major cities by “methods of astronomy.”¹⁴ In addition, he wrote extensive descriptions of topography and infrastructure he encountered during his journeys. After thirty years of observation and note-taking, he arranged his remarks into three volumes, which he then sent to Europe via Peter Jean Flohr, a physician with the Danish Colonies.¹⁵ Jean Bernoulli, Director of Mathematics at the Academy of Sciences and Belles-Lettres and Astronomer Royal in Berlin, learned of Tieffenthaler’s impressive treatise in 1776 CE, when its contents were discussed at length by Anquetil du Perron in the pages of the *Journal of Sçavans*. Bernoulli acquired the Latin manuscript from Dr. Kratzenstein, a professor of medicine in Copenhagen, in 1781 CE and immediately set to work on a translation.¹⁶ As published,

¹² My thanks again to Professor Thomas H. Watkins for his assistance with my Latin translations. Tieffenthaler took up correspondence with Anquetil c. 1759 CE, while the latter was in Surat. The letter is transcribed in Joseph Tieffenthaler, Duperron Anquetil, and James Rennell, *Des Pater Joseph Tieffenthaler's Historisch-geographische Beschreibung von Hindustan.*, trans. Jean Bernoulli, 3 vols., vol. 2 (Berlin: Der Herausgeber, 1785), 128-29. See also Sen, 78.

¹³ Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l'Inde*, 6; Noti, *Joseph Tieffentaller SJ: Missionar und Geograph in Grossmogulschen Reiche in Indien 1710-1785*, 11.

¹⁴ Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l'Inde*, 9.

¹⁵ Anquetil du Perron, “Observations sur trois cartes, l’une du cours du Gange, depuis sa source, ou plutôt depuis son entrée dans l’Inde jusqu’à son embouchure ; l’autre du cours du Gagra, depuis sa source jusqu’à Fatepour, où il se jette dans le Gange; la 3e, d’une portion du Gange & du Gagra ; dressées en partie sur les lieux par P. Tieffentaller Missionnaire Apostolique & accompagnées de vues de plans particuliers & d’une partie du cours, ou du moins de l’indication de toutes les rivières que reçoivent ces deux-grands fleuves,” *Journal of Sçavans* (December 1776): 806, n. 2.

¹⁶ Bernoulli issued a call for subscribers for the French translation in July 1783 CE, including a promise to bring out a German translation as well. As it turned out, the German run of the work began in 1785 CE, and the French edition was not available until 1786 CE. Ultimately, the subscriber list included interested parties from Germany, England, France, Holland and the Netherlands, Ireland, Italy, Poland, Portugal, Russia, Sweden, and Switzerland. Jean Bernoulli, “Prospectus d’une Géographie de l’Inde exacte & complete, écrite dans le pays même,” *Journal of*

Tieffenthaler's *Descriptio Indiae* [*Description Historique et Géographique de l'Inde* in French, or *Historisch-geographische Beschreibung von Hindustan* in German] was divided into chapters according to governmental divisions (that is, by hereditary states, or provinces, as the author considered them).¹⁷ Within each chapter, the provincial cities and towns were ordered according to their proximity to each other and to major transportation routes and rivers. Tieffenthaler paid scant attention to the particulars of most of the villages through which he passed, noting only their distance from neighboring towns, but he elaborated more fully on the character and monuments of those cities in which he was able to stop for a night or longer. For example, he devoted two full pages to Ajmer, the provincial capital of the eponymous state, and another two to Sambhar, a city on the banks of the largest saline lake in India.¹⁸ For the city of Jaipur, he reserved almost four pages, two of which were given over to a description of Sawai Jai Singh's observatory. This generosity of words suggests, at the very least, that Tieffenthaler considered the observatory a significant component of the local landscape. Certainly, he believed that it "merited more description," in comparison to the multitude of Hindu shrines he encountered in the region.¹⁹

Tieffenthaler's discussion of the Jaipur observatory opened with a general description of the site, indicating that it "is quite large and spacious, [and] is contiguous with the palace of the King; it is situated on a plain, surrounded by walls, [and] constructed expressly to view the stars."²⁰ He noted the presence of many of the major instruments: the Rāśivalayas ("12 signs of the Zodiac"), at least two equinoctial sundials, a Dakṣinottara Bhatti Yantra ("a meridian line"),

Ścavans (July 1783): 501-04; Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l'Inde*, xxxiii-xxxvi.

¹⁷ Sen provides an admiral overview of the publishing history and contents of the *Descriptio Indiae* in Sen, 75-99.

¹⁸ Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l'Inde*, 310-13.

¹⁹ *Ibid.*, 316.

²⁰ *Ibid.*

multiple lime-plaster astrolabes, a Nāḍīvalaya (“a horizontal solar dial carved into a large stone”), the Samrāt Yantra (“an *axis mundi* amazing in its height”), a Ṣaṣṭhāmśa Yantra (“a double gnomon...enclosed in a kind of chamber”), three forged-copper astrolabes, and a copper Cakra Yantra. In addition, the observatory contained several “less considerable” instruments, to which he paid no further attention.²¹ Instead, he described in more detail the construction and function of the Samrāt Yantra, as well as the purpose and location of the Ṣaṣṭhāmśa Yantra. He concluded his remarks with a thought regarding the disposition of the instruments, arguing that the observatory held considerably less value than it might have, due to its urban location. “It is located in a low place,” he pointed out, “and enclosed within walls, [so] it does not allow observers to see the rising and setting of the stars.” Moreover, the implementation of some of the instruments was lacking, making them less useful than they had been in plan. For instance, although in concept the Samrāt Yantra was sound, “with the equatorial axis and other parts being formed in plaster [rather than stone], one cannot make any accurate observations.”²²

In some ways, this assessment of the observatory differed little from the one Robert Barker would produce in Varanasi some thirty years later. Tieffenthaler, too, positioned himself as a reliable and knowledgeable eyewitness, claiming that he had been happy “to investigate very carefully all things which [he had] come across and to commit them to writing.”²³ By providing exhaustive lists of towns not yet shown on any map, documenting village industries, describing the routes of seasonal rivulets, and commenting on historical sites of interest to the local population, he established his ability to distinguish the smallest of details in a crowded tableau. With regard to the observatory in Jaipur, he provided only a few rough estimates of the

²¹ Ibid., 316-17. Tieffenthaler passes over the Digamīśa, Kapala, Jaya Prakāśa, and Rāma Yantras without comment.

²² Ibid., 318.

²³ Tieffenthaler, Anquetil, and Rennell, *Des Pater Joseph Tieffenthaler's Historisch-geographische Beschreibung von Hindustan.*, 129.

dimensions of the instruments (the gnomon of the Samrāt Yantra was “approximately 70 royal feet,” and the Rāśivalayas had diameters of “12 royal feet and more”); however, these dimensions were embedded in a treatise replete with measurements of distance, direction, and duration.²⁴ Not only did he orient every stage of his journey to the compass and the mile marker, he pinned every stopping point in place with coordinates taken with the assistance of his companion quadrant and armillary astrolabe.²⁵ For instance, he traveled seven miles, east-northeast, between Sambhar and Jobner; four miles east between Jobner and Pachar; and three miles east, six miles east-southeast, for a total of nine, between Pachar and Jaipur. Jaipur itself was described as a city situated at the foot of a mountain chain running from the north-northeast to the southwest, at a latitude of 26° 53’ and a longitude of 93° 43’. Although Tieffenthaler made a regular practice of including in his notes information about alternative routes that could only have been based on hearsay, these inclusions were accompanied by the same type of information—locative data, compass coordinates—that he used to establish his authority on other aspects of Indian travel. Tieffenthaler tucked his narrative of the Jaipur observatory deep within this well-developed discourse of authenticity.

In style, then, Tieffenthaler’s approach was very similar to the one that would be employed later by Barker, when he enlisted the help of the Company engineer, Archibald Campbell, to produce “on the spot” drawings of the observatory in Varanasi. In other ways,

²⁴ Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l’Inde*, 313-14.

²⁵ Tieffenthaler converted his miles from *kos*, the primary unit of distance measure in India during the 16th-18th centuries. The length of a *kos*, while regularized, varied regionally, and also by ruler. Under Babur, the *kos* was the equivalent of the 4,000-paced mile. According to Abu Fazl, Akbar fixed the length of the *kos* as 5,000 *Ilahi gaz*, with one *Ilahi gaz* equaling approximately 32 inches. Under Jahangir, the *kos* was roughly four kilometers. Tieffenthaler equates a mile with a length of 50 large *gaz*, with seven times the length equaling one Indian league. He dedicated several pages of his *Descriptio Indiae* to the comparison of the regional variants of the “Indian mile.” Subhash Parihar, *Land Transport in Mughal India: Agra-Lahore Mughal Highway and its Architectural Remains* (New Delhi: Aryan Books International, 2008), 13-14; Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l’Inde*, 23-28.

however, Tieffenthaler's engagement with the observatory at Jaipur was quite different from what would follow in the literature of India at the end of the century. In general, it is difficult to reconcile the image of indigenous lethargy implicit in Barker's and Hunter's descriptions with the liveliness encapsulated in Tieffenthaler's treatise. Like the landscape experienced by Gabelsperger and Strobl when traveling from Goa to Jaipur, Tieffenthaler's surroundings were saturated with activity.²⁶ The overall impression painted by his work is one of motion and movement through jungle, cultivated fields, desert, and city. Further, in keeping with the format of the rest of the treatise, the description of Jaipur and the observatory were written in the simple present tense, a rhetorical choice that was quite appropriate in the moment.²⁷ At the time of Tieffenthaler's first visit to the city, Sawai Jai Singh had been dead for only a year. The primary purpose behind his journey to the desert capital was to commune with the resident Jesuit, Father Andreas Strobl, an individual who had first-hand knowledge of both the observatory and its patron.²⁸ The past had scarcely arrived in the city, and Sawai Jai Singh's imprint as patron was still quite visible on its plan and architecture. Indeed, it would have been impossible to attribute any aspect of the built environment in Jaipur to anything other than the munificence of the recently deceased Maharaja Dhiraja. At the time of Tieffenthaler's visit to Jaipur, the instruments—even if they had been abandoned by Sawai Jai Singh's first heir, Ishwari Singh—would have been in a good state of repair, having suffered through only a single monsoon season without maintenance. Tieffenthaler explicitly mentioned the few disadvantages in the design and location of the observatory, but he did not imply that these flaws were in anyway due to decay or

²⁶ Father Strobl recounted the details of their "arduous trip" between the two cities in a letter written to his European brethren. In the letter, he described sea battles, land battles, residential patterns (for both visiting Jesuits and local inhabitants), greedy tax collectors and their custom houses, highway robbers, unbelievable encounters with old people, audiences with royalty, and the religious habits of Brahmin *pandits*. See Strobl, "Letter No. 643," 9-15.

²⁷ In French, the text is in the present indicative; in German, in the present tense.

²⁸ Strobl penned his last letter from Jaipur in October 1744 CE. Andreas Strobl, "Letter No. 646," in *Der Neue Weltbott mit allerhand Nachrichten dern Missionariorum Societatis Jesu*, ed. Joseph Stocklein (Augsburg: 1726), 22-25.

neglect. The instruments were part of the living (or at least very recently deceased) landscape, and his discussion of them reflects this status well.

Tieffenthaler's report of his first interaction with the scientific and urban landscapes composed under the watch of Sawai Jai Singh communicated to the reader a feeling of life and potential. As time passed, however, he devoted fewer and fewer lines to them in his travel narrative, as if he was easing them out of the land of the living and into the realm of the dearly departed. The progress of this physical and intellectual fall off is evident in the pages of the *Descriptio Indiae*. In 1745 CE, not too many months after his visit with Strobl in Jaipur, Tieffenthaler made the short journey north of Agra to the temple town of Mathura.²⁹ He found the city itself less than impressive having, in his opinion, fallen into ruin, with "narrow and dirty" streets.³⁰ He considered only three buildings worth mentioning: two mosques built during the reign of Aurangzeb and the city fort, the Kans ka Kilā, which he erroneously attributed to the patronage of an extremely rich Muslim. As he depicted it, the fortress sat "upon a hill, from which point one can enjoy a view over such a vast plain that the eyes cannot really measure it. One sees on top of the fortress the astronomical structures erected by the famous Raja Jaisingh, an admirer of astronomy."³¹ The characterization of the observatory that followed was noticeably brief in comparison to that which he had written about Jaipur:

The principal instrument is the gnomon, which represents an *axis mundi*, built of lime (or masonry) to a height of 12 Parisian feet. In addition, [there are] equinoctial dials (a span of) five *palms* in diameter. The others are smaller, set up for the latitude of the place. Beyond that, these instruments present various sections of the sphere.³²

²⁹ Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l'Inde*, 4.

³⁰ *Ibid.*, 201.

³¹ *Ibid.*

³² *Ibid.*, 201-02.

This laconic account is difficult to interpret when compared with the obvious attention paid to the observatory at Jaipur just a few months earlier, but there are several possible explanations for his brevity. First, Tieffenthaler had been making regular use of a portable quadrant and armillary sphere during his travels, and he may have reached the obvious conclusion that Sawai Jai Singh's instruments could do little more than his smaller bits of brass. Then, too, the observatory in its roof-top location was quite modest in size compared to the extensive grounds dedicated to the same purpose in the palace complex of Jaipur. Certainly, a Samrāt Yantra with a height of twelve Parisian feet was hardly notable when measured against an instrument that reached a full seventy feet. As Tieffenthaler opined, the Mathura observatory was “nothing but a feeble imitation of the one of Jaipur.” It did have “the advantage over the latter of being placed on an elevated place and of dominating an immense plain,” yet it appeared to offer little beyond that strength.³³

A full two years passed before Tieffenthaler found himself in the position to explore another of Sawai Jai Singh's observatories. In May 1747 CE, the Jesuit went to Delhi to spend three months in the company of his colleague and friend, Father Strobl.³⁴ Given the length of his residence in Delhi, and his interest in astronomy as occasionally exhibited in the *Descriptio Indiae*, we might have expected him to produce a detailed account of his exploration of the observatory outside the walls of Shahjahanabad.³⁵ However, he devoted only one paragraph to

³³ Ibid., 202.

³⁴ Ibid., 4. Father Strobl relocated to Delhi at the end of 1744 or beginning of 1745 CE, allegedly to work as an astronomer for the Mughal emperor. After leaving Delhi in July 1747 CE, Tieffenthaler relocated to Narwar, remaining there until 1750 CE. In 1749 CE, Strobl, too, was sent to Narwar. See H. Hosten, *Jesuit Missionaries in Northern India and Inscriptions on their Tombs, Agra (1580-1803)* (Calcutta: Catholic Orphan Press, 1907), 39.

³⁵ The *Descriptio Indiae* includes several mentions of Tieffenthaler's astronomical observations. In 1743 CE, he viewed the transit of Mercury while in Salsette, and in 1744 CE, he stopped to observe a comet while traveling from Surat to Daman. He also timed the occultation of Jupiter's moons to determine longitude on a regular basis, although he used mileage estimates to accomplish this task as well. Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l'Inde*, 3, 10, 511; S. N. Sen, “Tieffenthaler On Latitudes and Longitudes in India—An Eighteenth Century Study of Geographical Co-ordinates,” *Indian Journal of History of Science* 17, no. 1 (May 1982): 14.

the site and provided little detail beyond its general location and number of instruments. In his estimation, the observatory

differs little from the one that one sees in Jaipur, for here one finds the same type of parallactic or equatorial machine (*axis mundi*), a meridian (*gnomon*), and three great astrolabes; but that which this observatory has in particular: there are two round buildings constructed in the form of circles, and pierced with a quantity of windows, in the midst of which is fixed a cylinder divided (into sidereal time or) hours of the prime mover. This observatory is situated on a plain, the trees and neighboring buildings prevent one from enjoying an open view. Besides this, all the instruments, with the exception of the astrolabes, are patched with plaster, so that one cannot make any accurate observations.³⁶

While Tieffenthaler was not exactly dismissive of the observatory, his was clearly not interested in the place as a potential work site. It is even possible that this paragraph was written based on hearsay rather than firsthand experience, because while he remarked on the presence of the Rāma Yantra, he passed over completely the Jaya Prakāś Yantra resting at the foot of the Samrāt Yantra. While in Jaipur, he took the time to explore the chamber of the Śaṣṭhāmśa Yantra, but mention of it is noticeably absent from the paragraph quoted above. Moreover, it seems likely that he climbed the gnomon in Jaipur, as he indicated that “on top of this *axis mundi* [Samrāt Yantra] is a belvedere that overlooks the entire city, and so high that one cannot be there without one’s head spinning.”³⁷ He is entirely silent on the view and the vertigo obtainable from the Samrāt Yantra in Delhi, and he does not mention the presence of the Agrā Yantra at the summit of its gnomon. It may be that the instruments, forced to compete for his attention in a landscape replete with historical monuments, did not seem worth more than a cursory examination, particularly as they resembled so closely their counterparts in Jaipur. In addition, his last sentence on the subject suggests that the instruments were already losing some of their

³⁶ Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l'Inde*, 128.

³⁷ Ibid., 316.

usefulness due to neglect or ill-conceived repairs, and he may have thought it not worth his time to experiment with the instruments as he did in Jaipur.

Tieffenthaler encountered his fourth—and final—observatory in spring of 1750 CE while traveling from Delhi to Goa. On his way south from the imperial capital, he took the route through Burhanpur and subsequently passed through the province of Malwa and the city of Ujjain.³⁸ His report on the observatory here was appended to the end of a fairly lengthy passage listing the major features of the city: gated crossroads, a decrepit caravanserai, a vast market place, solid and beautiful houses fronted by trees, and reservoirs replete with waterfowl.³⁹ He located the observatory outside the city walls, in

a suburb, built by Jaisingh, Raja of Jaipur, former governor of this province. One here sees an astronomical observatory and instruments made of stones (*a caemento*): namely, two equinoctial dials, large and small; one *axis mundi* (gnomon) that is elevated according to the height of the pole at this place, and positioned on the meridian, at both sides a quadrant of a geometric circle, with a gnomon made of lime-plaster; but the meridian is carved of stone.⁴⁰

He made no mention of the Dakṣinottara Bhatti and Digamśa Yantras, which must have been in the same spots in which they sit today. Instead, he turned immediately to a discussion of the Kshipra River and the local practice of performing ablutions on its banks. It would seem that his interactions with the observatories were becoming briefer, or at least he was devoting fewer and fewer words to their documentation. Only six years had passed since Sawai Jai Singh's death, but already Tieffenthaler could find no reason to elaborate upon the observatories and their patron.

³⁸ Ibid., 4, 347.

³⁹ Ibid., 346.

⁴⁰ Ibid., 347.

It would be incorrect to conclude that Tieffenthaler chose to ignore the existence of the observatories in Delhi, Ujjain, and Mathura after his visit to the exemplar of Sawai Jai Singh's science in Jaipur. Still, as sites of interest, they received no more—and sometimes considerably fewer—sentences than were allowed for the descriptions of the mosques, temples, and bazaars favored by the local populace. By the time he visited the site in Ujjain, Sawai Jai Singh's observatories had been displaced from their position as loci of scientific investigation to mere curiosities in his guidebook. Interestingly, this degeneration in representation was probably not immediately obvious to his late eighteenth-century reading audience, because in the final manuscript, the geography was cleaved free of the chronological structure imposed on it by Tieffenthaler's own movement through the landscape. In his prefatory comments in the French and German editions of the *Descriptio Indiae*, Tieffenthaler offered a brief outline of his various itineraries, including just enough detail for us to be able say that he visited many cities (Daman, Surat, Jaipur, Delhi, etc.) more than once during his forty-two year sojourn in India.⁴¹ Judging from the dates provided in the preface, Tieffenthaler visited Jaipur first (in 1744 CE), and Mathura second (in 1745 CE), even though the latter city was quite close to his home base of Agra. He went then to Delhi (in 1747 CE), to Ujjain (1750 CE), and again to Jaipur (1750 CE). In November of 1751 CE, he relocated to Narwar, where he remained stationed for approximately twelve years, during which time he made “three or four” more visits to Agra and Delhi to visit Father Strobl.⁴² Only in 1765 CE did he finally reach Benares, where he apparently did not seek out the fifth observatory.⁴³ Yet, as published, the *Descriptio Indiae*

⁴¹ Tieffenthaler, Anquetil, and Rennell, *Des Pater Joseph Tieffenthaler's Historisch-geographische Beschreibung von Hindustan.*, 3-6; Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l'Inde*, 3-7.

⁴² Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l'Inde*, 5.

⁴³ Tieffenthaler's passage through Varanasi was undertaken as part of longer journey, the final destination of which was Calcutta. In July 1759 CE, King José I closed all Portuguese territories to Jesuit missionaries, and Tieffenthaler found himself in a financial and political bind after the death of the (Christian) Armenian governor of Narwar. By 1765 CE, he was broke and on his way east to plea for mercy and patronage from the English East India Company.

followed an organizational structure that served to erase any sense of development or changes in the landscape that would have been obvious to a repeat visitor.⁴⁴ If we approached the observatories in the order in which they appeared in either edition of the *Descriptio Indiae*, rather than the order in which the author encountered them, we would read first the description of the patchworks in Delhi. After this, we could read of the feeble imitation in Mathura and the apparently invisible observatory of Benares. Only then would the explosion of detail occur in Jaipur, to be followed by the immediate descent into brevity in Ujjain. Without a deliberate search through and re-arrangement of the final text, the reader would have been hard pressed to see the change in Tieffenthaler's terms of engagement with the observatories, much less understand why he compared the instruments in Mathura to a set that had not yet been introduced in the text.

On closer scrutiny, Tieffenthaler provided much more than a straightforward geographical description of India. On the one hand, his words allow us to view the observatories through the eyes of a European who was initially quite interested in the astronomical work being conducted at them and approached the instruments with something of an open mind. On the other hand, we can see also the seeds of Orientalist discourse in this work. The quality of Tieffenthaler's scrutiny disintegrated as his interest was captured by rival monuments, and he devoted less and less of his energy to depicting the observatories in text. Then, too, the observatories were portrayed by him as completely depopulated; he does not once mention the presence of a local guide or companion during his explorations, or take notice of any workers or

Sen, "Joseph Tieffenthaler and his Geography of Hindustan," 77; Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l'Inde*, 4-6, 228-29.

⁴⁴ As a single example of this phenomenon, Tieffenthaler concluded his passage on Jaipur (as published) with a mention of Ishwar Lat, the victory tower built by Sawai Jai Singh's heir, Ishwari Singh. However, he must have added this note to his text after a subsequent visit to the city, as the tower was not constructed until 1749 CE. Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l'Inde*, 318.

servants. In addition, his European biases made themselves known in passages not directly related to the observatories. Like most Europeans, he was effusive in his praise of Jaipur as the “most beautiful of all the ancient cities in India.” Jaipur was a “fragment of the modern, its regular streets, large and long,” and it stood in marked contrast to what he considered a typical Indian city in which “everything is ancient, the streets uneven and cramped.”⁴⁵ He was unremittingly dismissive of local religious practices (probably not surprising, given his Jesuit training), and spent much of his time in Narwar writing religious tracts in Persian in an attempt to win converts from Islam to Christianity.⁴⁶ While there is nothing condescending in Tieffenthaler’s tone when describing Sawai Jai Singh’s work, we can see hints of a history soon to come, one that would be less attentive to a living and thriving present than to the monuments symbolic of an ancient past.

This latent tension in the writing and reception of Tieffenthaler’s *Descriptio Indiae* has remained largely unexplored in the historiography of eighteenth-century India. His experience of the observatories is seldom cited by historians, even though his investigations predated those made by Barker, Williams, and Hunter. This lack of critical attention might be partially explained by the fact that his remarks came late to press in Europe, and as such, were probably read as supplemental, rather than foundational, comments on the subject at hand. Then, too, while an eighteenth-century audience would have been quite capable of reading a five-hundred page historical geography of India written in French or German, since that time, the history of the observatories has been written almost exclusively in English, and has relied on English-

⁴⁵ Ibid., 315. On the other hand, as Sen points out, unlike Rennell, who seldom bothered describing Indian cities, since “the description of one Indian city is a description of all; they being all built on one plan, with exceeding narrow, confined, and crooked streets; with an incredible number of reservoirs and ponds, and a great many gardens, interspersed,” Tieffenthaler described the architecture—from monumental palaces to the houses of poor—whenever he stopped in a major city. See James Rennell, *Memoir of a Map of Hindoostan*, 2nd ed. (London: W. Bulmer and Co., 1792), 58; Sen, “Joseph Tieffenthaler and his Geography of Hindustan,” 91.

⁴⁶ Tieffenthaler, du Perron, and Rennell, *Description Historique et Géographique de l’Inde*, 5.

language documents and translations for its authority.⁴⁷ Tieffenthaler's historical geography (in Latin, German, and French), as with most of the primary sources discussed in this dissertation, including the letters of Andreas Strobl (in German), the letters of Claude Boudier (in French), the letters from the Viceroys of Goa in regard to Manuel de Figueredo (in Portuguese), the construction records of Jaipur (in Rajasthani), the astronomical manuscripts of Sawai Jai Singh and his astronomers (in Sanskrit, Persian, Arabic, Hindi, and Latin), have all been neglected to a lesser or greater extent by historians.⁴⁸ To be clear, these records have not been missing, hidden, or otherwise unobtainable by scholars working on the history of the observatory. The reliance on English-language records was a matter of deliberate exclusion, one that produced an illusion of archival cohesiveness when, in fact, large parts of the written record were being passed over in favor of documentation supported by the authoritative voice of colonialism. It is important to keep in mind this archival bias, masquerading as ease of access or lack of linguistic facility, particularly given the recent proliferation of scholarly claims about the benign or accidental

⁴⁷ The exception to this statement are the few late twentieth-century works written in German, yet the authors of these works, too, ultimately relied on Kaye and Hunter for their historical context. Bernhard du Mont, "Der "Zij Muhammad Shahi" Die Kalenderreform Jai Singhs II," *Sterne und Weltraum* 30, no. 12 (December 1991): 732-35; Hermann Kern, *Kalenderbauten: Frühe Astronomische Großgeräte aus Indien, Mexico und Peru* (Munich: Die Neue Sammlung, 1976); ———, "Kalenderbauten. Das Observatorium des Maharaja Jai Singh II (1686-1743) in Jaipur (Rajasthan)," *Sterne und Weltraum* 17 (1978): 167-70; Andreas Volwahn, "Zur Architektur der Sternwarten des Maharaja Jai-Singh-II von Jaipur" (Technischen Hochschule München, 1969); H. von Klüber, "Indische Sternwarten," *Die Sterne* 12 (1932): 81-103.

⁴⁸ Following Thomas Trautmann, we can suppose that this effect was occurring even in the eighteenth century, as the British were able to co-opt the entire discussion of the history of Indian astronomy, even though the philosophical foundations of the field had been laid in French by Jean Dominique Cassini, G. Le Gentil, and Jean-Sylvain Bailly. Most of the relevant texts were composed in Sanskrit, and most of those who read Sanskrit were of British origin. Learning Sanskrit, and deciphering manuscripts, was a dialogic process, in which European Sanskritists relied on the cooperation and assistance of Indian *paṇḍits*. While the French had some opportunity to cultivate or coerce this type of relationship in Pondicherry, the Asiatic Society, backed by the military authority of Fort William in Calcutta and the institutional authority of the East India Company College in which company servants trained in Indian languages, held the monopoly on any Indian knowledge assumed to be derived from ancient texts. This may also help explain the lack of attention paid to Tieffenthaler's geographical survey: While the missionary included a lengthy consideration of the "Religion of the Brahmins" in his *Descriptio Indiae*, he was not a Sanskritist. Rather, he addressed his local Indian audiences in Persian in his religious tracts. See Sen, "Joseph Tieffenthaler and his Geography of Hindustan," 76, 84-85; Thomas R. Trautmann, *Aryans and British India* (New Delhi: Yoda Press, 2004), 135. Trautman's "collaborationist" model has since been extended and amplified in Philip Wagoner's study of Colin Mackenzie's Indian assistants as part of a larger discussion of historical epigraphy as a colonial form of knowledge. Phillip B. Wagoner, "Precolonial Intellectuals and the Production of Colonial Knowledge," *Comparative Studies in Society and History* 45, no. 4 (2003): 783-814.

nature of British imperialism.⁴⁹ The totalizing nature of the colonial archive, and its ability to make itself look complete although riddled with gaps and lacunae, was neither accidental nor a boon; rather it was the display of military and political control, one apparently capable of drawing historians over to its side in support. This is not to say that Joseph Tieffenthaler was in any way an agent of resistance, or a subaltern denied subjectivity by the colonial regime, but only to suggest that a sideways glance across the colonial archive can sometimes be as illuminating as deeper excavation through stacks of historical records. The suppression of his European voice highlights the seductive nature of the written record, and encourages us to occasionally deafen our ears to the siren song of the written word and pursue a course through alternative archives. Even at the end of the eighteenth century, the landscape and built environment told a far different story than what we would have been able to read in print: although scientific work had drawn to a close at the observatories at the time of Sawai Jai Singh's death, the instruments continued to live on, developing their own historical trajectories as living monuments managed and manipulated by local stakeholders with a variety of political and social agendas.

5.2 Life After Death

Well before the year of his demise, the Maharaja Dhiraja had passed the ceremonial power to his preferred heir, his elder son, Ishwari Singh (r. 1743-1750 CE).⁵⁰ With his accession, Ishwari Singh inherited the full responsibility of governing more than 20,000 square

⁴⁹ For two recent examples of this genre, see Niall Ferguson, *Empire: The Rise and Demise of the British World Order and the Lessons for Global Power* (New York: Basic Books, 2002); Bernard Porter, *The Absent-Minded Imperialists: Empire, Society, and Culture in Britain* (Oxford: Oxford University Press, 2006).

⁵⁰ Bhatnagar, 267; Bhatt, 176.

miles of *watan* and *jāgīr* land.⁵¹ Unfortunately, he also inherited a family feud, and so spent the most of his reign combating military aggression emanating from the quarter of his younger brother, Madho Singh, while simultaneously attempting to maintain Jaipur's position of political strength at the imperial court in post-Nadir Shah Delhi.⁵² Even had Sawai Jai Singh managed to cultivate in his son an interest in astronomical studies, it is difficult to see how the new raja could have marshaled the appropriate resources to make observations at the Jaipur observatory. He was constantly distracted by Madho Singh's claims to the cushion throne, and although he managed to sponsor the construction of some small architectural projects, such as the Ishwar Lat victory tower, he never established himself in a position of political and economic dominance such as had been enjoyed by his father. After Ishwari Singh's death by suicide (committed while Jaipur was under imminent threat of invasion by his brother's army), Madho Singh (r. 1750-1768 CE) took his place on the cushion throne. He soon found himself embroiled in as many political intrigues as he could have wished on his enemy brother.⁵³ However, there is some suggestion that despite Madho Singh's involvement in the continued unrest between the Mughals and the Marathas, Sawai Jai Singh's scientific interests experienced a brief renaissance under his patronage. For example, he constructed a Yaṣṭi Yantra ["Stick Instrument," or sundial] and an armillary sphere for the observatory of Jaipur, and there is reason to believe that he called for the

⁵¹ Bhatnagar, 269. Under the leadership of the Maharaja Dhiraja, the hereditary state of Jaipur and Amer had developed into an economic powerhouse (largely due to the trading populace settled in the capital city of Jaipur) and expanded in terms of geography to cover not only the lands traditionally claimed by the Kacchawāhā clan (roughly 9000 square miles), but approximately 5,200 square miles of Shekhawati, 3,000 square miles of Macheri (Alwar), and 1,800 square miles of Tonk, in addition to the regions of Gazi-ka-Thana, Kamau, Khorī, Pahari, Narnaul, Kanorh, Bhinai, Kekri, Parbatsar, and Piplad.

⁵² Harish Chandra Tikkiwal, *Jaipur and the Later Mughals (1707-1803 A.D.): A Study in Political Relations* (Jaipur: Hema Printers, 1974), 110-14.

⁵³ *Ibid.*, 116-36.

Miśra Yantra to be added to the observatory in Delhi between the years 1750 and 1754 CE, in an attempt to curry favor with the Mughal emperor, Aḥmad Shah.⁵⁴

After Madho Singh's death, the observatory at Jaipur sank into a state of disrepair. This cycle of cessation and recrudescence characterized the existence of the observatory for the next two centuries. Madho Singh's successor, Prthvi Singh (r. 1768-1778 CE) sponsored the restoration of the Nāḍīvalaya dial, but his heir, Pratap Singh (r. 1778-1803 CE) seemed to care little for the instruments and had several of them dismantled in order to make room for the Anand Bihari temple. Simultaneously, he gave much of the rest of the observatory over to the construction of a gun foundry.⁵⁵ Around 1876 CE, Ram Singh II (r. 1835-1880 CE) sponsored a large-scale renovation of the instruments that still remained on site.⁵⁶ Madho Singh II (r. 1880-1922 CE) also showed an interest in the observatory, initiating limited restorations as early as 1891 CE, and investing in a complete overhaul of the property in 1901-1902 CE under the guidance of Chandrahar Guleri and Arthur ff. Garrett (figures 5.1-5.2).⁵⁷ Since that time, the

⁵⁴ Arthur ff. Garrett and Chandradhar Guleri, *The Jaipur Observatory and Its Builder* (Allahabad: Pioneer Press, 1902), 61, 64-65; Virendra Nath Sharma, "Miśra Yantra of the Delhi Observatory," *Indian Journal of History of Science* 29, no. 3 (1994): 477.

⁵⁵ A. H. E. Boileau, *Personal Narrative of a Tour through the Western States of Rajwara in 1835; Comprising Beekaner, Jesulmer, and Jodhpur, with the Passage of the Great Desert, and a Brief Visit to the Indus and to Buhawulpoor; Accompanied by Various Tables and Memoranda Statistical, Philological, and Geographical* (Calcutta: Baptist Mission Press, 1837), 157; Garrett and Guleri, 65; Virendra Nath Sharma, *Sawai Jai Singh and his Astronomy* (Delhi: Motilal Banarsidass Publishers, 1995), 127, 172-73.

⁵⁶ Thomas Hendley notes that the Great Astrolabe, although still in working order, had spent some time serving as a target during musket practice, and also that a new Dakṣinottara Bhatti Yantra was being constructed to replace an older one. According to Hendley, few *panḍits* knew the names or functions of any of the extant instruments. Opinions differ as to whether the Small Samrāt Yantra was built at this time, or if it predated the 1876 CE restoration. Garrett and Guleri, 43; Thomas Holbein Hendley, *The Jeypore Guide* (Jaipur (Jeypore): Raj Press, 1876), 32-36; Sharma, *Sawai Jai Singh and his Astronomy*, 130, 142; M. F. Soonawala, *Maharaja Sawai Jai Singh II of Jaipur and his Observatories* (Jaipur: Jaipur Astronomical Society, 1952), 30.

⁵⁷ Arthur ff. Garrett was "loaned" to the Jaipur *darbar* by the North Western Railway in Lahore as part of the famine relief effort in 1899-1900 CE. Although the relationship between the restoration of the observatory and famine relief works remains unclear, Garrett's time in Jaipur was extended well beyond his initial appointment, first due the delayed return of Colonel S. S. Jacob, Superintending Engineer of the Jaipur State, from furlough, and then again to cover the furlough of Executive Engineer C. E. Stoddard. Garrett was assisted in his work at the observatory by *panḍit* Chandrahar Guleri, who later served at Mayo College in Ajmer by order of the Jaipur *darbar*. Garrett's history of the Jaipur observatory relied on William Hunter's article published in 1799 CE in *Asiatick Researches*, and included a transcription of Hunter's translation of the preface to the *Zīj-i Muḥammad Shāhī*. Garrett and Guleri,

instruments have been maintained in various states of (dis)repair. In 1945 CE, several gestures at refurbishment were made, the most significant of which was the replacement of the plaster scales on the gnomon and quadrants of the Samrāt Yantra with marble.⁵⁸ In 2007-2008 CE, under the guidance of the Archaeology and Museum Department, the observatory underwent the first large-scale restoration in over a century. The major instruments were stripped to their rubble cores and resurfaced with *chunā* (lime plaster). Exhausted turf was replaced, a well was dug for a new irrigation system, the observatory walls were restored with *kangurā* crenellations, and a new interpretive center and entrance were built in the western sector of the complex (figures 5.3-5.5).

As described in Chapter Two, the observatory at Mathura was dismantled completely in the first half of the nineteenth century, but similar stories of periodic restorations can be told about the observatories in Ujjain, Delhi, and Varanasi. In 1923 CE, the Ujjain observatory was repaired fully under the supervision of Gokul Chand Bhavan, the Astronomer Royal at Jaipur.⁵⁹ Small patchworks to the instruments have been ongoing since that time, and recent site renovations have included the construction of a new ghat on the riverbank, the installation of an 8” Meade telescope on rails, the addition of meteorological instruments, and the completion of a new headquarters for the scientists working there today (figures 5.6-5.8).⁶⁰ After apparently

15-18. For details of Garrett’s service, see above, Chapter Three, footnote 48. For Guleri’s later placement at Ajmer, see Chandradhar Guleri, Letter to Captain A. Gorham, 6 Sept 1910, fol. 1v, V 17486, Asia, Pacific and Africa Collections, British Library, London. For a description of famine conditions in Jaipur during this time, see Roy, 98-101.

⁵⁸ Soonawala, 29-30.

⁵⁹ *Administration of the Gwalior State During the Year 1922-1923 (From 1st July to 30th June)* (Lashkar: Alijah Darbar Press, 1924), 57; *Administration of the Gwalior State During the Year 1923-1924 (from 1st July to 30th June)* (Lashkar: Alijah Darbar Press, 1927), 196.

⁶⁰ In 1923 CE, the observatory was renamed the Shree Jiwajee Observatory in honor of its benefactor, the ruler of Gwalior state, Maharaja Madhava Rao Shinde. In 1942 CE, the observatory published a set of geocentric ephemerides “for use by astrologers and computators of Panchangas.” The observatory has continued its annual publication of astronomical tables to the present day. In 1964 CE, the authors of the series added Hindi language labels to their tables. See R. V. Vaidya, *Astronomical Ephemeris of Geocentric Places of Planets for 1942*

decades of neglect, the Varanasi observatory was restored in 1911 CE, also under the supervision of Gokul Chand Bhavan.⁶¹ The observatory has been under the management of the Archaeological Survey of India since c. 1947 CE, and photo evidence indicates that the instruments received a comprehensive re-plastering soon after 2001 CE (figures 5.9-5.10). The observatory at Delhi has been subjected to several types of restorations over the past 150 years. In 1852 CE, at the request of the Delhi Archaeological Society, the Raja of Jaipur, Ram Singh II, provided 600r-0a-0p to be spent on the refurbishment of the observatory; 442r-1a-10p of this money was directed toward the rehabilitation of the gnomon of the Samrāt Yantra.⁶² Between 1909 and 1911 CE, the sum of 11,364r-0a-0p was spent to improve the condition of the instruments. These projects were also completed under the supervision of Gokul Chand Bhavan.⁶³ In 1951 CE, the Miśra Yantra was resurfaced (figure 5.11).⁶⁴ Between 1975 and 1981 CE, the pit of the Samrāt Yantra was partially filled in an effort to prevent the pooling of groundwater in that area. At this time, the bottom third of the gnomon and quadrants were buried under concrete, rendering them permanently unusable, even for approximate demonstrations of their functions (figures 5.12-5.13).⁶⁵ A series of interventions into the site was proposed by members of the Astronomical Society of India in 1993 CE, but only minor

(Lashkar: Alijah Darbar Press, 1942); Kamalakant Joshi, *Astronomical Ephemeris of Geocentric Places for 1965* (Gwalior: Government Regional Press, 1965), i.

⁶¹ Sharma, *Sawai Jai Singh and his Astronomy*, 200.

⁶² “3rd June, 1852,” *Journal of the Archaeological Society of Delhi* (January 1853): 71; “6th January, 1853,” *Journal of the Archaeological Society of Delhi* (January 1853): 74.

⁶³ George Rusby Kaye, *The Astronomical Observatories of Jai Singh* (Calcutta: Superintendent Government Printing, 1918), 48; Sharma, *Sawai Jai Singh and his Astronomy*, 98.

⁶⁴ Sharma dates the plasterwork based on his interview of a guide at the Delhi observatory. A photograph taken by Reuel R. Sutton in 1955 CE shows the surfaces Miśra Yantra in excellent condition, so we can surmise that the work was completed before that time (figure 5.6). Sharma, “Miśra Yantra of the Delhi Observatory,” 486, n. 9.

⁶⁵ Photographs published in 1976 CE show cobbled slopes rising out of the lotus pond that had taken over the pit of the Samrāt Yantra (figure 5.7). Photographs published in 1981 CE show the concrete walls that are still in place today. See “The observatories of Maharajah Jai Singh II at Delhi and Jaipur,” *Architecture Australia* 65, no. 1 (February-March 1976): 78; Kern, *Kalenderbauten: Frühe Astronomische Großgeräte aus Indien, Mexiko und Peru*, 57; Pramod Kumar, “Sawai Jai Singh's Observatories,” *Arts of Asia* 11, no. 5 (September-October 1981): 129.

cosmetic repairs have been made in the past two decades.⁶⁶ In 2000 CE, a Memorandum of Understanding was signed by the Archaeological Survey of India, the National Culture Fund, and Apeejay Surrendra Park Hotels in which the hotel corporation agreed to pay for “the conservation, preservation, maintenance, upgradation and beautification” of the Delhi observatory. After years of delays, the Apeejay Group managed to install spotlights at the site in 2007 CE.⁶⁷ The promised patchwork repairs on the instruments and the renewal of exhausted grass and garden works were completed, at least in part, in anticipation of the Commonwealth Games 2010.⁶⁸

These restoration histories demonstrate that although the instruments may have been abandoned as tools of empirical inquiry after the death of Sawai Jai Singh, as historical sites they lingered in local minds and imaginations. The occasional renovations were sponsored by a multitude of interested parties who had different motivations: the 1876 CE work in Jaipur was probably inspired by the planned arrival in India of Edward, Prince of Wales; the restoration of 1901-1902 CE was entangled in the economics of famine relief; and the on-going debate over the need to restore full functionality to the Delhi instruments is a matter of civic pride. The sites never truly disappeared from the timeline of local, or indeed national, history. As built environments, they have always been available for manipulation by the ruling party, archaeological society, or institution of science. Unfortunately, our knowledge regarding the use

⁶⁶ G. S. D. Babu and V. R. Venugopal, “Programme for the Restoration of the Masonry Instruments at Delhi Jantar Mantar,” *Bulletin of the Astronomical Society of India* 21, no. 3-4 (9 1993): 481-83.

⁶⁷ Puja Birla, “Jantar Mantar: No Sign of Restoration,” *Express India*, October 4, 2002; Mandira Nayar, “A New Lease of Life, and Light, for Jantar Mantar,” *The Hindu*, September 7, 2005; “Historic Jantar Mantar Illuminated, 14 Others to Follow,” *Indo-Asian News Service*, May 4, 2007, <http://www.freshnews.in/historic-jantar-mantar-illuminated-14-others-to-follow-5956>, (accessed November 3, 2010); Richi Verma, “Jantar Mantar Now in New Light,” *Times of India*, May 4, 2007, <http://timesofindia.indiatimes.com/city/delhi/Jantar-Mantar-now-in-new-light/articleshow/1999817.cms>, 1, (accessed November 3, 2010).

⁶⁸ While the Apeejay Group and the ASI did complete some renovations, they felt short of their expressed (and somewhat questionable) goal to make the instruments usable to contemporary astronomers. Archaeological Survey of India, “Commonwealth Games-2010 Conservation, Restoration and Upgradation of Public Amenities at Protected Monuments Proposal,” (Delhi: Archaeological Survey of India, 2006), 33-34; Utkarsh Anand, “Will Get Jantar Mantar to Work for Stargazers Again, ASI Assures HC,” *Express India*, November 2, 2010

of the observatories during the past two-hundred years is imperfect at best. Since the veracity of Barker and Hunter's claim of lifelessness was never explicitly challenged, few have seen the need to catalogue changes made to the observatories after their "demise" in 1743 CE. What this means in practical terms is that the observatories have become more vulnerable to exploitation by a limited set of stakeholders, with the interpretation of each site being written into a narrative developed almost exclusively at the local level. This approach could be styled as a positive, in that having been left to the devices of local residents, the observatories have been allowed to recover some of the individuality stripped from them by the homogenizing forces of colonial discourse. The observatory at Jaipur, for instance, like the city itself, has become deeply embedded in a legend of Hindu patronage that posits Sawai Jai Singh and his intellectual work as exemplars of religious devotion.⁶⁹ Conveniently, this assignation of Jaipur and its architecture to the "Hindu aesthetic" lends itself well to recent touristic interpretations aimed at both local and global audiences that celebrate the royal family as heirs to the Rajput lifestyle, pursuing a timeless—yet vanishing—code of honor and wealth.⁷⁰ In contrast, the observatory at Delhi has shaken off its Rajput lineage in favor of an exclusively Persian/Mughal pedigree. From at least the time of Sayed Ahmad Khan's *Monuments of Delhi* (1852 CE), descriptions of the

⁶⁹ In most histories of Jaipur, the observatory is considered a small element of a greater city plan, the form of which is entirely dependent on Hindu/Vedic design principles. A typical—and influential—example of this interpretation of Jaipur and its landscape can be found in the work of Sten Nilsson. Architect Bonnie MacDougall also relies heavily on Sawai Jai Singh's identity as a Hindu king in her discussion of Jaipur and the observatory as symbols of the "solar dynasty" of the Kaccawāhās. The formal analysis of Jaipur by Vibhuti Sachdev stands as the most recent incarnation of this school of thought. Bonnie G. MacDougall, "Jantar Mantar: Architecture, Astronomy, and Solar Kingship in Princely India," *Cornell Journal of Architecture* 5 (1996): 16-33; Sten Åke Nilsson, "Jaipur: In the Sign of the Leo," *Magasin Tessin* 1 (1987): 4-59; ———, "Jaipur—Reflections of a Celestial Order," in *Aspects of Conservation in Urban India*, ed. Sten Nilsson (Lund: Lund University Press, 1995), 107-28; Vibhuti Sachdev, *Building Jaipur: the Making of an Indian City* (New Delhi: Oxford University Press, 2002), 3-31, 39-43.

⁷⁰ Barbara N. Ramusack, "Tourism and Icons: The Packaging of the Princely States of Rajasthan," in *Perceptions of South Asia's Visual Past*, ed. Catherine B. Asher and Thomas R. Metcalf (New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd., 1994), 235-55. For a more recent consideration of the internet's role in the marketing of Rajasthan and its royal family to tourists, see Carol E. Henderson, "Virtual Rajasthan: Making Heritage, Marketing Cyberorientalism?," in *Raj Rhapsodies: Tourism, Heritage and the Seduction of History*, ed. Carol E. Henderson and Maxine Weisgrau (Farnham, Surrey: Ashgate Publishing, 2007), 161-81.

observatory have been folded into larger discussions of architecture produced for tourists relating it to the early Islamic or Mughal dynasties, leaving little room for “indigenous” agency in the built environment.⁷¹ In the twentieth century, a finish plaster of “imperial red” plaster was introduced to the instruments, emphasizing a visual connection with nearby Mughal monuments constructed of red sandstone such as the Lal Qila, Humayun’s Tomb, and Safdarjung’s Tomb.⁷²

In Ujjain, the observatory is suffering from something of an identity crisis. It was founded and continues to exist within the intensely religious environment of a major Hindu pilgrimage city, and as such, communicates its presence to a peripatetic population in a language consistent with Hinduism. For example, while the colloquial appellation of *jantar mantar* is sometimes used to refer to the observatory, for the most part, publications and signage (in English and in Hindi) retain the Sanskrit word for observatory, *vedhśālā* (figures 5.14-5.16). Here, too, we see the most consistent use of Hindi, with English relegated to a secondary position in the explanatory signage attached to the instruments (figures 5.17-5.18). At the same time, the management at the observatory, now owned and operated by the State of Madhya Pradesh, has been working hard throughout the twentieth century to maintain a reputation as a “real” observatory by expanding the number of topics covered in their annual publication of ephemerides, installing a Meade telescope, and ornamenting the new interpretive center in a way that declares its right to a place in the modern world (figure 5.7, 5.19). In contrast, the

⁷¹ Joseph H. Garcin de Tassy, “Description des monuments de Delhi en 1852, d’apres le texte Hindoustani de Saiyid Ahmad Khan,” *Journal Asiatique* Tome 16, no. Cinquieme Serie (December 1860): 536-43; Sayyid Ahmad Khan, *Āṣār al-ṣanādīd: ‘imārāt-i Dihlī kī mustanad tārikh*, trans. R. Nath (Karachi: Pākistān Histārīkal Sosā’itī, 1966), 118.

⁷² As two of the three major sites on the “Golden Triangle” popular with foreign tourists to India, Jaipur and Delhi in particular struggle with the tension between local and global interpretations of cultural artifacts and landscapes. Although obviously dealing with different historical specificities, the situation of Montreal is parallel to that of Delhi and Jaipur in many ways, not least of which is the struggle to reconcile global touristic discourse with local history. Andrew Jackson’s reflection on the work and publications of the Devon History Society also speaks to the particular problem of writing local histories. See Graeme Evans, “Living in a World Heritage City: Stakeholders in the Dialectic of the Universal and Particular,” *International Journal of Heritage Studies* 8, no. 2 (2002): 117-35; Andrew Jackson, “Local and Regional History as Heritage: The Heritage Process and Conceptualising the Purpose and Practice of Local Historians,” *International Journal of Heritage Studies* 14, no. 4 (2008): 362-279.

observatory in Varanasi has been rendered almost invisible to the outside world. While the Hinduization of history in Jaipur and Ujjain allowed for the recovery of the observatories in those cities into a narrative of religious devotion, in Varanasi, the opposite has occurred: the observatory, managed today by the Archaeological Survey of India, is irrelevant in a city in which almost all public space is devoted to the non-secular, whether it be in the form of pilgrimage, cremation, or religious tourism.⁷³ The observatory here has grown more obscure as the bank side has become more crowded with religious devotees. The site is now managed by the Archaeological Survey of India, but for a tourist monument, it is exceptionally difficult to locate, and undoubtedly the least visited of the four extant observatories.⁷⁴

These highly particularized interpretations offer many advantages in that they are responsive to local interests, and they have helped the observatories to reclaim an identity that has been denied within the pages of scholarly tomes. This reassertion of cultural and intellectual identity has come with its own set of problems, however. First, it should be obvious that the assignation of these sites to separate streams of religious identity—Hinduism vs. Islam—reflects the worst type of partisanship in heritage discourse. Perhaps it is not surprising that these interpretations split across communal lines, but it is regrettable, because this feeds into a stream of ongoing discord and violence, and because only a very limited history of the observatories can

⁷³ It should be noted that while Varanasi is unquestionably a city that draws its identity from the religious, and is predominantly Hindu in its outward appearance, religious tourism and pilgrimage rituals also draw in a fair number of Buddhists because of the city's proximity to Sarnath.

⁷⁴ The ASI does not make visitor statistics available to the public. Anecdotally speaking, it is clear that the number of visitors to the Jaipur and Delhi observatories makes a dramatic leap upward in terms of foreign tourists during high season (roughly December-February), but even in the heat of summer, the observatories are well visited by tourists. The situation is different in Ujjain. In the 1930s, visitation statistics were high (7,910 in 1931-32 CE, and 10,468 in 1932-33 CE), but the 1940s saw a dramatic decrease in numbers (3,700 in 1941-42 CE). In my experience, the number of daily visitors to the observatory is even lower today. In the summer, the majority of the visitors arriving in a day came to visit the temple of Hanuman, although a few (2-5) stopped with the intent of exploring the observatory. In Varanasi, the numbers appear to be even lower. On two consecutive days during the rainy season (that is, during pilgrimage season), I was the only visitor to the observatory, and according to the ASI employee on site, this was entirely typical. *Administration of the Gwalior State During the Year 1933-1934 (From 1st July to 30th June)* (Lashkar: Alijah Darbar Press, 1936), 150; *Administration of the Gwalior State During the Year 1941-1942 (From 1st July to 30th June)* (Lashkar: Alijah Darbar Press, 1946), 53.

be told within a framework of religious devotion.⁷⁵ That this is true can be seen in Varanasi where the observatory suffers because the pilgrimage and tourist populations view the riverside landscape primarily in terms of Hindu rituals. Second, these extremely local interpretations run the risk of perpetuating assumptions about India's intellectual isolation in the present and in the past. As the situation stands today, we are left with little sense of the intended interconnectivity among the observatories as conceived by Sawai Jai Singh. The patrons and laborers who built the instruments, and the landscapes in which they existed, are assumed to be mute and/or tightly bounded and are discussed as if they had little connection to scientific discourse outside India. Thus, in the past fifty years, we have completed the process set in motion by Barker, Williams, and Hunter, turning sites once involved in a global discussion about astronomy into monuments limited in their meaning to their immediate environments and histories. In this dissertation, I have argued the need for a history of the observatories that interprets the instruments relative to their local and regional landscapes. But I have also demonstrated that though the observatories were tied to physical locations and concrete work environments, they also existed within a global scientific landscape and functioned within an international discussion of astronomy that stretched from the capitals of Asia to the capitals of Europe. While there are many different ways to tell the history of the observatories, at least one stream of thought should be capable of making visible the connection between the local and the global, disavowing the colonial assumption of intellectual and physical isolation.

⁷⁵ As David Lowenthal long ago pointed out, heritage is not history. "Prejudiced pride in the past is not the sorry upshot of heritage but its essential aim." Heritage discourse function to make the past "ours" and representative of "our story," not to highlight the complexities of history. The stripping of certain historical markers from the dominant popular narrative of the observatories is perfectly consistent with the common use of architecture and landscape to tell a story meaningful to certain groups of stakeholders. See David Lowenthal, "Fabricating Heritage," *History and Memory* 10, no. 1 (Spring 1998): 5-24.

5.3 Going Global

In a complicated twist, at the same time that the observatories have been denied global relevance in historical analyses, they have developed multiple global identities since the era of Sawai Jai Singh. Visual representations of the observatories have been in circulation since at least 1777 CE, when engravings of Archibald Campbell's drawings of the Varanasi observatory were published in the *Philosophical Transactions of the Royal Society of London*. Thomas and William Daniell published their highly romanticized images of the Delhi observatory at the turn of the nineteenth century in the second volume of *Antiquities of India*, and almost as soon as the camera arrived in India, the observatories became a favorite subject for tourist postcards. But since the beginning of the nineteenth century, the instruments have been not only been represented to, they have been borrowed by, foreign audiences for a variety of purposes, few of them related to their original functions as astronomical apparatuses. For instance, as early as 1817 CE, the Samrāt Yantra and the Miśra Yantra were plucked from their homes in Delhi, stripped of their astronomical associations, and dropped into the Parisian playground of Beaujon Garden to serve as the superstructure for a modern form of frivolity, the *montagne russe* (figures 5.20-5.21).⁷⁶ The arcs and lines of the instruments that had once referred to latitudes and horizons became curvilinear tracks and precipitous inclines, constructed solely for the entertainment of a suburban population. The practice of reducing the instruments to form, devoid of meaning, was repeated in various guises, particularly so by artists and art historians in the twentieth century. The astronomical instruments of Delhi and Jaipur became exemplars of Cubist and Surrealist "meaninglessness" and were praised as works of "beautiful pure function,"

⁷⁶ Penelope Chetwode, "Delhi Observatory: The Paradise of an Early Cubist," *Architectural Review* (February 1935): 59-60.

with no quarter given to lingering cultural or historical associations.⁷⁷ In the hands of an artist like Isamu Noguchi, the Jaya Prakāśa Yantra could be transformed into a sunken garden, and the Samrāt and Miśra Yantras could be distilled into the familiar shapes of playground equipment (figures 5.22-5.25).

Perhaps because colonial forces had drained the observatories of obvious meaning, or simply because they refuse to communicate directly as aesthetic objects, many of the instruments have been easily adapted as symbols to represent various political and economical agendas throughout the world. As representations, these images and objects operate as empty vessels, floating around the globe while waiting to be captured and assigned a new value. Once dislodged from their point of origin and re-anchored at a particular location—say, in Germany or Japan—the instruments are imbued with fresh meanings that are only intermittently responsive to the verifiable history of the observatories. Moreover, their symbolic emptiness also allows them to represent concurrently multiple and often contradictory positions. In a single moment, they can perform a narrative of antiquity and modernity, spirituality and science.⁷⁸ The imitative images sometimes speak exclusively of the past, sometimes only of the present. On occasion, they invite the audience to exist in both time frames simultaneously, deliberately drawing the observer into a traditional past while arguing for an understanding of India based on twenty-first century technomodernity.

One notable example of this phenomenon could be seen in Germany in 2006 CE, in the form of a sleek glass and metal replica of the Samrāt Yantra (figure 5.26). This mock-up was

⁷⁷ Ibid., 57-61; Isamu Noguchi and W.J.C., “The Observatories of the Maharajah Sawai Jai Singh II,” *Perspecta* 6 (1960): 68-77; Steve Parnell, “Back Issues,” *Architect’s Journal* 227, no. 24 (June 19 2008): 55; Stella Snead, “Observatories Reveal the Imagination of India and the Mind of a Maharaja,” *Industrial Design* 7 (January-June 1960): 56-61.

⁷⁸ Although the context is different, this ability of the symbols to communicate in several registers simultaneously is reminiscent of Hassan Fathy’s desire to reconcile the local, the particular, and the traditional with a transcultural technomodernity in his development for New Gourn, Egypt. See Panayiota I. Pyla, “Hassan Fathy Revisited,” *Journal of Architectural Education* 60, no. 3 (2007): 28-39.

displayed in tandem with an IRS Satellite at the Hannover Messe, an annual forum for showcasing industrial technology to an international audience. Each year, the trade fair celebrates the progress of a “partner country” and awards that country additional room in the show pavilion for the promotion of new developments in relevant industrial fields. The spotlight shone on India in 2006 CE and subsequently highlighted the work done by the organizing committee to “present a rounded image” of the nation and its industries.⁷⁹ The designers of the Indian showcase placed a replica of the Samrāt Yantra, a symbol of “India’s traditional pre-occupation with time and space,” in the supplementary display area to compel “the visitor’s curiosity so as to make him spend his unanticipated time at the Indian Pavilion.”⁸⁰ During several festive evenings, the instrument served as a backdrop for the “India Everywhere” fashion show, the Fashionnova Fashion Show, and an “India Evening,” all of which combined to provide “a holistic experience and showcas[e] different facets of India to the visitors (figure 5.27).”⁸¹ The replicas, which were intended to snag the curious gaze of the audience with their unusual formal characteristics, hovered somewhere between the past and the present, as the organizers of the Indian showcase relied on a representation of its “traditional” expertise in astronomy to lend a voice of authenticity to the display of their most recent endeavors in automotive, energy, engineering, research and development, subcontracting, digital processes, and microtechnology industries.⁸²

The designers of the Indian pavilion for the Hannover Mess might have been hedging their bets, gambling that if Europeans were not sufficiently intrigued with their invocation of

⁷⁹ Hannover Messe, “India Pavilion - Hannover Messe 2006,” <http://www.hannovermesse2006.com/india-pavilion.asp> (accessed September 5, 2007).

⁸⁰ Ibid.

⁸¹ Ministry of Commerce and Industry Government of India, “India at Hannover Technology Fair 2006,” (New Delhi: Indian Brand Equity Foundation, 2006), 37.

⁸² Ibid., 35.

India's past, the polish of materials or glitz of high fashion would capture much-desired attention. It was a delicate balancing act, ensconcing a historical symbol in the swag of the present and the promise of the future. This was a similar, but not quite parallel, move to the one made by the designers of the Inter-University Centre for Astronomy and Astrophysics (IUCAA) at Pune University in Maharashtra when they recreated the large Samrāt Yantra with modern materials in the early 1990s (figure 5.28). The guiding principle behind the design of the IUCAA campus was the architect's desire to create "a Model of the Cosmos...to express our own contemporary notions of what the Universe is about," and the replica Samrāt Yantra can be viewed as a mechanism for binding the eternal nature of the heavens with contemporary applications of the astronomical sciences.⁸³ The instrument refers openly to the past, but also implies a place in the present through its adaptation of form. The economizing pointed arches, necessary for reducing weight and cost in the massive stone structure of the original instrument, have been replaced with rectangular windows, and the plaster and marble quadrant scales have been transformed to steel.⁸⁴ The instrument retains half of its original purpose, functioning as a sundial in daylight hours, but is meant to be experienced more as a monument representing an eternal and thus timeless human desire to connect with the cosmos than as a working instrument with a specific historical reference.

⁸³ S. Ramaseshan, "IUCAA Revisited," *Current Science* 72, no. 4 (1997): 281.

⁸⁴ The appearance of the Samrāt Yantra in Pune is not surprising given the close ties between the architect of the IUCAA, Charles Correa, and heritage discourse in the city of Jaipur. Arguably, Correa has done more than any other living person to promote the so-called Vedic origins of the city plan, and relies heavily on astronomical symbolism in his explication of city space. A reification of his ideas on the relationship between Jaipur, space, astronomy, and materiality can be viewed in his design for the Jawahar Kala Kendra, a center for indigenous arts in Jaipur. See Charles Correa, "Jawahar Kala Kendra, Jaipur = Museum at Jaipur," *Spazio e società* 15, no. 16 (October-December 1992): 114-21; Patricia C. Jones, "Squaring the Circle: Jawahar Kala Kendra, Jaipur, Rajasthan, India: Charles Correa, Architect," *Architectural Record* 180, no. 3 (March 1992): 98-105; Vikramaditya Prakash, "Identity Production in Postcolonial Architecture: Re-Covering What We Never Had," in *Postcolonial Spaces*, ed. G. B. Nalbantoğlu and C. T. Wong (New York: Princeton Architectural Press, 1997), 39-52.

In other recent implementations of the instruments, however, the replicas speak only for the past. For instance, the Jaipur observatory has been exported to Japan in the form of full-scale concrete mock-ups of the small Samrāt Yantra and Rāśivalyas (figures 5.29-5.30). Built as part of an outdoor exhibition in Gunma Prefecture representing the history of observational astronomy, the instruments have been stripped of their communicative materials. Gone from the small Samrāt Yantra is the red stone cladding with its connotations of Mughal imperialism; cleansed from the Rāśivalyas is the yellow ochre wash that harmonizes the instruments with the Jaipur cityscape. By replacing these distinctive finishes with the flat gray of exposed concrete, by replicating angled surfaces oriented to the observing planes at Jaipur, the instruments no longer make specific reference to the time and place of their origin. This denial makes it all the easier to position the structures as an intermediary between the reproduction of Stonehenge and the new buildings of Gunma Astronomical Observatory. While not precisely equated with the trabeated architecture of the Neolithic/Bronze Age Stonehenge, the instruments nevertheless fail to obtain the modernity of the domes sheltering the reflector telescopes of the nearby observatory, even though they were designed and built at a time much nearer to the twentieth than the fifth century CE.

Within India, the observatories—or at least their likenesses—have been almost entirely subsumed under a discourse of national identity. Part of this is surely accidental: in Delhi, the observatory has become a locus for state politics, as its conveniently located grounds serve as the starting and/or finishing point for protest marches that demand attention at the national level, and encamped protestors line its fences with tarpaulin tents to draw attention to their cause. However, the elevation of the observatories to the level of the national can also be attributed to the choices made by individuals and institutions when searching for symbolic representations of

state. For instance, an abstraction of the Miśra Yantra represented the nation to its neighbors during the 1982 IX Asian Games, and more faithful depictions of the instrument continue to make periodic appearances around the world on postage stamps and first day covers (figures 5.31-5.32). Similarly, for many years running, a drawing of the small Samrāt Yantra from the Jaipur graced of the *Indian Journal of History of Science*, the proceedings of the Indian National Science Academy (figure 5.33). In print form, this reproduction of the Samrāt Yantra has traveled around the world representing an institution that claims the entire history of South Asian science in the name of the nation-state of India.⁸⁵ A similar connection was made between the observatories and the nation by the American publishers of Gyan Prakash's book *Another Reason: Science and the Imagination of Modern India*. In this case, Princeton University Press elected to reproduce an image of the Rāśivalyas in Jaipur on the cover of the book, despite the fact that these instruments formed no part of Prakash's arguments on the place of science in the formation of the modern nation of India (figure 5.34).⁸⁶

As these few examples show, it is difficult to predict how the observatories will be used or be received once their likenesses are released into the world. We should proceed with caution in handling such slippery symbols, but at the same time, such imitative implementations of the observatories offer us a chance to see just how far a representation can be stretched before it loses its connection with its history and purpose. The opportunity for this type of scrutiny is offered nowhere more clearly than in the Maharishi Vedic City, near Fairfield, Iowa, where followers of the Maharishi have constructed a 1.5 acre "Vedic Observatory" containing replicas of many of the instruments from the Jaipur observatory (figures 5.35-5.36). While these

⁸⁵ It is not clear, for instance, why the Samrāt Yantra should be considered by a global audience as a specifically "Indian" symbol, given that it was built more than two centuries before the nation-state of India was brought into being by Partition.

⁸⁶ Gyan Prakash, *Another Reason: Science and the Imagination of Modern India* (Princeton: Princeton University Press, 1999).

instruments retain some of the functionality of the original instruments, their work as miniature sundials has little to do with the purpose intended for them by the Maharishi. As promotional literature informs us,

the real fascination of the Vedic Observatory is the connection between the structure of the observatory, which mirrors the structure of the universe, and the structure of our own physiology. This connection is described in ancient Vedic literature. Visitors to the observatory will enjoy the experience of the [sic] their own inner intelligence and it's [sic] relationship to the orderly intelligence of the universe as displayed in the planets and stars. The result is increased balance of mind and body.⁸⁷

The masonry instruments, derivative of the eighteenth-century prototypes built in Jaipur, are meant to invoke the overtly ancient foundation of Vedic astronomy, and yet still communicate to the visitor in the present tense about the place of his or her body in the universe. The power awarded to these representations goes far beyond what Sawai Jai Singh must have envisioned while designing the instruments in Shahjahanabad and Jaipur. Moreover, the history of the instruments as written by the Maharishi denies their recent origins and assigns them instead to the Vedic era (the 12th to 10th centuries BCE). In addition, the spiritual influence of the instruments is not site specific, nor tied to the materiality of the instruments in any way. Graduates of the Maharishi University of Management have initiated similar projects in Europe, reproducing Sawai Jai Singh's "Vedic" instruments at the Maharishi European Research University in the Netherlands, for example.⁸⁸ In fact, one need not experience the instruments in their "natural" outdoor environment at all in order to appreciate their ability to reconcile mind and body. Case in point: the entire Maharishi Vedic Observatory may be purchased in table-top scale for home use (figures 5.37-5.38). In this case, the instruments and their alleged connection

⁸⁷ Maharishi Vedic City, "Maharishi Vedic Observatory," <http://www.maharishivediccity.com/attractions/observatory.html> (accessed November 22, 2010).

⁸⁸ Tim Fitz-Randolph, "Maharishi Vedic Observatory," <http://www.fitz-randolph.com/tim/tim.html> (accessed November 24, 2010).

to Vedic science become portable, but as objects, they cease to maintain even an illusion of functionality. The entire history of the observatories is elided, turning the instruments into emblems of an almost rootless twenty-first century spirituality rather than tools of observational astronomy.

5.4 Conclusion

That the observatories in Delhi, Jaipur, Ujjain, and Varanasi continue to exist as living sites in the built environments of their respective cities is unquestionable. As we have seen in Delhi, the observatory grounds have been drawn into the arena of national politics. In Jaipur, the large Samrāt Yantra has been adopted as a symbol of urban development by the Jaipur Nagar Nigam (Jaipur Municipal Corporation) (figure 5.39), and the observatory itself is operated by the State of Rajasthan as a lucrative tourist site. The observatory at Ujjain makes available published copies of the ephemerides compiled by astronomers on site and plays host to devotees of the neighborhood Hanuman temple. Because of the propensity of the Archaeological Survey of India to rent out historic monuments to filmmakers, the Varanasi observatory periodically pops up as part of the scenery in Bollywood blockbusters (figure 5.40). Each of the observatories is offered as an example of “the best” of their respective cities in guidebooks designed to lure in both domestic and foreign tourists. Representations of various instruments circulate throughout the world as photographs, sculptures, postage stamps, book covers, and coffee table collectibles. Yet, very little interpretive work has been done to ensure any of these uses—as a tourist monument, a political symbol, or a religious artifact—maintain a connection with the observatories or their historical context. Instead, the sites continue to be pushed along their own paths through time and space, exhibiting an amazing adaptability in use. This

flexibility can be viewed as one last legacy of a colonial historiography that characterized the observatories as void of meaning and history.

Figures 5.5

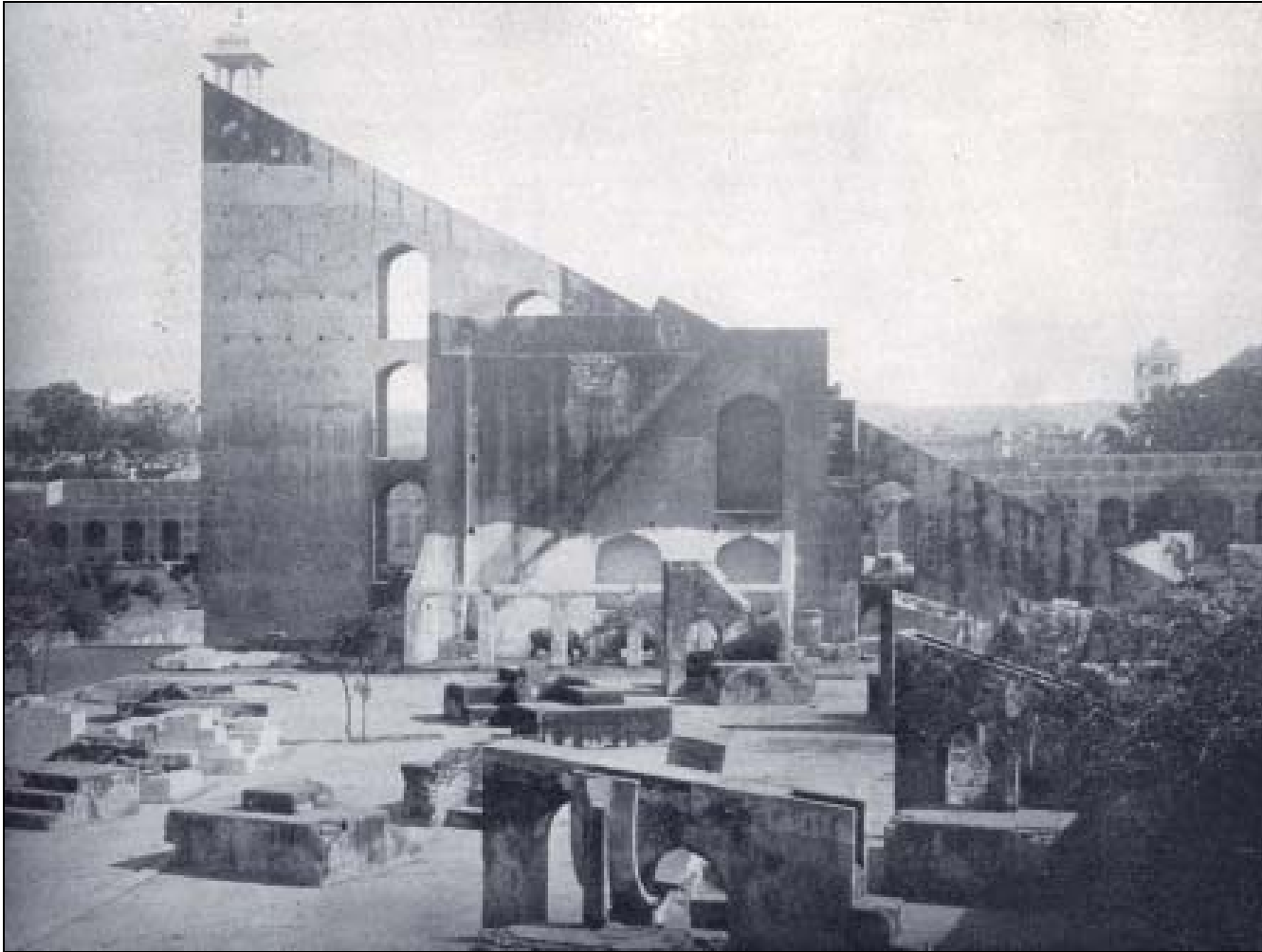


Figure 5.1. Photo-engraving of Jaipur Observatory, c. 1890 CE. From Shepp, 411.

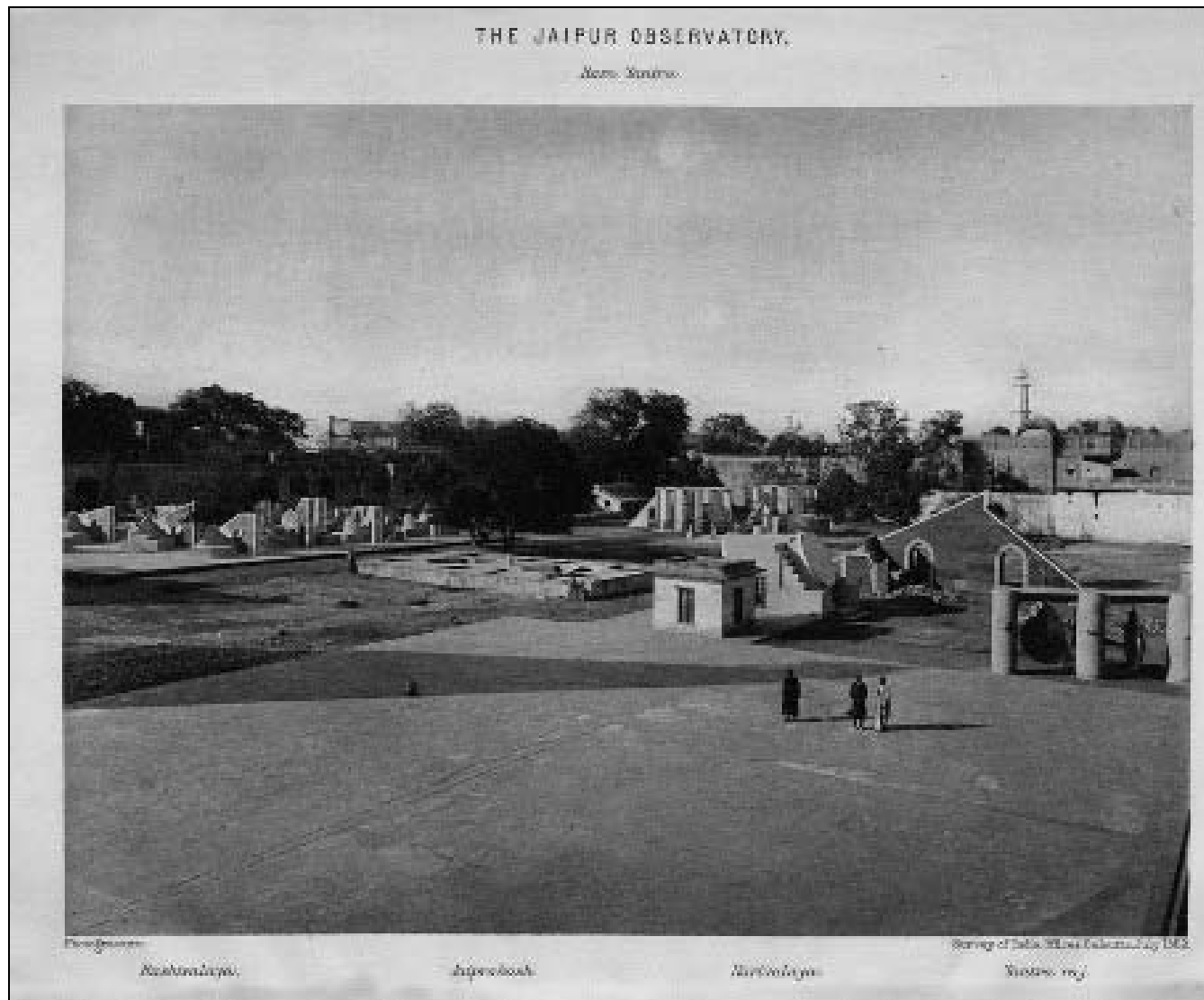


Figure 5.2. Photo-engraving of Jaipur Observatory after 1901 CE Renovation. From Garrett, n.p.



Figure 5.3. Rubble core of quadrant terminus, Samrāt Yantra, Jaipur, July 2007 CE.



Figure 5.4. Restored walls showing new *kangurā* at top, Jaipur, July 2007 CE.



Figure 5.5. Restoration work on Samrāt Yantra, Jaipur, July 2007 CE.



Figure 5.6. Former Headquarters at Ujjain Observatory, July 2007 CE. Courtesy of Crystal Watson.



Figure 5.7. Headquarters at Ujjain Observatory, August 2009 CE.



Figure 5.8. Telescope shelter and rails, Ujjain, August 2009 CE.



Figure 5.9. Samrāt Yantra before restoration, Varanasi, c. 2001 CE. Courtesy of Matthew Arcus.



Figure 5.10. Restored observatory, Varanasi, August 2009 CE.



Figure 5.11. Miśra Yantra, Delhi, 1955 CE. Courtesy of Reuel R. Sutton © California Academy of Sciences.



Figure 5.12. Lotus growth at Samrat Yantra, Delhi, c. 1975 CE. From Kern, *Kalendarbauten*, p. 63.



Figure 5.13. Concrete fill at Samrāt Yantra, Delhi, March 2009 CE.

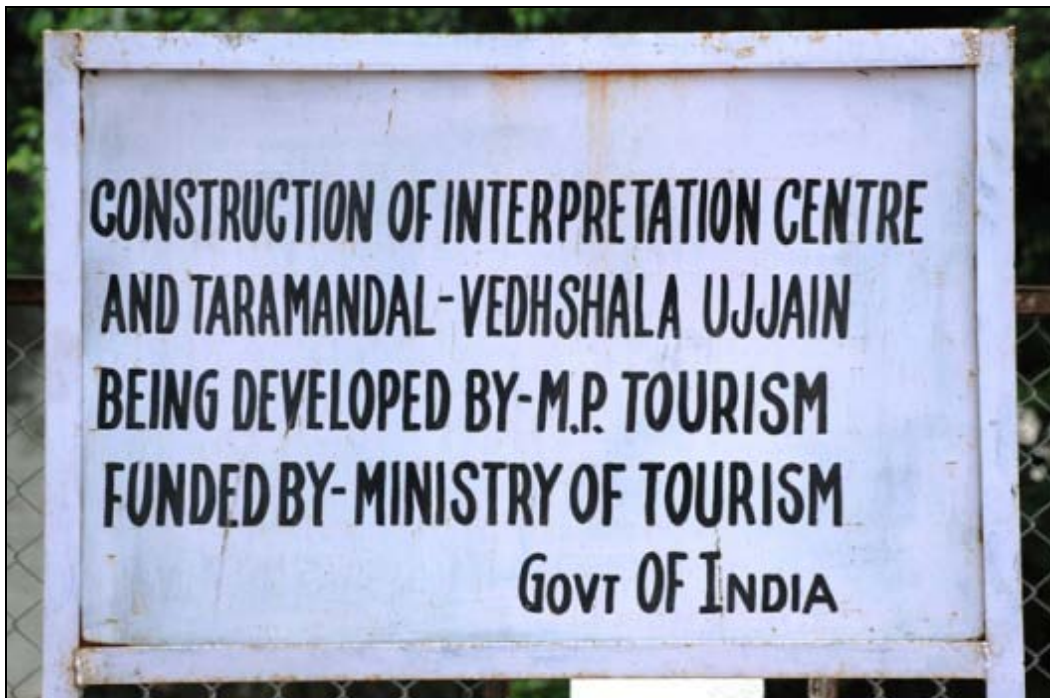


Figure 5.14. Observatory sign, Ujjain, September 2009 CE.



Figure 5.15. Observatory sign, arrow highlighting the Hindi words “Jantar Mantar,” Ujjain, September 2009 CE.

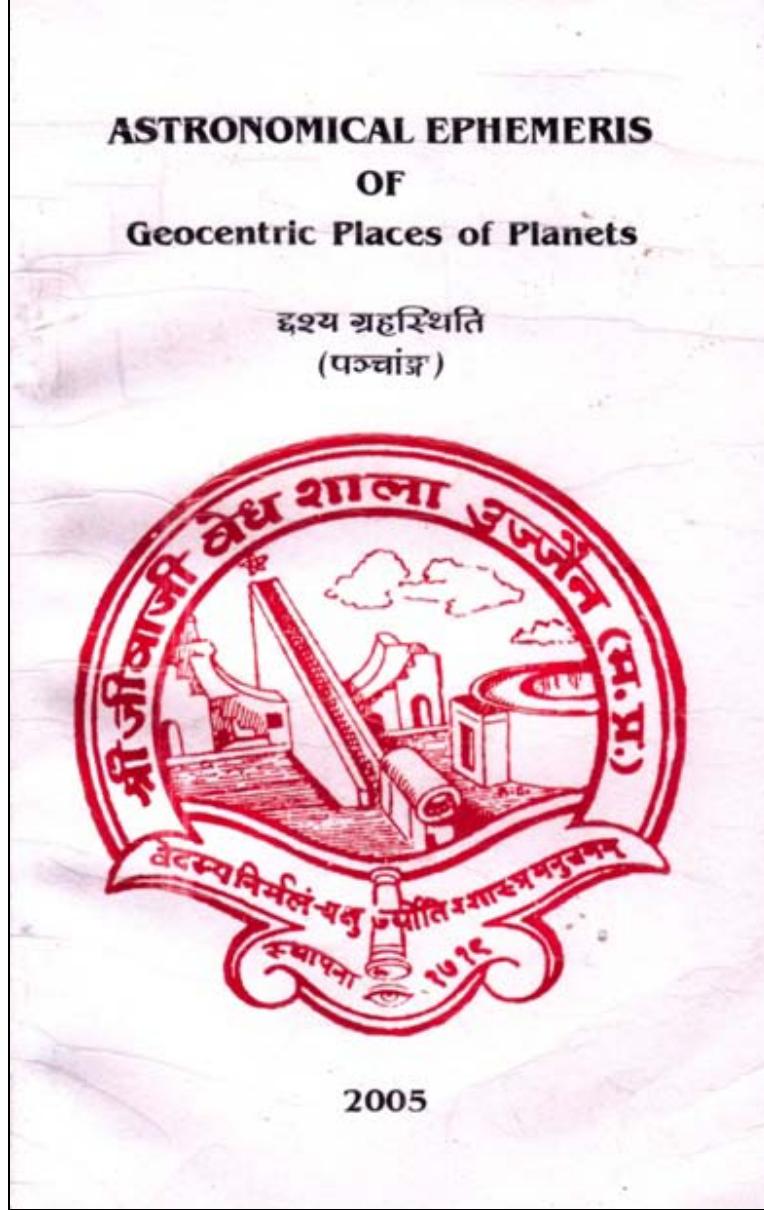


Figure 5.16. Cover of Annual Publication, Ujjain Observatory, with Hindi logo.

ननांशेभ्यः क्रान्तिस्तया सूर्यभुजः					
(सू. ति. अ. ३ श्लो. १४-१५)					
शुद्ध नतांशाः = दक्षिण नतांशाः :-			क्रां. अं. रा. स्पष्ट सूर्य		
क्रान्ति = अक्षोशाः :-			+ + भुजांशा		
" = " + ३०			+ - ६ रा - "		
			+ + ६ रा - "		
			- + १२ रा - "		
क्रान्तिशा	भुजांशाः	अक्षोशाः	भुजांशाः	क्रान्तिशा	भुजांशाः
अ. क.	अ. क. वि.	अ. क.	अ. क. वि.	अ. क.	अ. क. वि.
० ०	० ० ०	८ ३०	२१ ४८ १३	१० ०	४७ १६ ५३
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२ ०	५ १ ५२	१० ३०	२७ ४५ ७	१८ ०	५४ ५३ ४८
२ ३०	६ १७ ३४	१२ ०	२८ ३९ ५	१९ ३०	५७ ० ५६
३ ०	७ ३२ २६	११ ३०	३० ३ ५५	२० ०	५९ १५ २१
३ ३०	८ ४९ २८	१२ ०	३१ २९ ५१	२० ३०	६१ ३८ ४६
४ ०	१० ५ ४४	१२ ३०	३२ ५६ ५६	२१ ०	६५ १३ ४४
४ ३०	११ २२ १५	१३ ०	३४ २५ १२	२१ ३०	६७ १४ ९
५ ०	१२ ३९ ३	१३ ३०	३५ ५५ ३	२२ ०	७० १६ ४३
५ ३०	१३ ५६ १२	१४ ०	३७ २६ २९	२१ ३०	७४ ४ ४४
६ ०	१५ १३ ४२	१४ ३०	३८ ५९ २२	२१ ०	७९ ४ १६
६ ३०	१६ ३१ ३७	१५ ०	४० ३४ १६	२३ ०	८१ २० ८
७ ०	१७ ५६ ३७	१५ ३०	४२ ११ १०	२३ १५	८१ ४२ ५५

Figure 5.17. Sign in Sanskrit and Hindi at Ujjain Observatory, September 2009 CE.



Figure 5.19. Ornamental globe outside new interpretive center, Ujjain, September 2009 CE.

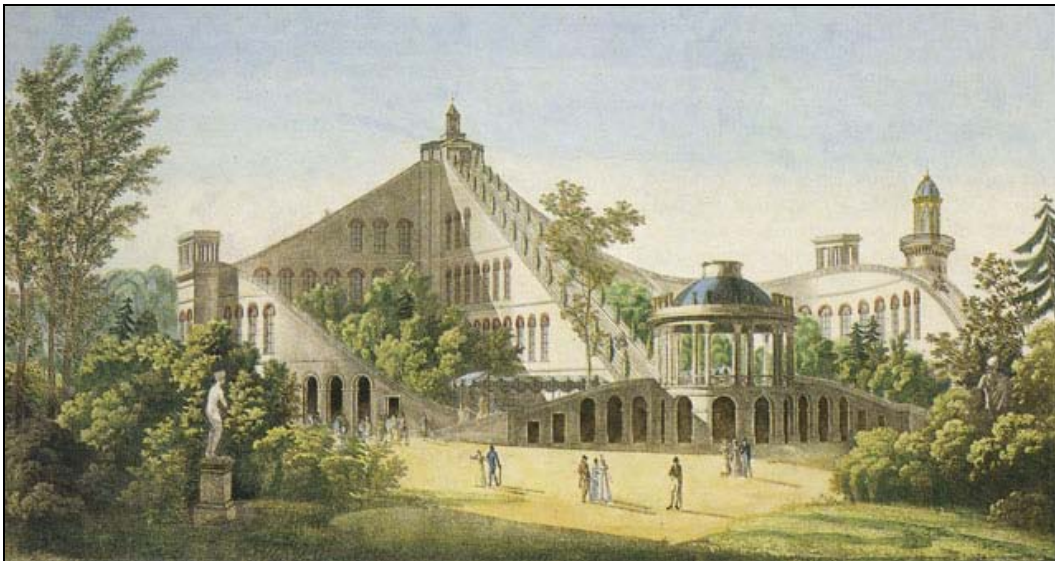


Figure 5.20. Gilles-Antoine Langlois. *Montagnes Beaujon*, c. 1817 CE.



Figure 5.21. Hand-colored engraving, after drawing by Louis Ambroise Garneray. *Promenades aériennes-Jardin Baujon, Honoré de la Présence de La Majesté, le 2 août 1817*. Courtesy of ParkOtheK.



Figure 5.22. Isamu Noguchi, Bronze, Unrealized model for Sunken Garden for the Beinecke Rare Book and Manuscript Library, 1960 CE. Courtesy of the Isamu Noguchi Foundation and Garden Museum, New York.



Figure 5.23. Isamu Noguchi, Black Slide Mantra, Odori Park, Sapporo, Japan, 1988 CE. Courtesy of Nan Jiang.

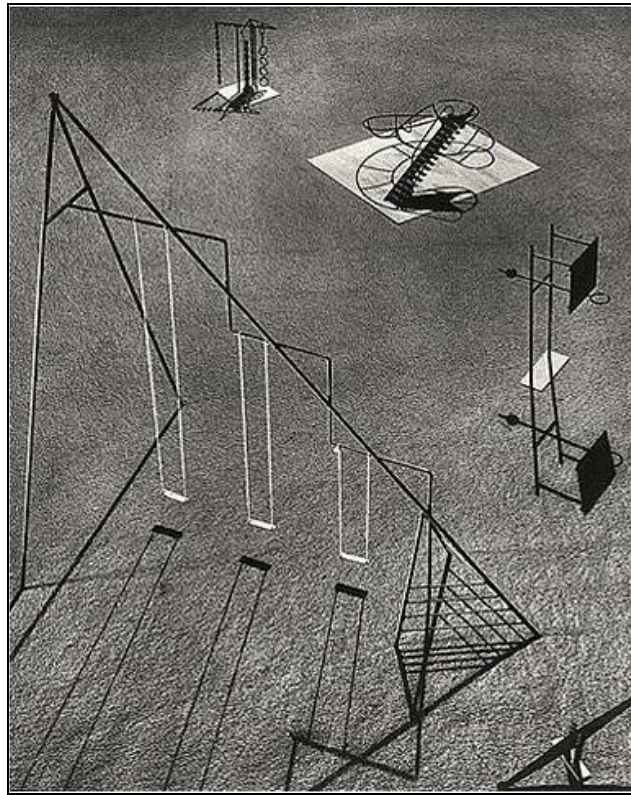


Figure 5.24. Isamu Noguchi, Model for Playground Equipment for Ala Moana Park, 1939-1940 CE. From Grove and Botnick, no. 167.



Figure 5.25. Isamu Noguchi, Playscapes, Piedmont Park, Atlanta, 1976 CE. Courtesy of Mary Ann Sullivan.



Figure 5.26. Samrāt Yantra replica at Hannover Messe 2006 CE. Courtesy of Hannover Messe.



Figure 5.27. Fashion show in the Indian pavilion, Hannover Messe 2006 CE. Courtesy of Hannover Messe.



Figure 5.28. Replica of Samrāt Yantra, Pune. Courtesy of Inter-University Centre for Astronomy and Astrophysics.



Figure 5.29. Outdoor Exhibition, Gunma Astronomical Observatory, with Small Samrāt Yantra and Rāśivalyas in foreground. Courtesy of Gunma Astronomical Observatory.



Figure 5.30. Outdoor Exhibition. Courtesy of Gunma Astronomical Observatory.



Figure 5.31. Asian Games Official Logo, abstraction of Mísra Yantra.



Figure 5.32. Postcard of Miśra Yantra with Asian Games stamp and cancellation. 1981 CE.

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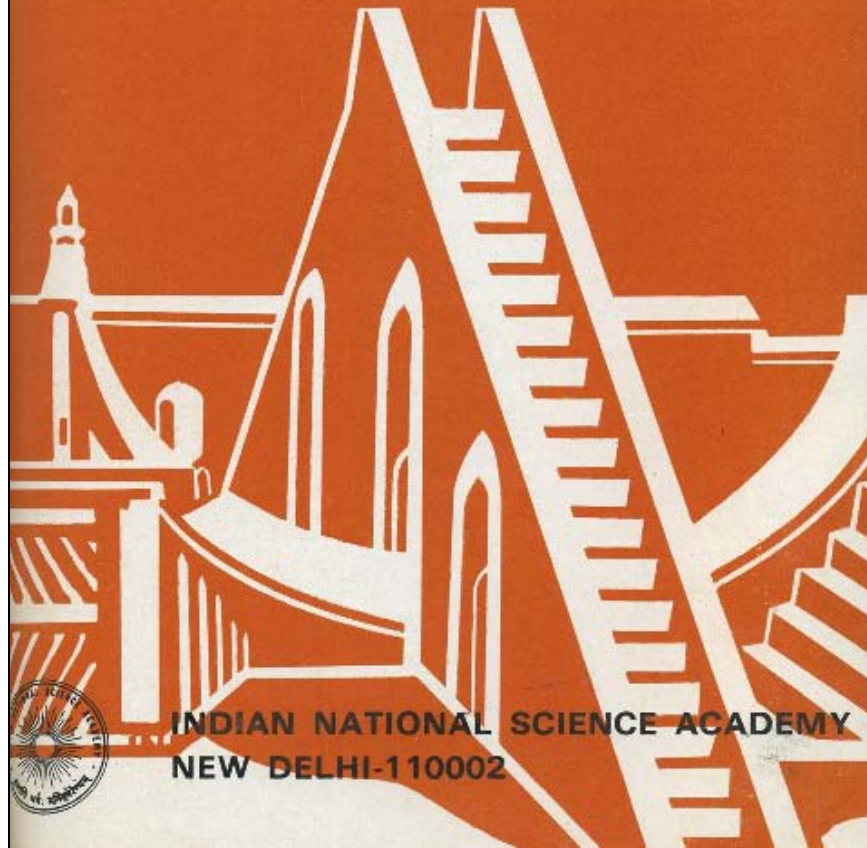


Figure 5.33. *Indian Journal of History of Science.*



Figure 5.34. Cover from Gyan Prakash, *Another Reason*, showing Rāśivalayas in Jaipur.



Figure 5.35. Aerial view, Maharishi Vedic Observatory. Courtesy Maharishi University of Management.



Figure 5.36. Rāma Yantra, Maharishi Vedic Observatory, Iowa. April 2010 CE. Courtesy of Ben Branch.



Figure 5.37. Tabletop version of Maharishi Vedic Observatory.



Figure 5.38. Sales samples of Maharishi Vedic Observatory.



Figure 5.39. Sign from Jaipur Nagar Nigam, with acronym forming the body of Samrāt Yantra, 2006 CE.



Figure 5.40. Opening scene from Bollywood super hit *Bunty aur Babli*, Mān Mandir Ghat, Varanasi, 2005 CE, with Digamśa Yantra at upper right.

CHAPTER SIX

CONCLUSION

This project is primarily an analysis of the relationship between landscape and patron, architecture and space, and as such, represents an alternative approach to the writing of history. It embraces the spatial and takes seriously the assertion that architecture and landscape are not simply witnesses to history but participants in the process of change, development, and loss. By turning away from the conventional archive, and examining instead the built environment and landscapes of northern India during the first half of the eighteenth century, we can begin to see a narrative of history that is underpinned by motion, exchange, adaptation, and fragility.

The astronomical observatories built under the patronage of the Maharaja Dhiraja Sawai Jai Singh II of Amer and Jaipur offer new territory on which to ground an analysis of the colonial discursive formations that have affected our understanding of the architecture of South Asia. My reading of the late-eighteenth-century CE English-language histories of the observatories demonstrates how heavily the burden of colonial history still weighs on the instruments and their respective environments. Though the observatory at Varanasi has long served as the paragon for understanding the form and development of Sawai Jai Singh's astronomical instruments, the observatory outside Shahjahanabad was the primary setting for the Maharaja Dhiraja's first experiments in instruments design and observational astronomy. The space at Shahjahanabad functioned as an open-air laboratory in which Sawai Jai Singh attempted to correct perceived flaws in his instruments through the adaptation and application of well-known building and construction technologies. An analysis of the instruments at the observatory in Jaipur makes obvious that the designs implemented there benefitted from the early building and observation experiments at Shahjahanabad. By c. 1730 CE the center of creativity and labor had extended to

more fully include the site at Jaipur, and it is from that location that Sawai Jai Singh established connections to the observatories at Mathura, Ujjain, and Varanasi.

When looking at the fiat city of Jaipur, it becomes obvious that the observatory in the City Palace complex participated in a mutable local landscape. It was intertwined with the *karkhāna* system, the residential palace, and the complexities of labor, all relationships that were being played through and on the local landscape. Here, we can see how Sawai Jai Singh was forced to facilitate the transfer of knowledge between disparate working groups. Within the walls of the observatory, day laborers and low-level astronomers cooperated to design and build the stone instruments. However, the creative output of the observatory also owed much to the group of literature astronomers working outside the grounds of the observatory proper. The efforts of all these workers were entangled in the productive spaces of the nearby Jaleb Chowk where the royal *karkhānas* produced the raw materials used to build the instruments, to write the astronomical treatises derived from the instruments, and to recompense the high-ranking astronomers. The institutional relationship between the workshops, the astronomers, and the manual laborers was made manifest by the frequent presence of Sawai Jai Singh as he traveled from the relatively private spaces of the Chandra Mahal, through the Jaleb Chowk, into the observatory, and back again. This spectacle of royalty was enacted on a larger scale as well whenever the Maharaja Dhiraja traversed the distance between his new residential palace and the former capital of Amer, especially during the first five years of work at the observatory. Winding its way along the improved road between the two cities, the royal entourage reminded the residents of Sawai Jai Singh's expanding kingdom of his relative position of power as a patron of architecture and science.

The passage of the king's body through space signified wealth and power to the local populace. However, this dissertation demonstrates that Sawai Jai Singh's figurative grasp could be made weak, and that the connections between the institutions in Jaipur and those located in extramural space were oftentimes fragile. Sawai Jai Singh was always striving toward the intramural, attempting to import even more knowledge resources from foreign locales so he could settle them in his kingdom on a semi-permanent basis. He made three separate appeals to the Society of Jesus for aid in bringing information about and experts in European astronomical practices to Jaipur. On the surface, it seemed as if these attempts were successful, as he was able to set Portuguese, French, and Bavarian Jesuits in motion in pursuit of his goal. He was able to exploit the communicative networks of the Society in such a way that he was freed of the obligation to travel as well as the possibility of indebting himself to foreign states by requesting the right of passage through their territories. However, distance and time turned out to be almost insurmountable obstacles in this endeavor, as were the weather and the demands made of the Jesuits as they moved across an unpredictable topography. In addition, the institutional culture of the Society of Jesus slowed communications to the point that their combined efforts still turned out to all but useless for Sawai Jai Singh's work. Taken together, these issues made it almost impossible for Sawai Jai Singh to avail himself of European astronomical expertise while constructing his observatory in Jaipur, and he went to his death in 1743 CE without having managed to fully explore ideas developed on the subcontinent of Europe.

After the death of the Maharaja Dhiraja, all evidence of the production and movement of knowledge was slowly erased from a historical landscape, at least the landscape as described in English-language sources. Some trace of the liveliness and motion that characterized Sawai Jai Singh's labors as an astronomer can be read in the treatise of the Austrian Jesuit, Father Joseph

Tieffenthaler. However, Tieffenthaler's descriptions of the observatories arrived on the European stage at the precise moment British colonial power was being consolidated in east India. Because the British had recourse to experts in Sanskrit, the language they was assumed to represent the entirety of India's astronomical tradition, colonial scholars working out of Calcutta became the de facto representatives of Indian astronomy and subsequently Sawai Jai Singh's observatories. For a variety of reasons, not the least of which is the disciplinary tendency to cite one's intellectual genealogy in one's scholarship, the colonial characterizations of the observatories has been well rehearsed in academic literature and continues to inform the standard narrative of Sawai Jai Singh's work.

Although the observatories ceased to function as working observatories soon after the death of Sawai Jai Singh, as built environments, they remained available for interpretation by various interested parties. They continue to exist in their local landscapes, and for now, they play often contradictory roles in local and regional heritage discourse, sometimes representing India's Mughal heritage, sometimes celebrating Hinduism or Vedic science. On the global stage, the observatories are often stripped of specifically historic references and are asked to communicate using only shape, form, and design. At the earliest moments of their lives, the observatories served as catalysts of motion, as knowledge, workers, patrons, and priests moved through space in response to their construction or use. Today, the observatories remain still, yet they circulate around the globe in representational form—photographs, sculptures, mock-ups, miniatures—simultaneously representing their country of origin as exemplars of antiquity and modernity. The diversity of interpretations assigned to these representations demonstrates how distant they stand from the observatories as historical objects, once firmly rooted in time and space, but now floating almost freely, waiting to be inscribed with new meaning.

Ultimately, this dissertation argues that Sawai Jai Singh's observatories and their stone instruments should be interpreted as part of a larger system of knowledge, spatial, and temporal control. While each site can be read within the context of local building and cultural practices, the observatories were not designed to operate as solitary institutions, but rather as components of a dynamic network of information production and exchange. In some ways, the observatories stand as monuments to a powerful patron, an individual who managed to pull together a massive amount of resources in support of an ambitious agenda of scientific inquiry. At the same time, the observatories offer evidence that regardless of the privileged position of the patron, the best laid plans will go astray, particularly if those plans are dependent on the successful navigation of the north Indian landscape. Most importantly, the observatories demonstrate that the study of the built environment and the landscape offers numerous interpretive opportunities that are not supported by material contained exclusively in the written or visual archive. It is only when we consider the place of the observatories in the historic landscape that we are able to see more clearly the role they played in the creation, mobilization, and adaptation of cultural and scientific knowledge at the court of the Maharaja Dhiraja Sawai Jai Singh II of Amer and Jaipur.

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