FROM FRAGMENTS TO A MUSEUM DISPLAY: RESTORATION OF A GAUTIER MERIDIAN CIRCLE

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Abstract: The *Museu de Astronomia e Ciências Afins* (MAST), which opened to the public in 1985, is a research institute of the Brazilian Ministry of Science and Technology. One of its main activities is to preserve its collections, especially the most important one, its collection of scientific instruments, which grants MAST its identity as a museum of science and technology. Among the 2,000 objects in the collection there is a Gautier meridian circle that has a 190-mm diameter objective lens and a focal distance of 2,400mm, with its axis aligned east-west. It should be noted that this instrument was at great risk of being lost to the collection, as it had been left dismantled since the 1960s, and the top part of the dome that sheltered it had been demolished in the 1980s, leaving just a vestibule and the base of the dome, which was in danger of completely collapsing. The intervention philosophy applied was not to put the instrument back in working order, but to allow it to be viewed and understood by the public within a coherent display space. As for the dome, a shelter was built for the instrument using a metal cover of a similar volume and appearance to the original, but with a different function, i.e. it is no longer designed to permit astronomical investigations, but rather to protect the exhibition space and merge harmoniously with the rest of the listed architectural complex. This paper presents information about the history of this meridian circle and its restoration, as well as about the Imperial Observatório do Rio de Janeiro/Observatório Nacional where this instrument was originally used.

Keywords: Gautier meridian circle, restoration, scientific instruments, museum of science and technology

1 INTRODUCTION

Restoration, in the terms used by the International Council of Museums (ICOM) Committee for Conservation (2001), is a physical intervention designed to lengthen an object's lifespan by ensuring its continued material, aesthetic and functional integrity. An appropriately-restored object reverts as closely as possible to its initial state. Using intervention techniques, restorers conserve and make functional those objects that are likely to be presented and related to a particular theme or historical period.

A key starting point is to clarify what it means to restore a scientific instrument. Miniati (1991) draws parallels with certain aspects of art restoration, in that many instruments, especially the oldest ones, have aesthetic, decorative and material features whose treat ment is analogous to that applied to works of art. Others are quite different.

Interventions should be performed on historical scientific instruments only when absolutely necessary for the survival and future conservation of the object. It is easy to understand how people who are unfamiliar with museological issues might have trouble understanding why a hydraulic pump or a microscope should have its integrity conserved to the utmost, and that any new element will be added only if it ensures its integrity, and this should bear a permanent physical mark aside from the record of the intervention in the paperwork pertaining to the piece. To draw a parallel, it would be difficult for a mechanic who deals with industrial parts to learn to give due value to many such cultural heritage objects (Sebastian, 1995).

Independent of the practical work involved, the restoration of a scientific object also demands an in-depth study to find out about its function, its manufacturer, and its time period. In other words, the idea is to obtain as much information as possible about it, and especially about the physical principles upon which the instrument was based.

Once a decision is taken to restore an object, the curator and restorer should carry out extended research to identify the correct restoration method, especially in the case of lost parts to be replaced or the repair of previously damaged parts. Access to newspapers from the time and specialized journals is an invaluable research asset.

In the view of André (1999), the guidelines for an ethics of restoration should be as follows:

(1) gather ample documentary evidence before beginning any intervention;

(2) always bear in mind the principle of minimum intervention;

(3) respect the integrity of the object, preserving as many original elements as possible without adding new elements; and

(4) make sure that the intervention is reversible.

In practice it is not always possible to follow all of these principles. One of the most important points is to understand the object, and further, should it be used for exhibition, to understand how it will be presented to the public.

Many issues have been raised concerning reversibility, especially about what actually constitutes a reversible intervention. Meehan (1999) addresses this point at length within the specific context of industrial collections. Dismantling is a reversible stage which generates a great deal of knowledge about such instruments but which is not an option for most other historical artefacts. However, many examples described by Meehan show that reversible procedures are often either not feasible or not even appropriate. An action must be guided by the principle of minimum intervention with a view to preserving the original components of the object in the long term. Perhaps the guiding principle is not to undertake reversible interventions, since no act is totally reversible in itself.

2 CURRENTS IN THE RESTORATION OF SCIENTIFIC INSTRUMENTS

Scientific instrument restoration practices follow different currents, much as is the case for other objects of cultural value. There are two clear lines of thought with somewhat different perspectives. The first one, advocated by scientists interested in the historical aspects of science, considers making the instrument functional again the primary aim of any restoration. The goal is to get the object to work just as it did when it was manufactured, provided this is the feature that differentiates it from other museum objects. This often implies quite major interventions which sometimes alter some of the object's features. The second school, led by science historians and art restorers, takes as its fundamental aim the preservation of the historical evidence contained within the object, which often means that the object will still not work after it has undergone the intervention.

Many arguments can be put forward to support the first approach, the best formulated of which, from the literature consulted, is by Mann (1994), of the Science Museum, London. In his paper, he takes as his starting point the governing ethic in most museums (of art, archaeology, ethnography, history, etc.), whose primary aim is the preservation of historical evidence, and concludes that this is not the case for science museums. As he sees it, a new ethic is required for such museums, which has actually already been practiced by its defenders until current times, though it has not been set out explicitly. This new ethic is primarily concerned with exploiting artefacts for the benefit of the public and to the detriment of the mere preservation of material evidence. Such a change in the overriding purpose is based, in turn, on the shift in the concept of artefacts as material evidence to also include functional evidence.

Still following Mann's line of argument, the scope of a museum of science and technology could permit one type of evidence to be destroyed so that another, of greater value, could be revealed to the public by sectioning the pieces and putting the instruments and machines to work. In this way, such museums become quite different from others because their primary aim is to explain how things work rather than to keep a collection of artefacts. In other museums, even if the objects have a functional nature, they are not collected because of this nature but rather because of their aesthetic features or historical properties.

According to this school of thought, the practices of many science and technology museums the world over, where machines and instruments have been sectioned to show their working parts or are displayed in action, are correct in that they help the visiting public understand these pieces. Yet Mann disregards the fact that scientific objects are also collected for their historical interest, for they make it possible for people to evaluate and reflect upon the development of science and technology.

Still in the UK, there is a more conservative viewpoint expressed by Newey (2000), who defends the use of replicas as the most suitable way of showing the public the information they seek, rather than actually putting the historical artefacts themselves to work.

The restoration of scientific instruments is a recent practice that does not have a strong, established tradition (Brenni, 1999). More often than not, such restoration work has paid greater attention to technical issues than to the instruments' historical value. The literature produced around the world is limited and the few existing treatises simply provide information on how to repair instruments. While collectors, technical experts and physicists favour the in-depth restoration of objects based on the overriding priority of regaining their functionality, art restorers tend to defend a very limited restoration with no parts replaced or any actual repairs made to the object. Both attitudes seem extreme and both have undesirable consequences, leading either to over-restoration or under-restoration. The former is more common in the attempt to restore the object back to its original state, but no restoration can wipe out the action of time even if it so desires, and it may end up removing the marks left by time, which may be very important for a better understanding of the object and its history. The second type of intervention, which is far rarer, attempts not to turn the clock back, but to stop it, interrupting the life of the object artificially.

Undoubtedly, sectioning an artefact or leaving it running and thereby causing more wear and tear could compromise such evidence and should not be permitted in most cases. This argument is concise and logical, yet is based upon the belief that the overriding aim is to preserve evidence and that this is of a purely material nature. If these underpinnings change, as put forward by Mann (1994), one would need to alter the ethic for such conservation.

It might be more fruitful to take the middle ground. When the object was manufactured as part of a series and more than one example still exists, or where the object's historical importance *per se* is minimal, it could be justified to carry out a deeper intervention, trying to get the object working again. However, in the case of very special items imbued with historical content, or unique objects, a better course would be to conserve the object preventively and use replicas to give the visiting public a better understanding of its appearance and function.

Any procedures, work or type of action that may alter the principle of the basic design, shape, appearance, style, basic idea and details of the object should be avoided. In particular, any addition should be scrupulously avoided, because this could be construed as a forgery. The only parts that can be replaced by new ones are those about which there is absolute certainty as to their shape, size, relative position, movements, appearance and other details, so that they correspond exactly to the original, or those that may pose an obvious risk to people's safety.

Finally, in 2002, a presentation was made of the summarized findings of a study that was carried out by a group set up by the *Direction des Musées de France* in 1996 to discuss and reflect upon a definition of conservation and restoration methodologies for scientific, technical and industrial artefacts (Rolland-Villemot, 2002). The working group set down seven points to be considered before any conservation or restoration should be carried out on such objects:

(1) the status of the object (whether unique, a proto-

type, a mock-up, an object produced in series, a teaching object), which is decisive in the choice of the restoration procedure;
(2) the diagnosis (a precise evaluation of its state of conservation and integrity);
(3) a scientific and cultural project regarding the object: the object must first be studied from all possible perspectives, even should one or another of these be given precedence later for museological or technical reasons;
(4) the setting up of an interdisciplinary team;
(5) the drafting a list of responsibilities with a precise definition of all the interventions to be made on the object;
(6) the sequence of the tasks and the precise nature of the roles of each participant (matrixes);
(7) the paperwork that must be gathered for a precise understanding of the object to be reached, and to assist in the restoration tasks.

The restoration of scientific instruments requires a high level of training in materials, which range from wood to a broad range of metals, glass, etc.; a profound knowledge of and sensitivity to history, allowing for a highly-attuned interaction with science historians; in-depth knowledge of the peculiarities of the object; familiarity with mechanical construction techniques, enhanced by examinations of different examples of the same type and contact with scientists; and highly developed manual dexterity so that, if necessary, the missing pieces of whatever type can be recreated in a historically-appropriate and technically-efficient way (Bonsanti, 1999). A multidisciplinary team must be set up to cover this range of prerequisites since a single person could hardly be expected to be skilled in all the different areas required.

All restoration work must be detectable, though not necessarily immediately visible nor even visible upon closer inspection. It should, rather, be detectable by an observant non-expert equipped with a magnifying glass and left alone with the object for five minutes (Ashley-Smith, 1994).

3 CONSERVATION AND RESTORATION OF SCIENTIFIC INSTRUMENTS AT THE MUSEU DE ASTRONOMIA E CIÊNCIAS AFINS IN BRAZIL

The *Museu de Astronomia e Ciências Afins* (MAST) in Rio de Janeiro, Brazil, opened to the public in 1985, and is a research institute in the Brazilian Ministry of Science and Technology. One of its main activities is to preserve its collections, especially the most important one, its collection of scientific instruments, which grants MAST its identity as a museum of science and technology. The museum is located in the grounds of the old National Observatory, and occupies a number of buildings belonging to that facility. These historic buildings, as well as the collections that originated within them, are preserved by a Federal Law that was passed in 1986 (IPHAN). MAST's main building, which was recently restored, houses the museum's technical store, where much of the collection of historical scientific instruments is kept.

The MAST collection, which contains 2000 objects, is one of the most important of its kind in Brazil. Around 1700 of these objects originally belonged to the old National Observatory, and were used in service and research of great importance to the country, such as determining and broadcasting the official time in Brazil, forecasting the weather, observing astronomical phenomena, determining Brazil's borders, and magnetically mapping Brazilian soil. Most of these instruments date back to the nineteenth and early twentieth centuries, though some of the more aesthetically-interesting pieces, like the quadrant by J. Sisson and the G. Adams theodolite, are from the 1700s. It is an extremely diverse collection, and can be compared with the great collections of this kind around the world (Brenni, 2000). Many of the objects are connected to astronomy, topography, geodetics, geophysics, meteorology and optical measurements. They are typical of this kind of institution, but the collection also touches on other scientific areas, such as electricity, magnetism and chemistry.

The great variety and high quality of the objects in the collection merit a special word. Together with instruments that can be found in similar institutions and museums (telescopes, theodolites, meridian circles, transits, precision clocks, magnetometers, meteorology instruments etc), MAST also preserves some very peculiar, rare pieces. These include a Kelvin tide-predicting machine, an Henrici analyser, a Salmoiraghi instrument for determining a personal equation, instruments to install cross-threads in reticules and other special instruments. At least one instrument at MAST is unique: an altazimuth from the end of the nineteenth century, invented by the astronomer Emanuel Liais and manufactured at the Hermida Passos workshops in Rio de Janeiro. This instrument won a number of awards in different exhibitions in Brazil and Europe.

About 98% of the objects in the MAST collection are in a good or satisfactory state of conservation. The remaining 2% are forty items that could be evaluated as to their need for restoration. Most of the collection only requires periodic cleaning which is being done at a rate of one cleaning per object every two years.

Concerning restoration, four instruments have already passed through interventions: a theodolite, made by Brunner Frères; an equatorial telescope with a 32 cm objective lens, made by Thomas Cooke and Sons; a meridian circle, made by Paul Gautier; and a Metron star finder, made by C. Baker. The first three were made in the late 1800s, while the fourth was made in the early twentieth century. They were selected according to the following criteria:

(1) the items' historical potential, as they could have been used in important research work at the Observatory;
(2) their makers, who are known to have produced objects of scientific quality using great technical skill;
(3) the deterioration of the metal surfaces, which were highly oxidized, with the loss of part of the original lacquer; and
(4) the absence of some parts of the instruments, in the case of the theodolite and the meridian circle, which would allow one of the more critical parts of the process to be done: the replacement of parts.

In all these interventions the same procedure was used. First, historical research was undertaken to gather information about the item to be restored, including how it worked. Next, the instrument was completely dismantled and the parts were mechanically cleaned. The parts to be restored were then separated from the rest. The corrosion was removed by mechanical means only, and then cleaned with ethyl alcohol and trichloroethylene. Finally, most of the parts were protected by lacquer or paint, depending on the original treatment they received. A meridian circle manufactured by Gautier was selected from the set of restored objects to present in greater detail the work carried out.

4 THE IMPERIAL OBSERVATORY OF RIO DE JANEIRO

During the eighteenth century, the Portuguese Government did little to encourage scientific activity in Brazil. It was only after Dom João VI arrived in the country, fleeing Napoleon's invasion of Portugal, and later under the rule of Dom Pedro I, that this situation took a turn for the better. Rudimentary astronomical observations were made during the early nineteenth century at the Escola Militar (Military School) in Rio de Janeiro, but it was only on 15 October 1827 that the Emperor decreed the creation of an astronomical observatory with the purpose of producing astronomical and meteorological data, as well as giving courses in astronomy to students from the military and naval academies (Morize, 1987).

For various reasons, the Observatory only began its work in the middle of the century. It was first based at the Escola Militar under the Directorship of Soulier de Sauve, who died a year later. It was then transferred to a more suitable location on Castelo hill, Rio de Janeiro, in an unfinished Jesuit church.

In 1846, the observatory was given its official name, Imperial Observatório do Rio de Janeiro, in a decree that also established the work it should undertake (Videira, 2002). Not only would it be responsible for astronomical and meteorological observations and training students from the Escola Militar and the Academia da Marinha (Naval Academy), but it would also publish an astronomical yearbook and supply accurate time for ships docked in the port.

In 1858 and 1865, the new Director, Antonio Manuel de Melo, organised observations of solar eclipses and published some astronomical tables. The largest instrument from this period of which there is mention was a Dollond refractor telescope with an aperture of 7 cm. Figure 1 shows a picture of the Imperial Observatory on Castelo hill.

After the Paraguay War (1870), Emperor Dom Pedro II, who was keen on astronomy, reorganised the Observatory and appointed the French astronomer Emmanuel Liais (1826−1900) as its Director. This was the beginning of a period during which much research was produced at the Observatory and was presented by Liais at European academies. According to a study of the period by Christina Barboza (1994), the Observatory was held in higher regard than any of the other Brazilian scientific institutions of the day. An indication of this is the invitation it received to take part in a major event organised by the French to observe the 1874 transit of Venus across the solar disk. Under Liais' Directorship, the Imperial Observatory became a hotbed of scientific activity, yet little of the knowledge acquired was actually applied. Liais managed to split the observatory off from the Escola Militar, but his administration was also dogged by many controversies, until he was finally dismissed in 1881 (Videira, 2002).

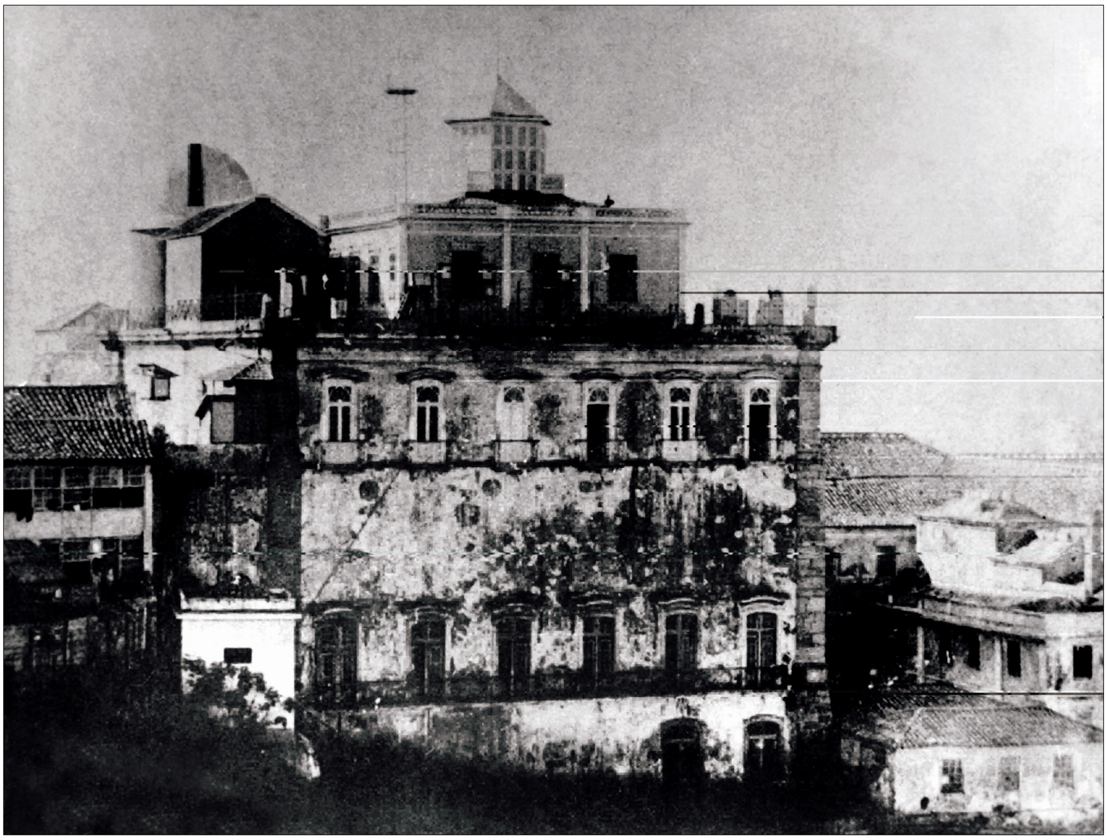

Figure 1: Photograph of the Imperial Observatory on Castelo hill taken in the second half of the nineteenth century (courtesy: MAST archives).

Liais was succeeded by his main collaborator, a Belgian engineer named Luís Cruls (1848–1908). Under his Directorship a number of scientific expeditions were undertaken: to Punta Arenas to observe the 1882 transit of Venus; to the Central plateau to demarcate the Brasilia quadrilateral, the site of the future capital city of the nation (1890); and to the border with Peru and Bolivia to determine the exact location of the source of the Javari river, which was crucial in the conflict between the countries (1898) (*Relatório* …, 1898b). At the same time, in 1887, the Observatory was invited to take part in another major international event also organised by France: the Carte du Ciel project which involved photographically mapping the entire celestial sphere (see Turner, 1912). The standard scientific instrument needed for this project, a 33-cm equatorially-mounted astrograph with 26-cm guide scope, was even purchased, but the political upheavals surrounding the proclamation of the Republic in 1889 prevented the Observatory from actually taking part in the project and the instrument was never installed in its intended dome.

With Brazil now a republic, the Observatory was renamed the Observatório do Rio de Janeiro, and then in 1909 the Observatório Nacional (National Observatory), which continues to be its name to this day. At the time, it was entrusted with organising a national meteorological service, much against the wishes of its then Director, Henrique Morize (1860–1930). Many meteorology instruments were acquired by the Observatory and these are now part of the MAST collection.

The location of the observatory on Castelo hill had been the subject of much debate since the mid-1800s. Reports by its Directors had repeatedly pointed to the unsuitability of the site because the land (composed of decomposing gneiss) was unstable, which severely limited its activities and made the use of large-scale astronomical instruments unfeasible. A mixture of political factors and plans to modernise the city were instrumental in the decision to find a new site for the Observatory. After several sites were considered, Morro de São Januário hill in the aristocratic district of São Cristóvão in suburban Rio de Janeiro was finally selected (Morize, 1987).

Work on the new architectural complex was begun in 1913 and completed in 1920, and in the following year the Observatory was moved there (see Figure 2). Meanwhile, demolition work that was underway in the centre of the city, including at the Castelo, inspired rumours that treasures hidden by the Jesuits were to be found there.

The tasks of the observatory included the following technical and research activities: determining the official time for the nation; weather forecasting; construction of astronomical tables; demarcation of the Brazilian borders; systematic observations of solar eclipses from Brazilian territory; and magnetic mapping of Brazilian soil (Barreto, 1987). Many different scientific instruments were used for these tasks, and they now make up a varied collection which includes some high quality instruments.

Figure 2: Photograph of the main building of the National Observatory on São Januário hill taken in 1922 (courtesy: MAST archives).

At this time, several institutional and financial hurdles stood in the way of the acquisition and functioning of these instruments. There are cases of instruments that took years to be repaired or years to be delivered. Naturally, this meant the set of instruments needed for research could not be kept up-to-date. Also, the number of people employed by the observatory was minimal, so much so that there was a shortage of technical staff, while the scientific personnel were often underqualified. One example of how this affected the work at the Observatory was an intended study of latitude variations. A programme was prepared for the project, but it had to be abandoned because there were not enough staff members to do the calculations (Morize, 1987).

These two factors illustrate a characteristic feature of the early Republican years: the absence of 'institutionalised' research activity. This only developed in the second half of the twentieth century, after the instruments needed for such work had been obtained.

Almost all the Directors made an effort to ensure that the Observatory was supplied with the latest equipment. This culture was passed down from the very first Directors during the Imperial era, who had managed to assure the effective engagement of the work carried out at the Observatory with the international astronomical community. The Directors were fully aware of the institutional and financial restricttions, and what was needed for the practice of astronomy, but there were countless difficulties to be overcome.

The instruments in the MAST collection and the uses to which they were put give us a good picture of what kind of institution the National Observatory was: what role was envisaged for it, and what its activities actually were. An analysis of these instruments shows us what could be done and allows us to draw inferences about the development, or in some cases the stagnation, of the methods used. The National Observatory is an active research centre to this day, and still stands on the same historic site in new premises inaugurated in 1985.

5 RESTORATION OF THE MERIDIAN CIRCLE

A meridian circle is a kind of telescope designed to determine the position of stars to a high degree of accuracy (Herbst 1996). It was crucial for determining the coordinates (right ascension and declination) of celestial bodies, which were used to prepare catalogues of the position of stars. The Gautier meridian circle in the MAST collection has a 190 mm diameter objective lens and a focal distance of 2,400 mm.

When we began the restoration process in 2003, this instrument was at great risk of being lost to the collection as it had been left dismantled since the 1960s, and the top part of the dome that sheltered it had been demolished in the 1980s, leaving just a vestibule and the base of the dome, which was in danger of completely collapsing. The intervention philosophy applied was not to put the instrument back in working order, but to allow it to be viewed and understood by the public within a display space in the Museum. As for the dome, a shelter was built for the instrument using a metal cover of a similar volume and appearance to the original, but with a different function, i.e. it is no longer designed to permit astronomical investigations, but rather to protect the exhibition space and merge harmoniously with the rest of the listed architectural complex.

During the second half of the nineteenth century, the top European and American makers were capable of producing high precision instruments for metrological, geodetic and astronomical measurements. One of the leading French makers was Paul Ferdinand Gautier (1842–1909), who, alongside the Brunner family, became the foremost representative of the French precision industry in the second half of the nineteenth century (Brenni, 1996). However, a refractor he designed to be shown at the Paris Universal Exhibition in 1900—the biggest instrument of its kind in his day—contained a design flaw, and the failure of this instrument ultimately drove Gautier to financial ruin and his brilliant career was cut short.

Ten years before this tragedy, Gautier received a commission from the Rio de Janeiro Observatory[1] to build a precision scientific instrument: a meridian circle with a 7” diameter objective lens (*Relatório* …, 1891: 25). The late 1800s were a time when a meridian circle was crucial for the work of any serious professional observatory, and it was also the period when the Rio de Janeiro Observatory was at the height of its activities.

The instrument was finished in 1893 (*Relatório* …, 1894: 19) and ended up with a 7.5 inch (19-cm) objective lens. However, it was still in boxes five years after delivery because there was no one at the Observatory who could assemble it (*Relatório* …, 1898: 125). In those days, the Observatory was in downtown Rio de Janeiro, on land which was not stable enough for large-scale astronomical instruments. Even so, in 1900 the meridian circle was installed there in a makeshift wooden shelter (Morize, 1987: 129), but the conditions were far from suitable and the instrument could not be used correctly.

In 1913, after the move of the Observatory to its new site on Morro de São Januário hill, Carl Zeiss (MAST, 1913) was commissioned to build a wooden shelter and an observatory dome with an iron structure to house the meridian circle. The masonry structure for the dome was built in 1915 by the contractor João de Mattos Travassos Filho (MAST, 1915), but a number of faults were discovered, including leaks, which meant that rainwater even splashed onto the transit telescope. The necessary repair work was done, and a document was then sent from the Observatory to the Ministry of Agriculture, Industry and Trade (MAST, 1928) stating that on 30 March 1928 the meridian circle was put into service to catalogue the stars, which would allow a more accurate Brazilian time-service to be maintained.

The oldest known photographs of the meridian circle (e.g. see Figure 3) date from after it was installed at Morro de São Januário inside the Zeiss dome.

Alongside the meridian circle, other supplementary instruments were installed in the dome, including a synchronized pendulum, manufactured by L. Leroy & Cie., and a recording chronograph, by the Gaertner Precise Instrument Company of Chicago. These instruments were needed for the measurements made using the meridian circle.

As some of the activities at the National Observatory were gradually phased out, the pendulum and some of the meridian circle's accessories started to be used in other areas. According to a former Observatory employee, the circle was dismantled in 1962. One year later, the anteroom to the dome was stripped of its panelling because it was infested with termites. The neglect of the dome, the deplorable oxidation of the metal parts and the deterioration of the wooden parts led to its demolition between 1980 and 1985, leaving only the masonry vestibule and the base of the instrument mounting. The opening between the vestibule and the instrument room was bricked up and the room was left to its process of decline.

After the Museu de Astronomia e Ciências Afins was established in 1985 the ruins of the instrument room came under its protection, while the vestibule was to be safeguarded by the National Observatory. The architectural complex, as already mentioned, was listed, and it includes both of these parts of the dome.[2]

Most of the parts of the meridian circle were deposited in a ground floor room in the Museum's main building, while a few components were kept in other parts of the campus. As of 1997, the restoration of this instrument was adopted as one of the primary goals of the Museum. The reasons for this were that it (1) was the only surviving object of this kind and by this maker in Brazil; (2) was the only large-scale instrument not to have been installed in its own shelter on the campus; and (3) was at risk of being lost forever because it had been dismantled. In 2003, the restoration of the meridian circle was begun through a partnership with the Fundação VITAE, which also included the restoration of the shelter.

Before the restoration of any instrument commences there must be a moment when it is questioned whether this process is really worthwhile, bearing in mind the expense and time involved. Miniati and Brenni (1993: 55) discuss this issue at length and suggest an artefact's rarity, age, complexity and origin are useful factors that must be considered. However, they also note that instruments can take on different meanings depending upon their context. For instance, an electrostatic machine, the type of which was produced by the thousands and was very commonplace in the late nineteenth century, could be earmarked for intensive restoration work if it were part of a homogeneous, comprehensive collection of equipment of this kind, because its loss would leave a conspicuous gap in the collection.

From this perspective, the MAST's Gautier meridian circle is indeed a rare piece, as the only one of its kind in Brazil, and the fact that it was listed by the Brazilian cultural heritage agency, IPHAN, and its Rio de Janeiro state equivalent, INEPAC, is also important. Added to this, the meridian circle was the only large astronomical instrument at the Observatory that was not installed in its own shelter.

Having decided this instrument was worth restoring, the next step, as is the case for most cultural objects, was to make a detailed diagnosis of its state of conservation to define the type of intervention to be carried out. In this particular case, at this important initial stage in the restoration process, there was no single object to consider, but rather a set of objects (i.e. the instrument's constituent parts). And to make matters worse, it was impossible to tell whether all of the parts, or at very least those needed to reassemble the meridian circle, still existed. Thus, prior to any discussion on how to restore the instrument, we contacted observatories and science and technology museums in Algeria, Australia, France, Germany and the USA which might have similar instruments by the same manufacturer, in the hope of gathering data that could help us identify the various parts in MAST's technical store.

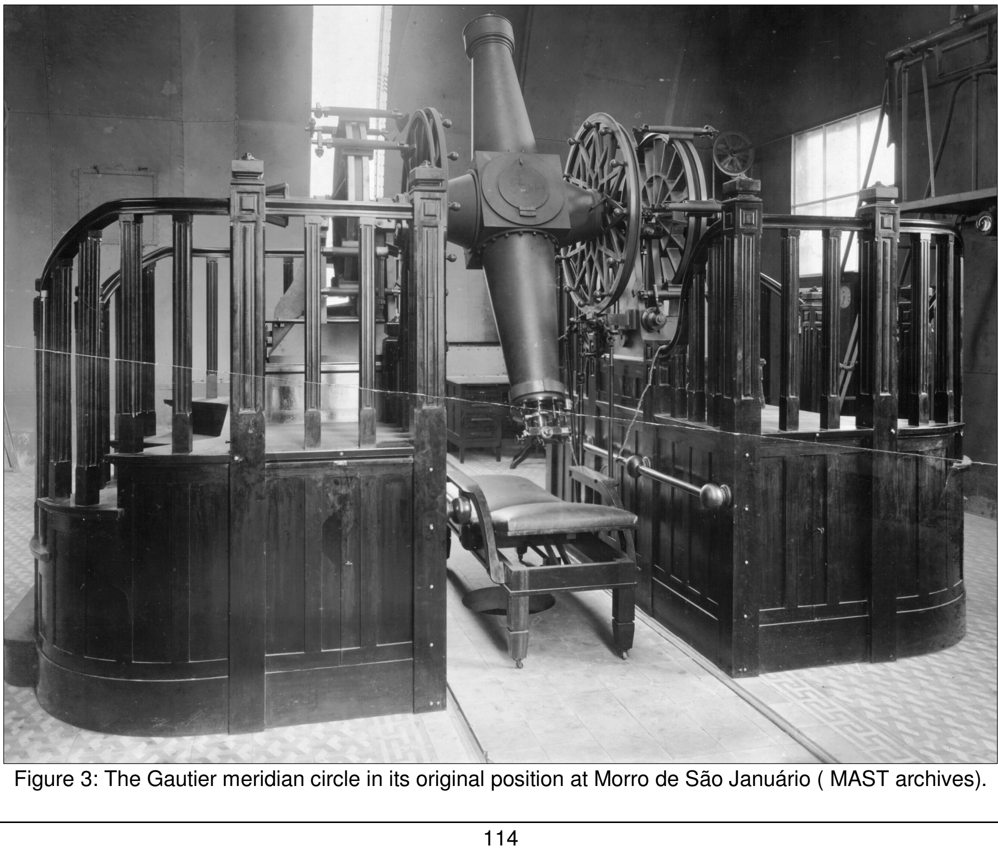

Figure 3: The Gautier meridian circle in its original position at Morro de São Januário (MAST archives).

This effort bore fruit, as the Besançon and Toulouse Observatories in France and the Algiers Observatory in Algeria all had Gautier meridian circles dating from the same period. These instruments had been acquired in 1885 (Besançon), 1888 (Algiers) and 1891 (Toulouse), and the first two had the same size objective lens (19-cm) as the MAST instrument and similar focal lengths (2370mm and 2400mm, respectively). Both the Algiers and the Toulouse meridian circles were acquired for the Carte du Ciel project.[3]

The conclusion drawn from the many digital images received from these institutions was that it would be possible to reassemble the Brazilian meridian circle, but that some parts were indeed missing. Details of some of these missing parts were obtained from the French observatories.

Armed with the information from the foreign observatories, the next stage ensued: a search of the MAST and Observatory campus for the instrument's missing parts. All the drawers, storerooms and rooms in the Museum were checked, and many professionals from the Observatory were contacted to help identify whether the items that were found during this search belonged to the meridian circle. Key finds were two brass shafts with a support at one end, which were linked to the brake system; two iron bars to support the counterweights, with pins to keep them in place; two square brass sheets; and a number of screws.

After recording all the information gathered and organising and grouping the various parts, we had to decide which parts required intervention treatment. Only four parts needed no restoration: the two cones from the system of mirrors, the Gautier micrometer and the micrometer manufactured by Édouard Bouty. The remaining parts were in an extremely poor state. Some had lost all their original varnish, many were painted in a colour different from the original and this paintwork was damaged, and there were large areas of metal that were badly rusted or had some mechanical damage.

The original Gautier micrometer supplied with the meridian circle must have been faulty because another micrometer, manufactured by Edouard Bouty (Paris), was acquired in 1923 (*Relatório* …, 1923) and used for research from 1928. A decision was therefore made to install the Bouty micrometer on the restored meridian circle, and to display the original micrometer in a showcase inside the dome as part of the overall exhibition. The Gautier micrometer did not need restoration because it was in a good state of repair, but the Bouty micrometer did require treatment.

Upon analysing the Bouty micrometer its circular base was found to contain the inscription "Gautier 1893 Edouard Bouty 1923", revealing that this part was originally from the Gautier micrometer and was adapted to the new micrometer in 1923. After it was cleaned, the piece was mounted inside the optical tube using the original screws.

All of the remaining components of the micrometer then had their surfaces and mechanical parts cleaned, after which the restoration philosophy was discussed. As already mentioned, two lines of thought about the restoration of scientific instruments have prevailed for many years. One of them favours a comprehensive restoration of the object with the primary aim of getting the instrument to work again. It should be added here that many studies regard science and technology objects as different from other cultural objects in that they have a functional dimension, and that this should prevail over all other considerations in any restoration work.

The opposing restoration philosophy defends a more selective restoration, whereby the parts should not be replaced nor the object be repaired. Miniati and Brenni (1993: 53-54; my translation) clearly explain this less radical course of action:

> Lost parts often do have to be replaced. When we are sure about the original state of the instrument, we can reconstruct the object or parts that are missing. We do not share the view concerning old materials that one should not tamper with the "dust of time", which is normally just dirt, being satisfied to conserve a virtually useless relic.
>
> Obviously, each intervention should be reversible and recorded in detail on a restoration form. Also, mistakes and confusion can be prevented by marking the replacement part to make it easily identifiable.

At the time this text was written, certain conservation measures were still thought to be reversible, although the precepts of contemporary conservation theory would now argue that no action on a cultural object can be reversed, not even the simple act of cleaning using brushes (see Viñas, 2005). Strictly speaking, nothing is reversible. A corollary to this concept is the current principle of minimum necessary intervention for achieving the desired goal based on the guiding principle of the object's communication potential.

Other authors have also discussed the issue of making instruments from museum collections work again, including Mohen (1999), who is particularly interested in technology and music museums. He believes such institutions could be tempted to revert the objects to their initial function, like a clock that chimes on the hour or a violin played in a concert. He warns that it is illusory to think that one can recreate the conditions in which an object was originally used, such as medieval musical instruments for recreating old music, since the instruments themselves will have changed over the years, as will the music they play and the audiences themselves. You cannot recreate the past.

Turning to the Gautier meridian circle in the MAST collection, the guiding principle for its restoration was not to use it for educational or experimental purposes, which meant it would not be put to work as an example for the visiting public to see. Instead, it would be a museological and educational element in the new exhibition space and would never be used in practical demonstrations. Thus, there would be no intervention to make it work again.

Large instruments like the meridian circle discussed here have a great number of screws, and one of the first things to be assessed is the replacement of lost screws. It is a great temptation to just put in a new screw, even if this means remaking the hole, but depending on the alterations needed to do so, the result may be ethically unsound. Wheatley (1986) states that if screws must be replaced, the replacements must be identical to the originals. In the present restoration work, only a few screws needed to be replaced. Others that were missing did not affect the structural integrity and stability of the instrument so were not replaced.

Only when it was absolutely necessary were screws replicated, but in such instances the existing holes were used, so that no new holes had to be drilled.

Figure 4: The meridian circle parts before intervention began (author's photo).

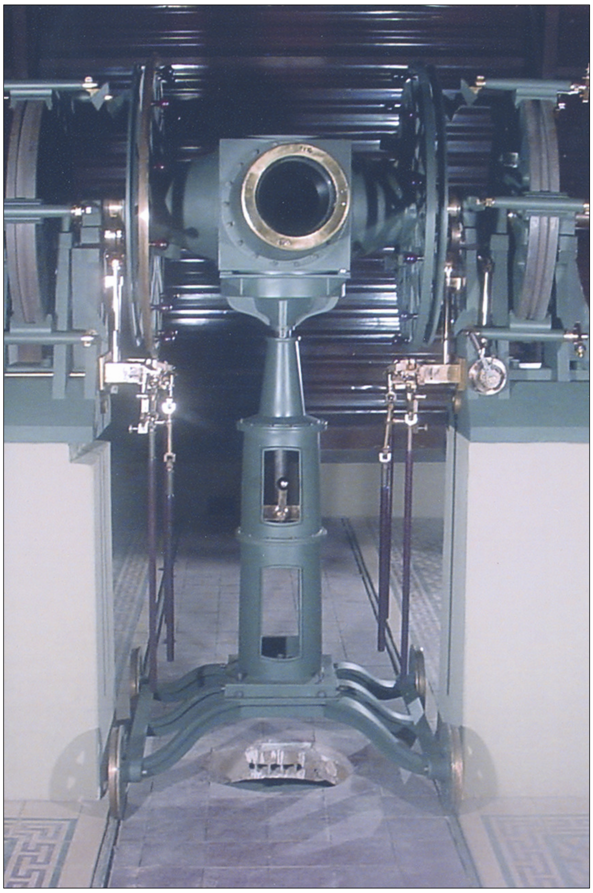

Figure 5: The meridian circle during the intervention process (author's photo).

Moving on to the third phase of the intervention process on scientific instruments, namely dismantling, the circumstances of this particular object were exceptional, in that it was already in pieces (see Figure 4). To compound matters, it was dismantled in the 1960s without any recourse to the modern precepts of conservation, meaning that the process was not recorded or documented. As far as screws are concerned, Keene (1999: 61) notes:

> Even the seemingly innocent action of dismantling an instrument in order to clean and reassemble it can cause damage. For example, in removing screws, many people would not appreciate that in scientific instruments each screw was specially made for its hole … It is essential to record the position of each one when dismantling an object. The screw slots are often specially shaped. A skilled and knowledgeable conservator will make a screwdriver to exactly fit the screw head - otherwise the heads can be torn, as they often have been, and the surface of the instrument damaged.

Thus, the meridian circle had to be reassembled carefully after its parts were restored, yet even the greatest of care could not rule out some divergence from the original, because it was impossible to tell exactly where each screw should be. Even so, the members of the group were unanimous in their decision to carry on with the restoration.

The procedures used in the interventions were similar to those employed on other instruments from the MAST collection (Granato, et al., 2005a, 2005b). When the restored parts still had some remaining varnish, they were cleaned with a methylene chloride solution, then rinsed thoroughly in water to remove all traces of the solution and dried. The oxidized parts were treated to remove the layers of oxidization products using mechanical processes, such as polishing pastes and fine sandpapers. For the finishing, 320# and 400# grit sandpaper was used. Finer grades (600# or 720#) were not used because they would result in a very shiny surface, which would be very different from the finished surface on the original instrument. Throughout the mechanical process, the surface of the parts was cleaned periodically with cotton to remove the suspension of oil and oxidation products. A scalpel was also used wherever there was pit corrosion on specific areas, where treating the entire surface of the piece was not necessary.

The parts which were originally produced using a mechanical lathe and originally bore machining marks had their layers of rust removed using a lathe, which also reproduced the concentric circles typical of this process.

Once the corrosion products had been removed, the unvarnished parts were degreased using trichloroethylene and then protected with a coating of microcrystalline wax. All the parts that were treated and protected with varnish were also degreased and then immediately had a new coat of varnish applied using an airbrush.

The right paint for the parts that were originally painted was chosen by studying areas of original paintwork that were revealed when the parts were dismantled. Their outside parts were then painted in a mixture of three synthetic gloss paints (brand: CORALMUR), at a ratio of around 38% green (code no. 9159), 38% grey (code no. 9152) and 24% blue (code no. 9295). When necessary, the inner parts were painted matt black (optical tubes, central shaft and objective lens protector), replicating how they were originally painted (see Figure 5). The final result is shown in Figure 6.

The most complex restoration work to have been undertaken at MAST was the meridian circle and rehabilitation of its pavilion. The whole project was carried out by a multidisciplinary team and was based on historical research into the object and its shelter over a period of three years. It was accompanied by an exhaustive photographical account of each stage of the work, covering the diagnosis of the instrument's state of conservation, its restoration, the rehabilitation of the pavilion and the return of the instrument to its original position, as well as a museological account of the area, providing the visiting public with information about the restoration work carried out.

6 FINAL CONSIDERATIONS

Over the past three years, different Brazilian and Latin American institutions have approached MAST for assistance in the conservation and restoration of their scientific instruments. It would appear that we are witnessing a 'discovery' of museum instruments of historical value on this continent, which means that some of them will need conserving and occasionally restoring. Being aware of the need to contribute to the preservation of these collections, MAST is in the process of setting up a new laboratory for the conservation of scientific instruments, which will be opened in 2009. It is hoped that it will then be able to meet the demand for training and services which has grown steadily in recent years.

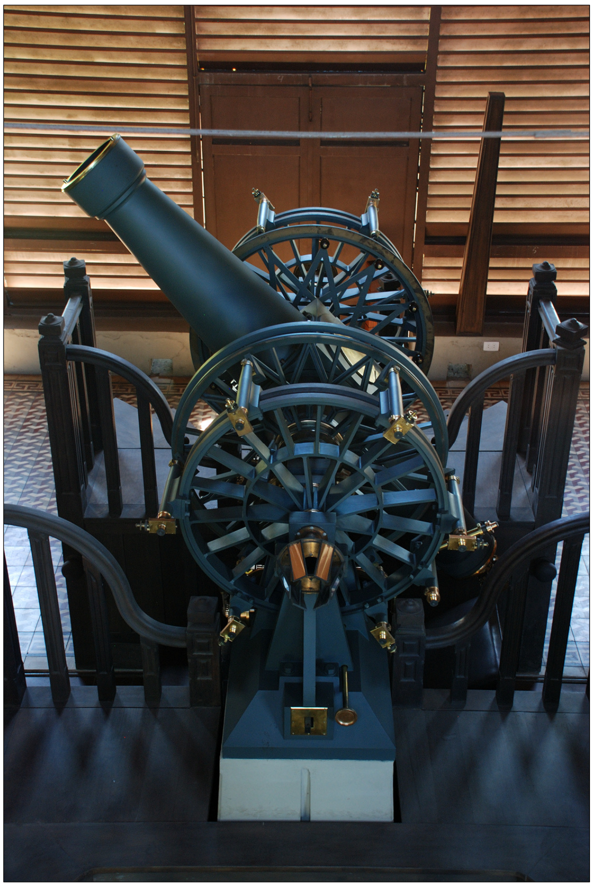

Figure 6: The fully-restored Gautier meridian circle.

7 NOTES

1 The Imperial Observatory of Rio de Janeiro was renamed the Rio de Janeiro Observatory on 31 May 1890 after the country was declared a Republic, and was included under the auspices of the Ministry of War (1891 Report).

2. The listing of the complex was in recognition of the uniqueness of its features, where the instruments had not been modernized and were still in their original sites.

3. This was an international project to photographically map the positions of all stars brighter than the 11th or 12th magnitude. Devised and initiated in 1887 by the Director of the Paris Observatory, Admiral Ernest Mouchez, it initially included the following observatories: Greenwich, Rome, Catania, Helsinki, Potsdam, Oxford, Bordeaux, Toulouse, Algiers, San Fernando, Tacubaya, Santiago, La Plata, Rio de Janeiro, Cape Town, Sydney and Melbourne (see Lamy, 2009; Turner, 1912).

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