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Presenting Indian Science and Technology Heritage in Science Centres

Part III

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Introduction

Continuing from where we left off in the second part of the article, in this third and final part, areas that find a place in Our S&T Heritage gallery at National Science Centre, Delhi (NSCD), namely the technologies like Cannons, Coins, Glass, Art, Architecture, Music, Traditional Crafts, etc in which India has made profound contributions will be covered.

Cannons in India

India has a very rich heritage in the field of Cannons and that Cannons of varying sizes, shapes and material composition are found all across the Indian sub continent. India is perhaps one of the very few countries that can boast of a very rich presence of cannons. Not until long ago these treasures of India's past were not very well documented. Fortunately late Prof R Balasubramanium has carried out extensive research and made profound contributions on the rich collection of Cannons in India and his labour of love and extensive research has resulted in his publishing an internationally acclaimed book, The Saga of Indian Cannons, that has very rich illustrations supported with drawings and stunning photographs[1]. The choice of Cannons as a subject and for dedicating a section of the gallery at NSCD to this subject was largely based on the publication of a special thematically dedicated issue on this subject by INSA in its journal The Indian Journal of History of Science[2]. The display consisting of 3D models of different cannons, their engineering and fabrication details, material composition, dimensions and the technology of the cannons, were based largely on the findings made by Prof Balasubramanium and several of his coauthors in different articles of this special thematic issue and also in the paper Development of Cannon Technology in India[3] during the 16th to 18th Cent AD.

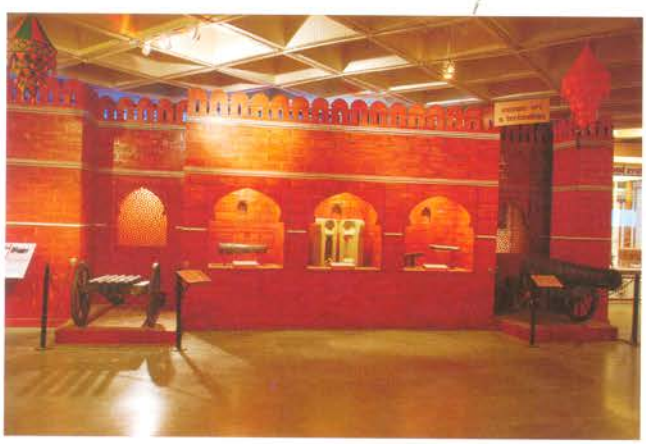

Fig. 1. Thematic display of the cannon section in "Our Science & Technology Heritage" gallery of NSC, Delhi.

This section of the gallery has a thematic display where a historic Moghul fort has been recreated in the exhibition space and this serves as a background to the display where cannons have been covered. This has been created in consideration of the fact that most of the cannons found across India are used mostly in the ramparts of the forts and *quilas*. In the foreground 3D models of some of the wonderfully crafted cannons of India have been displayed. Also on display are scaled down models of some of the cannons that depict the techniques that were used in making of these large sized forge welded cannons both of wrought iron and bronze. Cannon is any large tubular firearm designed to fire a heavy projectile over a considerable distance. Panchanan Neogi published the first catalogue of some of the wonderful forge welded iron cannons of India in his landmark 1914 book[4]. The use of cannons in warfare completely changed the complexion of the battles, an example of which can be seen from the first battle of Panipat fought in 1526 in which Babar won a stunning victory largely by using Cannon fire power skillfully. The high status of iron and steel technology in ancient and medieval India, which was covered in the previous issue of this journal, is amply reflected in the manufacture and use of forge welded massive wrought iron cannons of medieval India. These massive sized brilliantly forged and artistically crafted wrought iron cannons, since their introduction in Indian sub continent in the middle of fifteenth century right up to the pre-modern period, are scattered all over the country and their history, design, metallurgy, construction and technology have now been well researched and documented[1,2]. The 3D models of the cannons displayed in the gallery are based on the engineering drawings that show the actual dimensions and the manufacturing methodology used in forging these cannons, from the IJHS special thematic issue on Cannons.

The most notable cannons of India have been very richly illustrated in the gallery and also in the multimedia presentations that supplement the exhibition. These include the Rajagopala[5] cannon at Tanjore, the Dal Mardan – Forge Welded Iron Cannon

at Bishnupur[6], the Forge Welded Iron Cannon at Bada Burj, Golconda[7], the Bhavani Shankar Forge – Welded Iron Cannon at Jhansi[8]. There are other notable iron-bronze cannons and bronze cannons located in different sites across India including the famous Mulik e Maidan at Bijapur, and Jhoola *thop* at Gulbarga which also find a place in the gallery. Design, construction methodology and other significant technical features of some of these spectacular cannons, researched and documented by scholars, primary among them Prof Bala, have been presented in the exhibition. Museums, monuments, forts and palaces in India have a very large collection of the cannons. The collections of cannons in possession of the Chennai Museum have been very well researched and documented[9]. A high level of engineering skill was involved in the construction of these cannons. Some insights on the possible method of manufacture have been interpreted from detailed study of their structural condition and Ultrasonic measurements carried out on the walls of the cannon which also provide insight into the different layers of rings and their dimensions and the type of fittings adopted in the manufacturing of these cannons.

Fathullah Shirazi

The gallery has on display three interesting 3D models of the cannon innovations made by Fathullah Shirazi[10]. The first model is a large sized working model of ingenious cannon cleaner – the *Yarghu*. Fathullah Shirazi, a versatile genius engineer, under Emperor Akbar's regime, designed and developed an ingenious machine for cleaning multiple barrels. This machine was called 'Yarghu'. Shirazi was born and brought up in Iran and he migrated to India on invitation from Sultan Ali Adil Shah of Bijapur. Emperor Akbar recognized his genius talent and invited him to join the Moghul Court at Agra. Fathullah Shirazi designed several utilitarian machines like the Portable Cannon, Multi-barrel Gun, Portable Floor Mill and Yarghu. The Yarghu machine could clean 16 gun barrels simultaneously thus providing an advantage for the invading army. The whole structure was constructed in an octagonal frame mostly made of angle iron. It consisted of toothed wheel with spokes with the hub fixed on the central vertical shaft. The machine could easily be detached and carried from one site to another on elephant back thus providing easy mobility to the machine. It consisted of eight bars; each bar was a composite structure made of a pinion and two brush-rods of equal length. The Cannons, which were required to be cleaned, were lifted up to the frame and placed in the 16 sockets provided in the frame. A bullock was used to rotate the whole machine. When the bullock rotated the axle at the base the wheel mounted on the top would start rotating. The teeth of the wheel, which had a gearing system of rack and pinion arrangement, provided the requisite motion. During the motion the brush-rods, meant for cleaning the cannons were set to motion with the movement of the pinion. The soft cleaning material mounted on each of the 8 shafts easily cleaned all the 16 cannons that were mounted on them as the machine was set to motion by the bullock[11]. Shirazi's ingenious method of translation of motion from linear to vertical with gearing mechanism of the pinion and the wheel in a single composite mechanical structure was a remarkable technological step in the 16th century technological know-how anywhere in the world.

Fig. 2. Yarghu, the cannon cleaner.

Portable Cannon Machine

Shirazi also invented an interesting portable cannon device which made carrying artillery very easy. This machine was very light thus facilitating easy portability and providing advantage for the marching army. It had several parts, which could be screwed one into another and separated making it easy for portable transportation. The machine could be mounted ordinarily on a light carriage, and easily carried on to the top of a hill and rejoined for use. A greater advantage of it lay in its easy portability during post-haste expeditions. The emperor Akbar inducted many such machines into his army and extensively used these machines in very large numbers especially in places where transportation of very heavy artillery would prove to be a liability. A scaled down 3D model of a portable cannon device is displayed in the gallery.

Multi-barrel Gun

Shirazi also invented an ingenious Multi-barrel gun machine, a 3D model of which is placed in the gallery. This machine could serve the purpose of firing

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multiple artilleries with a single operation. All the barrels in this machine were cast or welded in a row so that they could be fired in quick succession by a single match-cord. The entire machine was transported from

Fig. 3 . Multi-barrel gun invented by Fatullah Shirazi.

one site to the other using elephant drawn cart, which was used as its mount. This machine was especially useful for battering forts and breaking the concentrations of outnumbering enemy. In very quick succession multiple guns were fired from this machine, which acted like a modern day automatic machine gun. Induction of this machine proved to be a decisive advantage for Akbar in his innumerable conquests. Some authors argue that this machine could rightly be called the forerunner of modern machine-gun.

Coin Making

Of all the materials of antiquity coins are the smallest, yet, as a class are most authoritative in records and also are the widest in range. Thousands of specimens of coins have been found in India all across the country and this rich collection of coins have now been preserved in different museums and also in private collections[12]. Coins have symbolized an important aspect of India's History and Culture. To the ancient Indians a coin was not a piece of inanimate metal with an official stamp but a form pulsating with symbols, names of Kings, Gods, Goddesses, etc. Sources of our knowledge of minting coins in ancient India comes from the indication given by relevant coins, archaeological findings of different coins and other references in literature. The ancient Indian coins were mainly made of silver, copper, gold, lead, bronze, brass, etc. Historians have used coins of different periods as a source for reconstructing Indian history. This is particularly important for ancient and early medieval periods where written records are not available in adequate numbers. Coins corroborate evidence gathered from other sources, in addition to their helping in the reconstruction of major historical events. One such utility of the coins can be found in corroborating the period during which the famous Delhi Iron Pillar was forged and also the emperor who was responsible for forge welding this metallurgical wonder[13].

Among the Indian coins of antiquity the gold coins from the Gupta period have a special significance[14] and as such the exhibit on coin making has a miniature diorama presentation where the coin manufacturing scene of ancient times is depicted. The manufacturing methodology used in the coin making of the golden coins from the Gupta period and the exemplary artistic skills that show case sculptural finesse of the artisans involved in the manufacture of these coins using die striking method stand testimony to the fact that these coins are the works of art rather than the currency used for financial transactions[15].

From the studies of eminent scholars we are now in a position to understand the development of Indian coinage in different parts of the subcontinent under various dynasties through the centuries. Some of the eminent coins from ancient India include the Kusana coins, Gupta coins, Sangam age coins, Satavahana coins, Banavasi Kadamba coins, Chalukya coins, Rashtrakuta coins, Hoysala coins, Pallava coins, Chola coins, Pandya coins, Kakatiya coins, Sultanate coins, Moghul coins, Maratha coins, Sikh coins, Vijayanagara coins, Hyder & Tippu coins, East India Company coins and other foreign coins. The exhibition has on display some of the replicas of coins from ancient India.

A recreated coin-minting scene is also shown in the exhibit which reveals typical technological practices used in ancient Indian coin making. The main techniques of coin making in ancient India included the Droplet Technique, Punch Marked Technique, Casting Technique and Die Striking Techniques. The exhibit also has on display a mould used in the minting of the coins in the diorama. The mould for making multiple coins displayed in the model is reconstructed from the findings of the rare mould discovered by Dr Birbal Sahni. This ancient clay mould for casting of a coin was discovered by chance by Prof. Birbal Sahni at Rohtak in 1938[16]. This discovery later led to the discovery of many thousands of fragments of terracotta moulds, which were used for casting of coins[17]. The bronze coin, about 19 mm. in diameter, of the Yaudheya series, discovered at this site has been dated to about 100 B.C. From the very large amount of material available, Prof. Sahni has been able to work out in greatest detail the entire story of the casting technique employed in manufacturing these Yaudheya coins.

Yaudheya Coin, 200 BC

In recognition of the uniqueness and antiquity of the Yaudheya coins the Department of Posts, Government of India, released a stamp of a denomination of Rs.2.00 and named it the Yaudheya Coin, 200 BC, on the eve of the Festival of India on 7th June 1985. The first day cover of this stamp finds a place in the display in the gallery. The stamp depicts a copper coin of the Yaudheya dynasty from 200 B.C. that symbolizes *Ahimsa*. The coin, whose obverse is seen on the stamp, is a numismatic rarity. Issued by the Yaudheya tribal republic of 200 BC, the coin is rich in the symbology so typical of those times. The deer represents the gentle and compassionate doctrine of "Ahimsa", the philosophy of Buddha, which held all life to be sacred. Above the deer appears the *"Kalash"*, the pot of plenty: and above the pot, the symbol of "Shri", goddess of good fortune and wellbeing. The reverse depicts the Republic's Deity, *Karthikeya*, the second son of Lord Shiva and His Consort Parvati[18].

Glass Technology

It was generally believed, based on the archeological findings from Arikemedu and some other south Indian sites, that glass and glass technology came to India from the Rome in the early centuries of the Christian era. However this belief has now largely been laid to rest by recent findings. Although the knowledge of use and manufacture of glass in India is much later than in some other parts of the world, the art of manufacturing glass attained a high degree of technological perfection in ancient India. The archeological excavations from different sites in India have revealed various glasses and glass like objects used mainly for the ornamental purposes and from this it is established that glass manufacturing began in India in the first quarter of the first millennium BC[19]. The earliest specimens of glass have been found from period II of Rupar, Hastinapur and Alamgirpur which date back to 1000 BC. The glass specimens unearthed include, beads, bangles, vessels, tiles and other miscellaneous objects. Mention of glass (*Kaca)* also occurs in early Sanskrit and Buddhist literature such as *Satapata Brahmana* (1000 BC) and *Vinaya Pitaka*[20]. A number of glass objects have been found at Maski in south India (1000-900 BC), Hastinapur and Taxila (1000-200 BC). Glass slag has also been found at Kolhapur, Nevasa, Paunar and Maheshwar. In this period glass and glazes were coloured by the addition of metal oxides[21] which acted as the colouring agent. Other ancient texts that mention use of glass in ancient India include the texts of *Ramayana*, *Brhatsamhita*, Kautilya's *Arthasashtra* and *Sukranitisara.*

The recent archeological excavations by Alok Kanungo of Deccan College, Pune have revealed the presence of a traditional glass factory at Kopia in Basti district of Uttar Pradesh. A large number of glass objects have been found at Kopia during the excavation and these finds point towards a definite presence of a large size glass manufacturing units/ industry at Kopia during the third century BC to third century AD. Blocks of glass, weighing more than 50 kg and measuring 45 cm x 30 cm x 23 cm have also been found at the site. These findings probably give an indication about the massive scale of glass manufacturing operations that was in vogue at Kopia during this period[22].

Most of the early evidence for glass has been in the form of glass beads. In India, glass is reported from about 200 archaeological sites starting from the early Iron Age period, with the exception of four beads from the Chalcolithic site of Maski[23]. There has been much discussion on ancient India being the leading bead (both stone and glass) exporter to the world at large. Interestingly, India enjoys much the same position even today. Indian glassmakers had well developed technological skills in the manufacture of beads, bangles and a few other glass articles. From the observation of various glass objects excavated at different sites, it may be inferred that Indian glassmakers employed methods such as moulding, folding, twisting and double-stripping. Perhaps, a method known as wire-winding was also adopted for preparing beads of various types[24]. The exhibit on Glass in the gallery mainly consists of a scaled down model of an ancient glass furnace with supporting visuals that shows the ancient glass map of India. There is also a display of variety of special tools that were used in the glass manufacture. The model of the glass furnace is made from the solitary reference of the ancient Indian glass furnace that comes from Nevasa, where a glass making kiln dated 3rd to 4th century AD was unearthed. The furnace was circular oven in shape and 2'6" in diameter and 1'7" depth and was made of burnt clay. Most of glass furnaces in ancient India were of open fired type, which used solid fuel and the melting was carried out in a clay pot.

Tipu's Rockets

In recognition of the unique Indian contributions in the field of Rocketry the gallery has on display an exhibit on Tipu's Rockets. The name "Rocket" comes from the Italian "Rocchetta", meaning "little fuse", a name of a small firecracker created by the Italian artificer Muratori in 1379[25]. India finds a special mention in the use of Rockets in the battlefield

by the British. Rockets, or "fire-arrows" in some form or the other, have been known for a long time. From historical records it is now fairly well established that the Chinese were the first to use rockets some time during 1232 A.D[26,27].

With the advent of the Cannons and their improvement as a powerful tool in warfare, during the 14th and 15th century, the rockets went into oblivion. The rockets reemerged as effective ammunition in battlefield during the second half of the 18th century in India. Hyder Ali and his famous son Tipu Sultan effectively used the rockets against the British army during the 18th century. The use of innovatively designed rockets by the army of Tipu Sultan against the British, in the famous battle of Pollilur (1780) in which the British were defeated provides a spectacular evidence of supremacy of the rockets in the battle and this has been chronicled in Indo-British technological history[28]. The rockets used by the Tipu Sultan's army were much more advanced than what the British had ever seen or known. The superiority in rockets were attained mainly by use of iron tubes for holding the propellant which enabled higher bursting pressures in the combustion chamber resulting in higher thrust and longer range for the missile. The rockets consisted of a tube about 60 mm diameter and 200 mm long fastened to a sword or 3 m bamboo pole, and had a range of 1-2 km[29]. The famous battle of Pollilur, (1780) in which the British were defeated, is depicted in a painting scene shown on the walls of Darya Daulat Bagh in Srirangapatna[30].

The British having witnessed a decisive power of the Indian rockets took an active interest in the rocket technology that they encountered during their Srirangapatna battle and developed it further during the 19th century. Several of these rockets were sent to England, and after thoroughly examining the Indian specimens, William Congreve son of the Comptroller of the Royal Arsenal, Woolwich, London, carried out an extensive research and development programme at the Arsenal's laboratory for improving the Indian rockets[31]. Congreve prepared a new propellant mixture, and developed a rocket motor with a strong iron tube with conical nose, weighing about 32 pounds (14.5 kilograms). The improved version of the solid fuel rockets designed by Congreve was first demonstrated by the Royal Arsenal in 1805. These improved rockets were effectively used by the British during the Napoleonic Wars and the War of 1812. These improved rockets were then used in the military throughout Europe.

Architecture

India has a rich tradition of architecture and the existence of this tradition is evident from the examples of architectural excellence of various eras that are visible even today and also through the presence of architectural literature of different geographic locations and ages[32].

Temple Architecture

Ageless enduring beauty of rich Indian heritage and culture is embodied in the temple architectures that depict outstanding sculptures which are evidently visible in ancient and medieval temples present all across the Indian sub continent. The skill and mastery craftsmanship of the unsung architects and workers who painstakingly designed and carved out these architectural beauties reveal unique styles that are expressed with such unbroken continuity to display the spirit of the Indian Culture. Art formed the central theme of these architectural masterpieces since ancient times and almost always every monument contained an element of religious reference[33]. Every style of building construction portrays a distinctive basic principle that symbolizes a particular culture and era. In this context the Indian Hindu temple architecture, the Nagara – or the North Indian style temples and Dravidian or the South Indian style temples are not only the abode of God and place of worship, but they are also the cradle of knowledge, art, architecture and culture. The design and construction of these temples synthesize the art, geometry and structural aspects in to a finely blend architectural marvel[34,35].

In recognition of this unique Indian contribution to architecture a large section has been dedicated to the Indian architecture in the gallery and the presentation depicts the outstanding contributions of ancient and medieval India in the field of art and architecture. One of the most enduring architectures of India that has the world take notice of is evidenced in the characteristics of the Buddhist / Mauryan architecture. *Stupas* and Rock cut cave temples are the prime examples of the Mauryan architecture style and these structures largely displaced the extant use of terracotta and wood as sculptural medium with that of the stones.

The architecture section of the gallery begins with a specially created artistically elegant entry. Early Buddhist art has no finer expression than these *toranas* (entry gates) that surround the great stupa. Carvings of inspired intensity and imagery that depict the tenets of Buddhist art are depicted in these *toranas*. Visitors entering through this gate like structure are encountered with a series of exhibits that have been housed in a typical architectural style in which each of the models and exhibits are housed. These models and exhibits showcase different architectural styles from ancient and medieval India found across the Indian subcontinent. The first exhibit represents the

architectural styles of the Mauryan period mostly representing the Buddhist style of architecture. A scaled down model of a Sanchi Stupa is presented in the

Fig. 4. Replica of Sanchi Stupa and its *torana*.

exhibit and is amply supported with visually rich information on the architectural styles of the Buddhist era. Sanchi Stupa is the oldest stone structure in India and is 36.5 metres in diameter and 16.4 meters in height and built in a hemispherical dome, this stupa stands in eternal majesty with the paved path surrounding the stupa worn down by pilgrims over the centuries. The next exhibit is housed in a structure representing the rock art caves symbolized by the famous rock cut cave temple of Kailashnath temple found at Ellora. Models of different styles of temples and their plans and so also the material and construction methods used in building these temples have been duly illustrated in the visual information that supplements the exhibit. A specially designed touch screen multimedia computer is used in the exhibit that blends well with the structure and the contents of the multimedia would more than satisfy the serious visitor's urge for detailed information on the subject.

The typical form and style of the Hindu temples were mostly created during 600-800 AD in southern India starting with the *Chalukya* rule in the early 7th century. These temples were inspired from the Buddhist architecture as evidenced in Lad Khan temple and Durga temple, at Aihole. The temples evolved from simple rock cut shrines to large and highly complicated structures. The temples in this period were large square building with a projecting porch and decorative pillars. The roof of the temple had small structure which later emerged as the *shikhara*. The rock cut structures developed during the 7^{th}-9^{th} century under the rule of Pallavas. The Pallava rulers lead the way of Dravidian style of temple architecture and they built the temples at Mahabalipuram. During the Pandyas rule the south Indian temples were added with the lofty gateways the *gopurams* at the entrance. The *gopurams* made the

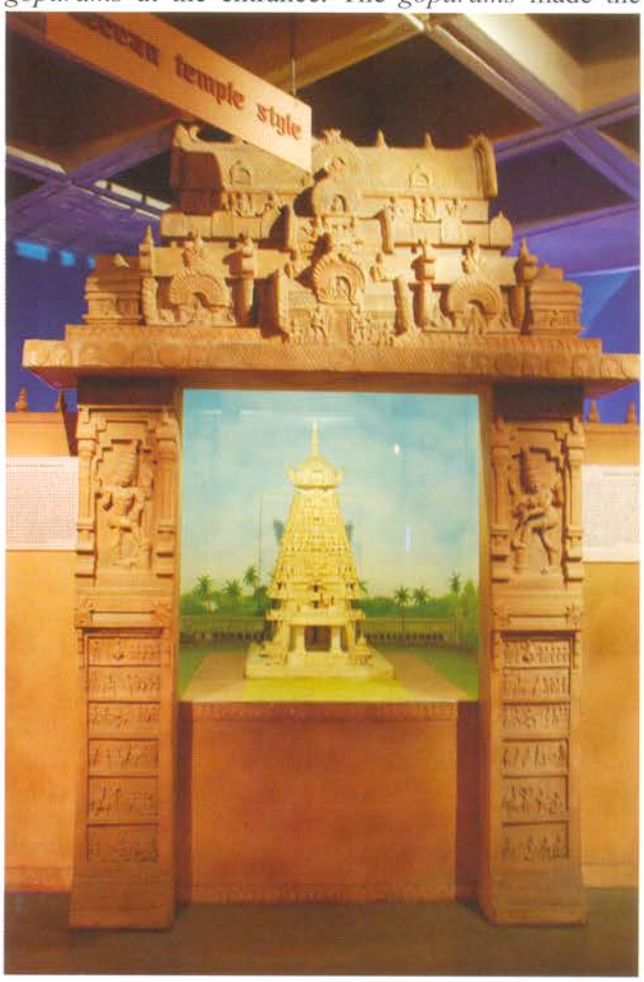

Fig. 5. A model of Brihadiswara temple showing typical temple architecture.

temple visually attractive and also provided the temples with an enclosure. The *garbhagriha* (usually square in plan), or the sanctum sanctorum housed the

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main idols and images of gods and goddesses to which the temple was dedicated and this could be approached through a *mandapa*. The roofs of the temple shrine are pyramidical in shape with a vertically attenuated dome like structure known as the *sikhara*. The main temple as a whole was raised on a massive plinth and was often surrounded by subsidiary shrines and by an enclosing wall with one or more gigantic gateway towers or the *gopurams*[36].

To symbolize this aspect of the Temple architecture in the gallery the next exhibit is created in a specially designed artistic structure that is typical of a south Indian temple architecture. The cabinet houses a scaled down model of one of the tallest temples, with a height of 60 metres, the famous Brihadeshwar temple at Thanjavur (1100 AD) from the Chola dynasty.

Moghul architecture

The beauty of ancient and medieval Indian architecture culminates with the epic saga of the Mughul architecture a glimpse of which is embodied in the great Taj Mahal and other Moghul monuments that include the Red Fort of Agra and Delhi, the forts and monuments in Fathepur Sikri and the Jama Masjid in Delhi. The Taj Mahal complex is one of the most visited and well-known moghul archaeological structures of India that is now one of the seven wonders of the modern world. Numerous publications have covered in detail different aspects of this world heritage complex. The most comprehensive research work on Taj is seen in a book by Koch[37]. The next set of exhibits in the section on architecture are dedicated to the Islamic rulers. The structure of the cabinet is so designed to represent the Islamic style of architecture and housed in these cabinets are the models of the Taj Mahal and the Qutab Minar. Also on display is a model of a typical Masjid with different components that explains the basis of the style of architecture chosen. Visually rich information that supports these exhibits also cover information on several other notable examples of Muslim architecture present in India including the great monuments built under the Adilshahi rulers in the likes of the Gol-Gumbaj, arguably the largest unsupported dome structure in the world, and the Ibrahim Roza monuments at Bijapur. Space being a premium in the gallery and in consideration of the fact that a vast canvas of the subject of our S&T heritage was to be covered in the gallery we had to restrict the section on architecture without covering the great influence and architectures of the Roman style of architecture that India houses which include the famous Victoria Memorial and other famous Churches from Goa that have the Portuguese influence in their architecture styles.

Traditional crafts

The tradition of arts and crafts in India goes well beyond 5,000 years. The exquisite stone and metal sculptures and the lapidary craft of the Harappans are examples of the genius of Indian craftsmen. Even today Indian craftsmen are revered for their unique quality of work. Traditional craft works produced by them are in huge demand both in domestic and international market. Some of the traditional crafts items which have received world acclaim include exquisite textile items like intricately weaved and hand embroidery bedcovers, sheets, cushions, curtains, tablemats, and bags, metal works like bidri and silver filigree, furniture, wooden and marble inlay, finely carved boxes, cabinets, wood furniture, toys, utensils, garden pots, terracotta items, brass and silverware, leather products, papier-mâché products, cane, jute, lac, coir products etc. Most of the units producing utilitarian craft items have now attained the status of small-scale industry. A number of these traditions of crafts have continued to be practiced since ancient and medieval times in India. It is in recognition of this that the gallery has on display exhibits that highlight the traditional crafts of India.

A dedicated exhibit in the gallery show cases some of the exquisite wood works produced by Indian craftsmen including an artistically and richly carved elephant in rose wood. Wood has been an integral part of Indian life and culture since times immemorial. Indian wood craftsmen exhibit the tradition of exquisite wooden handicraft that include impeccable carvings in sandalwood, rose wood, teak wood etc. The vast cultural and ethnic diversity has enabled a variety of motifs, techniques and woodcrafts to

Fig. 9. Collection of exotic wood works.

flourish in India. Unique in their style, wooden handicraft reflects the mood in Indian heritage. The early wood carved temples bear witness for this. Each

region in India has developed its own style of wooden structures and carvings. Local traditions and locally available wood varieties influence the style of carvings. Painstakingly carved and inlaid, the wooden articles of Uttar Pradesh are quite a rave with all lovers of woodcarvings. Saharanpur is known for its carvings in hard *sheesham* and particularly for its famous vine-leaf patterns. The range of designs includes floral, geometric and figurative decoration. Uttar Pradesh is also known for its woodwork inlaid with brass wire on ebony or black *sheesham*. The states of Jammu & Kashmir, Gujarat, Karnataka and Kerala also have developed distinctive styles of woodcarvings. Even Rajasthan is noted for its carved sandalwood and rosewood besides heavy ornamental furniture. A variety of wooden works produced by traditional craftsmen exhibiting unique traditional skills have been displayed in the exhibit. These craftsmen who produce these works of art continue to work in the style of their ancestors with the simplest of tools.

Metal crafts

Of all the traditional metal crafts that are being practiced in India the Bidri Ware stands out for its metallurgical excellence. Bidri is valued all over the world for its fine craftsmanship. Its sleek and smooth dark coloured metalwork with intricate eye-catching designs on its glossy surface makes it a unique and highly valued traditional crafts. This metalwork as well as the technique to produce it is found in India since ancient times. Bidri is a high zinc, low copper alloy that contains 76 to 98% (around 95%) zinc, 2 to 10% copper, up to 8%. lead, 1 to 5% tin and trace of iron. The craft of Bidri Ware is a kind of damascene work, which has been defined by Sir Georgy Birdwood as "the art of encrusting one metal on another not in crustae, which are soldered or wedged, but in the form of wire, which by undercutting and hammering, is thoroughly incorporated into the metal which it is intended to ornament..."[38]. The gallery has on display some exquisite bidri ware products. The exhibition also has on display different stages of making of a bidri ware product which is duly explained in common man's language. A wide variety of exquisite bidri wares from the past are in collection of various museums across India and the ones in possession of the National Museum, Delhi have been duly studied and documented[39]. Bidri wares from India also form a prized collection at the Victoria and Albert Museum, London and these objects too have been thoroughly researched and well documented for their unique metallurgical and artistic properties[40].

Bidri ware involves inlaying of gold or silver on a steel or copper base. The content of zinc in right proportions gives the alloy a typical deep black colour which is so unique to every bidri ware products. It is engraved or overlaid with silver or brass. After casting and moulding, the surface is filed smooth till it acquires the typical Bidri sheen. It is then temporarily blackened with copper sulphate solution and etched into a traditional design

Fig. 10. Intricate Bidri work.

using a sharp iron tool. Silver wire or sheets are beaten into the designed grooves, making it stand out like the stars in the night sky. During the final oxidation process, the shiny surface is briefly heated and rubbed with a thick paste of ammonium chloride. The chemical is supposedly mixed with special clay from the walls of the Bidar Fort. It is for this reason that the name Bidri ware is associated with this metal craft. In the final step groundnut or coconut oil is used to polish each item, which may be a vase, bangle, bracelet, goblet, ashtray, plate, Jewellery box etc.

Susan La Niece and Graham Martin have carried out replication experiments and found that the black colour of the *patina* was due to copper. They have also postulated that ammonium chloride preferentially dissolves the zinc from the Bidri Ware and the resulting copper-enriched surface is oxidized by potassium nitrate which produces this black colour[41]. The mystery of the black patina has not yet been fully solved. How the ancient craftsmen developed such intricate chemical procedures are difficult to imagine.

Historical evidence for bidri ware indicates that the beautiful articles presented to Alauddin Bahamani II (1434-57 AD) on the occasion of his coronation impressed him so much that he invited the craftsmen of Bijapur to settle at Bidar itself. The Russian traveller Althanasins Nikitin, who visited Bidar during 1470-74 AD, took with him some of the early Bidri Ware specimens for presentation to the Russian Emperor. A large number of articles of Bidri Ware were made for presentation to the Prince of Wales when he visited India in 1875. Thus the glory and fame of the Bidri

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ware spread far and wide. Bidar and Hyderabad museums have beautiful collections of this kind of ware. The traditional crafts exhibit also has on display several other products of traditional crafts which are so unique to India.

Musical Instruments

India has a very rich culture in music and the instruments that go with the classical music. The music of India is said to be one of the oldest unbroken musical traditions in the world. The origin of culture of music in India goes back to the Vedic period. C V Raman, Indian Nobel Laureate in Physics, has through his research findings and publications has confirmed that the percussion instruments of India produce pure harmonics in comparison with their western counterparts, which indicates that Indian musical instruments, that support the classical vocal music, were produced with some scientific basis. It is in recognition of this feature that we decided to have a very large exhibit presented in the gallery to portray the rich heritage and culture that India has in the field of music and musical instruments. However to present music in the context of science and technology heritage of India was of great challenge for us. After a brain storming session of the conceivers of the gallery, we decided to present the material evidence that exists to support presence of music and musical instruments in ancient and medieval India in the wonderfully crafted temple sculptures especially in the temples at Belur and Halebidu[42,43]. Karnataka is home to many architecture sites with richly decorated sculptures and some of these sculptures vividly depict the musical instruments. From these musical instruments, found in sculptures, one can apply a traditional Indian classification of musical instruments to note the four categories of the instruments namely: *Ghana vadya* (idiophones); *Avanaddha vadya* (drums, membranophones); *Sushira vadya* (wind instruments, aerophones); *Tata vadya* (stringed instruments, chordphones). These classifications match with the system found in the modern classification method of the musical instruments propounded by Curt Sachs and Erich von Hornbostel.

The exhibit structure symbolically represents typical temple architecture in the Hoysala style with fibre glass fresco sculptures shown on the wall surface. It is supplemented with the display of various types of musical instruments that are found in the Hoysala sculptures seen at Belur and Halebidu. On the wall surface of the exhibit a wired mural display has been created to show case different types of musical instruments that were in vogue in ancient and medieval India. Three large LCD televisions constantly keep scrolling to depict information about various musical instruments that have existed in India since ancient times and how these instruments have been represented in different sculptures. The wire mural line drawings have been created based on the well researched publication of Jean Deloche[43].

Exhibition Information at a glance

One specially designed multimedia based exhibit has been added to the gallery which has visitor interaction facility. Interested visitor can browse through a touch screen multimedia computer screen and chose subject of his choice. He/She will be able to get substantial information on the subject of his choice and this information is spread across three large sized LCD TV screens and each of these TVs show different information which is mostly based on peer reviewed research publications. A typical NCSM interactive technology has been adopted in this exhibit.

Video Wall: The Concluding exhibit

Our Science and Technology Heritage exhibition ends with a video wall, which summarizes, in 12 minutes, very well conceived, scripted, edited and professionally produced video documentary based on researched data, that is exhibited on a very large screen (56 inches each) 2x2 seamless video wall. A visitor who has less time at his disposal to peruse every single written matter of the exhibition has the privilege of comprehending what the gallery is all about by just watching this brief video presentation.

Acknowledgement

I would like to acknowledge the contributions of all the people who were involved in making of "Our Science and Technology Heritage" gallery at Delhi. My thanks are due to the DG, NCSM, Shri G S Rautela and his entire team at NCSM Hqrs., the Chairman, Executive Committee, NSCD, Dr S N Joshi and all EC members of NSCD. Shri Anurag Kumar and Subrato Sen, curators, owe my thanks for playing the key role in conceptualizing and completion of this gallery. The gallery has taken the present artistic shape due to the artistic contributions of Shri Bhargav, Satish Pandita, Banerjee, Sarkar, Bharat and others in art section. Shri Khimnani and his team of workshop technicians have given physical shape to the exhibition. Multimedia and electronics have been artistically blended in the exhibition and were created by Shri Manas Bagchi, Ramdas Iyer, Vijay Shanker, Bharti, Neelu and their team.

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