APPENDICES

HISTORY OF CUBA UP TO TACÓN

The discovery

It is interesting to recall that Cuba was discovered by Christopher Columbus on 27 October 1492, only two weeks after he had first sighted land belonging to the American Continent, namely the little Island of *Guanahani*, which he named *San Salvador*. At sunset of the following day, 28 October, Columbus dropped anchor near the estuary of a river, roughly about where the town of *Mayari* is currently located, on the northern coast of Cuba, which he hoped would be a suitable site where to moor his caravels. However, as the bay was not wide and deep enough, on the following day he sailed west and continued to navigate along the northern coast of Cuba for over one hundred miles, until he found an excellent berth close to what is now the port of *Nuevitas*. At last he could moor his caravels and begin to explore the inland. Many years later, in honor of the *grande almirante* (Great Admiral) or *gran genovés* - as Columbus was called by most Hispanic writers, from then on - the Strait between the *Sabinal* peninsula and the island of *Guajaba*, near *Nuevitas*, was given the name *Boca de Las Carabelas* (mouth of the caravels).

In the new land Columbus hoped to find gold, silver and precious stones with which to pay back Queen Isabel for her great sacrifice, as she had sold her jewels to finance his endeavor. Unfortunately, however, he found no such thing, despite the help provided by the few natives who lived along the coast and who, although their level of civilization was comparable to that of the Stone Age, proved to be hospitable, docile and respectful people.

The first explorers of the New World could not possibly imagine that the exceptional fertility of the land they were crossing, which greatly fascinated them, could be as valuable as the gold they sought. Thus, with some disappointment, Columbus lifted anchor on 12 November and sailed in the opposite direction, towards the east. He wanted to

Itinerary of the discovery of Cuba and Haiti by Christopher Columbus

assess the length of that interminable coast, on the opposite side from which he had arrived. On 5 December he reached what is currently known as the *Punta de Maisí*, the easternmost tip of the island, which the natives called *Cuba* or *Cubagua*, and which he had baptized *Juana*, in honor of the Infante of Spain, *Don Juan*.

According to Columbus, considering its extension, that land was likely to be the stretch of a continent (Asia, in his opinion) rather then an island. That is why he called today's *Punta de Maisí*, *'Alfa y Omega,'* to indicate that it marked the beginning and the end of the "New World." Then, instead of sailing round the *Punta de Maisí* and exploring the southern coast of Cuba, Columbus continued to sail south-east; on Christmas day, 25 December 1492, he reached the island of which the western half is currently called *Haiti*, whereas the eastern half is known as *Santo Domingo*. Columbus called it *Hispaniola* (which is the name that is still used to indicate the entire island), and this is where he founded the first European colony of the New World which he named *Villa de la Natividad* to celebrate Christmas day. One might say that, from then onwards, *Hispaniola* was the Spanish beach-head to the New World, and a few years later it became the headquarters of the government and of the equally important Archbishopric.

In 1508, the Spanish Governor of Hispaniola, *Nicolás de Ovando* assigned *Sebastián de Ocampo* (who had traveled with Christopher Columbus on his second journey to the New World) the task of exploring the coasts of Cuba, to discover whether it was an island or, as Columbus had thought, the tip of the new continent. The exploration lasted eight months and it definitively proved that Cuba was indeed an island. It is worth recalling that during this exploration Sebastián de Ocampo discovered a port that was perfect for his ships and was thus called *Puerto de Carenas*. This is where the city of Havana was built eleven years later.

A few years after the exploration of the island, Spain decided to proceed with the military occupation of the latter; thus, in November 1511, *Diego Velázquez* landed with 300 soldiers. In two months he overcame the resistance of the natives and became the first Governor of the island. He was appointed *Teniente del Almirante de Las Indias*, and, in turn, received royal orders from the *Buen Gobierno de Las Indias*, which was to be as good (*buen*), at least in its intentions, as the *Buon Governo Toscano* we know so well …

Thus began the long history of Spanish colonial domination in the Americas. In Cuba it lasted 407 years, from 1492 to 1899, much longer than in all the other Spanish colonies, which gained independence from Spain between 1810 and 1824.

History of Havana

Havana - or rather *La Habana* - was not the first city to be founded by the Spaniards in Cuba, chronologically speaking. Cuba's first city was founded by Velázquez in 1512 and was called *Nuestra Señora de la Asunción de Baracoa*. The city, which is currently known simply as *Baracoa*, is located on the northern coast, near Punta de Maisí, therefore close to Haiti, whence all Spanish expeditions set off. Baracoa was also the first municipality and Bishopric of Cuba. Only a few years after Baracoa was built, the cities of *Bayamo, Santiago de Cuba* (where the Governor of Cuba, Velázquez, resided from the year of its foundation, in 1515), *Puerto Príncipe*, *Sancti Spíritus, Trinidad* and *San Juan de Los Remedios* were founded.

The founding of Havana, instead, was more complicated as it was initially built some fifty kilometers south of its current location and was subsequently transferred twice. More specifically, on 25 July 1514, the day dedicated to St. Christopher (*San Cristóbal*), a city named *San Cristóbal de la Habana* in honor of Christopher Columbus, was founded along the estuary of the *Rio Mayabeque*, on the southern coast of Cuba on almost the same longitude as current Havana. The little town of *Batabanó* is situated there today. The city was named after Christopher Columbus for the latter had landed there in mid June 1494, during his second journey to the New World. Approximately four years after it was founded, therefore in 1519, *San Cristóbal de la Habana* was moved by Velázquez from the southern to the northern coast, near the estuary of the *Rio Almendares* (*Boca de la Chorrera*), about six kilometers west of its current location, where it was finally transferred only a few months later. The reason why it was transferred a third time had to do, as was mentioned previously, with the presence in the bay of the excellent Puerto de Carenas, which had been discovered and used in 1508 by Sebastián de Ocampo. Thus, although it is not the oldest city, Havana can be considered to be the oldest port of Cuba, with the exception of the older but smaller port of Nuevitas, mentioned above. The advantages offered by the port of Havana were and are so great that they prevailed over the disadvantages that its first inhabitants had to endure; indeed, they were forced to stock up on drinking water at the *Boca de la Chorrera* (that is at the previous location) and they had to carry it either in barrels by boat or in jars on mule-back, covering a distance of over six kilometers from the Rio Almendares to the city.

Havana's first Municipal Council (*Cabildo*) was held in the year of the city's final settlement, 1519. It is commemorated by a small building called *El Templete*, which was built in 1828 and still stands, well preserved, on the site where the first *Cabildo* was held, namely in the today's Plaza de Armas; the latter is well known to present-day tourists as the heart of

The large and ramified bay of Havana

Coat of arms of the city of Havana

the so-called *Habana Vieja* (Old Havana).

In view of its growing strategic importance, Havana became the residence of the Governor of the island of Cuba in 1553, depriving Santiago de Cuba of this privilege. Finally, on 20 December 1592, exactly one hundred years after the discovery of the new Continent, King Philip II of Spain granted Havana, which had four thousand inhabitants at the time, the title of city and defined it *"llave del Viejo Mundo para el Nuevo Mundo"* (*key of the Old World to the New World*). He clearly referred to the crucial role of its port, which was an obligatory landing-place for all traffic to and from the American continent. That is why a gold key was included in the city's coat of arms, which was officially recognized on 30 November 1665 by the Queen Regent *Doña Mariana of Austria*, the widow of King Philip IV. The three castles on the coat of arms represent the three most ancient fortifications that were built to defend the entrance to the port of Havana, namely: the *Castillo de la Real Fuerza* (the oldest Spanish fortification in the Americas) built in 1553, the *Castillo de San Salvador de la Punta*, built in 1600, and the *Castillo de Los tres Reyes del Morro* (usually called *El Morro*), built in 1630.

The first aim of these fortifications was to defend Havana from the many pirates and buccaneers which not only intercepted naval traffic between Spain and the important ports of Veracruz and Honduras but even attacked and sacked Havana itself. Following the sack of the city in 1555 by the French pirate *Jacques de Sores*, the Castillo de la Real Fuerza, which had proved to be inefficient in protecting the city, was demolished and completely rebuilt. This took two decades, and the work was completed in 1577. Moreover, the study of a complex system of defense of the city was entrusted to the Italian military architect *Giovanni Battista Antonelli*, who finalized the project in 1589. From that year onwards, the construction of the two foregoing castles began, which were situated along the entrance canal to the port (*Canal del Puerto*). Two other castles were completed in 1643, which were positioned along the coast, a few kilometers from the city: the *Castillo de Santa Dorotea de Luna de la Chorrera* and the *Castillo de Cojímar*.

Instead, the impressive *Fortaleza de San Carlos de la Cabaña* (over seven hundred meters long, the cost of which was estimated to amount to fourteen million pesos of the time), also envisaged in the Antonelli project, was completed only in 1774, following the defeat of Havana's garrison by the English troops. In fact, the latter landed and attacked *El Morro* from the inland, precisely where Antonelli had planned to build the *Cabaña* fortress, which had not been constructed. In conclusion, through subsequent additions and reconstruction, Havana began to look more and more like a city-fortress based on the European model which flourished after 1500, according to the principles of the German *Albrecht Dürer* and the Italian *Michele Sanmicheli*, aimed to optimize defense and guarantee the self-sufficiency of the inhabited area in the case of long sieges.

The threat of pirates was dealt with drastically towards the end of the seventeenth century when England, Spain and Holland joined forces to defeat them. However, they were successful only in part, as it was impossible to get rid of this bane altogether, and it was especially difficult to drive them out of Cuba, where many had their shelters and the population lived in constant fear of sacking and assault for over one century. At times, the alarm that rang from the *Torreón de San Lázaro* - little more than one kilometer west of the inlet to the Bay of Havana, which served as a permanent sighting post to guard against pirate ships - was of little use. This situation of immanent panic ended only in 1834, thanks to the drastic measures adopted by the governor of Cuba, *Don Miguel Tacón*, which will be described hereinafter. Actually, the definitive solution was only achieved one year prior to the arrival in Havana of Antonio Meucci and his wife.

The city-wall played a basic role in the defense system of the city. It protected the west side, the one that faced inland, for over two kilometers. Its construction began in 1633 but afterwards was suspended for various reasons. After 1654 - when England conquered the nearby island of Jamaica - its construction was resumed and lasted over two decades. It was finally completed in 1674.

Nevertheless, during the famous *Seven Years' War*, when Spain and France were allied against England following the controversy on the succession to king Charles II and other matters concerning the reigning Bourbons, Havana was occupied by the English on 30 July 1762. The latter possessed very precise information on the city plan (rumor had it that the information was provided by an Englishman who had visited Havana as a tourist a few years before). They landed simultaneously at Cojímar, some four kilometers east of the entrance to the Bay of Havana, and at Boca de la Chorrera, approximately four kilometers west of the city, which thus found itself under a crossfire. The English fleet commanded by *Sir George Pocock* was very powerful and consisted of fifty ships, armed with two thousand cannons, and a landing force of fourteen thousand men. The city resisted for over a month and a half, and may have resisted longer if new troops had not arrived from Canada to help those already laying siege. The city was forced to surrender and a vast area of the inland was occupied. Santiago de Cuba then became the capital of the part of Cuba that remained under Spanish control. On 10 February 1763, after eleven months of occupation, with the *Paris Peace Treaty*

Scheme of Havana's fortifications in the early nineteenth century

England accepted to return Havana to Spain, even though it had won the war; however, in exchange, it annexed Florida. With the same treaty France surrendered Canada and Louisiana to England, which thus gained control over all of North America's East coast. Hence, England became the world's leading colonial power, taking the place of Spain.

Immediately following the departure of the English from Havana, the works for the extension of the wall were resumed, as a lesson was learned from the defeat. Moreover, a work force of four thousand men rebuilt the *Morro* (almost completely destroyed by English shelling) and work also began on the already-planned *Cabaña* fortress and the *Atarés* castle, the latter being situated at the tip of the south-west branch of the bay. The wall was also equipped with a large water moat and internal communication trenches. When construction was completed (in 1797), the wall was truly impressive: it was one meter and forty centimeters thick, ten meters high and had nine gates, eleven bastions and two semi-bastions. It was patrolled by a garrison of three thousand four hundred soldiers and was equipped with over one hundred and eighty pieces of artillery. A cannon shot (*cañonazo*) at nine o'clock in the evening (eight o'clock in winter) warned the population that the gates were being closed; the latter were reopened at dawn. Curiously enough, the custom of the *cañonazo de las nueve* has been maintained to this day, despite the fact that the wall was demolished back in 1863, as the city gradually extended inland. Havana's defense system, thus rebuilt and perfected at the end of the eighteenth century, served its purpose to protect the city (or discourage potential enemies) efficiently throughout the following century, until Cuban independence was achieved.

But the departure of the English from Havana did not only lead to a strengthening of fortifications. The English occupation had put an end to Spain's total economic and political dominion of its colonies. Indeed, Spain had not only held a monopoly over tobacco, but it had also controlled all trade - which had been limited to a small number of ports - and had hindered the relations of the island with other countries. This exclusive relationship had stifled local activities, which for a long time had been limited to livestock breeding and the little farming required to meet the population's needs, with the exception of sugar cane and tobacco growing. Other negative effects of these limitations were flourishing contraband, which, along with piracy, had become one of the most profitable activities of the Spanish colonies. After having occupied Havana, the English demonopolized tobacco and decreed free trade for all products in the western part of the island that they had occupied. So when Spain regained possession of Cuba, due to the pressure exerted by the municipal councils (*cabildos*) of the island, as well as because it wanted to prevent Cuba from following the example of other English or Spanish colonies that were rebelling against the occupiers, it decided to confirm these liberal measures, though diluting their enforcement over a period of two decades. The Royal Decree of 10 February 1818 provided for the opening of all Cuban ports to foreign trade.

Thus, only after the English occupation the island woke up from a long period of neglect and abandonment on the part of the *metropolis* (as Spain was called by its colonies). New crops and related industries started, such as that of a new variety of sugar cane (the *Tahití*, with higher yields then the local variety), coffee, cotton, Indian plant (to obtain indigo), silk-worms and bees for honey. Therefore, the island finally began to produce, hence to grow economically, also to the advantage of the Royal Revenues (*Rentas Reales*), to the extent that the first Spanish governor of Cuba who took over after the English occupation, the *Conde de Ricla*, created a new body for their administration, called the *Intendencia de Hacienda* (the Revenue Office). In the years that followed, the *Intendente de Hacienda* - often simply called the *Intendente* - was to become the most powerful man on the island after the governor, and at times he was even considered to be equally important.

To convey a better idea of just how backward Havana was at that moment in time, suffice it to say that the Conde de Ricla had to give a name to many of the city streets and numbers to the houses, despite the fact that the city's population already amounted to about forty thousand inhabitants. Immediately thereafter, he organized an internal mail service - which did not exist before - and regularized the one with the metropolis.

The Conde de Ricla was followed by over half a dozen governors, before the moment that is of interest to us, that is when the *Coccodrillo* sailed into the port of Havana. Just think that *Don Miguel Tacón* - the Governor in office at the time - was the eighty-eighth governor of Cuba, if Diego Velázquez is considered as the first. Said governors generally held office only for a few years (the actual average was three and a half years) especially due to the fact that, back in Madrid, the many ploys of those who coveted this desirable office often got the upper hand of even the most efficient and adamant behavior of any governor in power in Cuba, unless the latter was backed up by extremely powerful people at the Spanish Court. The official title of the governor was *Teniente General*, but he was usually called *Capitán General*, as shown by the nameplate that hangs on the palace in the *Plaza de Armas* which was his residence and was called *Palacio de Los Capitanes Generales*.

This palace - which stands just behind the *Castillo de la Real Fuerza* - was begun (but not completed) by the *Teniente General Marqués de la Torre*, who governed between 1771 and 1776. He became famous as he was the first person in the history of the island to conceive and implement a vast program of civil and public works, the purpose of which was to beautify the town and to provide leisure to the population. He was able to take advantage of a favorable moment in the history of the island, which already displayed signs of remarkable economic growth accompanied by a strong expansion of foreign trade. Among the early works of the *Marqués de la Torre* it is worth mentioning the first *Paseo*, created in 1772, just outside the walls of Havana. It was also called the *Nuevo Prado*, after Madrid's homonymous *paseo.*

This tree-lined avenue - reserved for pedestrians in the central part, which was slightly raised with respect to the carriage-lanes on the two sides, changed its name in the subsequent years, also because it was extended further and restructured. As of 1797 it was called the *Paseo Extramural*, then, in 1840, it was re-baptized *Paseo de Isabel II* (or *Paseo Isabella Secunda*) in honor of the Queen of Spain. Today it is called the *Paseo José Martí* (or *Paseo de Martí*) even though in commercial maps and often on the street signs, along with the names adopted by the current regime, the most important names of the past also appear (in this case, the name *Paseo del Prado* was chosen out of the ones mentioned above). However, since our story takes place in 1835, we will use the name it went by at the time, namely *Paseo Extramural*. This *Paseo* started by the ocean, where the previously-mentioned *Castillo de San Salvador de la Punta* stood. It followed a straight line along the external side of the wall, for slightly less than one kilometer and ended roughly in correspondence with the *Puerta de Monserrate* (the fourth gate of the wall, starting from the ocean). The effect of the rains was such that just outside of the wall the terrain became very rough, alternating deep troughs and mounds. Thus, in order to implement the *Paseo* it was necessary to build embankments and supporting structures, so as to trace a reasonably straight and flat path.

Another pleasant *paseo* inside the walls, which was reserved to pedestrians - also slightly raised with respect to the road level, as was the custom then - was finished a few years later, in 1776, and was called *Alameda de Paula*. It began from the *Plazuela de Luz* - whence the homonymous *Calle de Luz* and the wharf called *Muelle de Luz* also began - and continued in a straight line for about two hundred and fifty meters, along a stretch of the beach, towards south-west. This *paseo* ended in correspondence with the *Plazuela* and *Iglesia de San Francisco de Paula*. It is

Alameda de Paula - View from the Teatro Principal towards the Iglesia de S. Francisco de Paula

worth highlighting that the word *alameda* derives from the fact that most of these avenues for pedestrians were lined with rows of willows (*álamos*).

In 1775, one year before the *Alameda de Paula* was completed, the *Marqués de la Torre* inaugurated Havana's first civic theater. It was situated right at the beginning of the *Alameda de Paula*, in front of the *Muelle de Luz*, between the ocean and *Calle Oficios*. This theater, which succeeded the ancient *Casa de Comedias* (not bearing into account the various traveling theaters or theaters mounted on temporary stages) was initially called *El Coliseo*, or *Teatro de la Alameda*. Later, in 1808, when it was rebuilt and moved (slightly) towards the median line of the Alameda de Paula, it was given the name *Teatro Principal.* As was mentioned previously, the Italian Opera Company made its debut in this theater, a few weeks after its arrival in Havana. For this reason, as of 1836, it was also called *Teatro de la ópera*.

We have deemed it appropriate to point out all the names of the most important sites for, otherwise, the reader who should wish to consult historical documents dating back to this period might be confused by the wide range of names that were used, sometimes at once, for the same site. As we have done heretofore, for the time being we shall adopt the names that were in use in 1835, hence the foregoing theater will be referred to as the *Teatro Principal*.

It must be said, however, that at the beginning of the nineteenth century, Havana's population was not yet mature enough to appreciate the theater, at least not as much as it enjoyed strolling along the paseos, for instance. Indeed, whereas the beautiful and popular Alameda de Paula soon became a meeting point for the elegant youth of the capital, the people quickly lost their interest in the Coliseo and in 1800, though built solidly in wood and brick, it stood abandoned and half-destroyed. From that time, the city was left without a civic theater up until 1808, when the Teatro Principal was rebuilt very close to the area where El Coliseo once stood by order of the previously-mentioned governor *Marqués de Someruelos*. From the outset, the Principal enjoyed a happier fate than the Coliseo, especially owing to the fact that it could benefit from the presence of many good actors who had decided to abandon Spain following Napoleon's invasion. Today, tourists cannot even admire its remains, for the Principal, completely destroyed by the tremendous hurricane of 10 and 11 October 1846, was never rebuilt, also because it had been superseded by the new and larger *Gran Teatro de Tacón*. Conversely, the Alameda de Paula still exists, though it has been engulfed by the port area, quite unsuitable for night-wandering tourists wishing to savor again the old-fashioned pleasure of promenading. The sole vestige of the past splendor of the Alameda is the marble *Columna O'Donnell*, which stands at the center of the avenue and is still well preserved, though it bears no plate recalling its name, so that not even the people who live in the area seem to be acquainted with it.

As for the already-mentioned building of the *Palacio de los Capitanes Generales*, it is worth mentioning two important circumstances. The first is that this building was planned in 1776 by the Marqués de la Torre, along with the enlargement of the Plaza de Armas, which was made possible by the demolition of a church that stood in that area and which allowed to restructure the entire area between the Castillo de la Real Fuerza and the Muelle del Comercio (used for mooring passenger ships at the time). The second is that, actually, this palace was called *Casa del Cabildo* at first, as, prior to serving as the residence and office of the governor, it was the seat of the municipality and of the public jail, which latter was situated in its large basement and can still be seen today. The palace was completed in 1791 and was inaugurated by one of Cuba's most famous governors, *Don Luis de las Casas*, who took office in July 1790 and ruled until December 1799.

Under *Don Luis de las Casas*, the population of Havana proved to be mature enough to appreciate cultural entertainment, like more advanced countries. It is true that this inflexible and upright governor was so enterprising and resolute in his cultural initiatives as to drag the uneducated subjects of the island in the wake of his enthusiasm. To mention only a few of his many achievements, he promoted culture and education at all levels by creating the *Sociedad Patriótica de Amigos del País* (later known as the *Sociedad Económica de Amigos del País*).

Indeed, *Don Luis de las Casas* founded the first elementary schools, vocational training schools, some art academies, and he also opened the first public library in 1793 and the first higher education Chairs. As for the latter, it is worth highlighting that although a Pontifical University had existed in Havana ever since 1734, the only subjects taught there, by the Dominican Fathers, were basic philosophy, theology, and canon law. *Don Luis de las Casas* also founded a permanent periodical press in Havana and in particular the island's most ancient newspaper, called the *Papel periódico de la Habana*. It is also worthwhile mentioning the first census of the population, ordered by *Las Casas* in 1791, according to which the island's total population totaled at that date 272,000. He was also responsible for Havana's first public lighting system, which was implemented that same year. According to many historians, *Don Luis de las Casas* was by far the best Spanish governor of Cuba.

Historians also claim that the thirty years between the government of *Don Luis de las Casas* and that of *Don Francisco*

Dionisio Vives mark the period in which Havana registered its greatest development. Indeed, during that period, as a consequence of different causes, three waves of skilled and educated immigrants reached Cuba, which undoubtedly contributed to said development. Precisely, in 1791, in the wake of a rather widespread revolt of slaves in Haiti, many companies were forced to close down and some transferred their activities to Cuba. Some have said that it is thanks to the immigrants from Haiti that Cuba became the first producer of sugar in the world in only a few decades, thereby deserving the title of *azucarera del mundo* (*the sugar-basin of the world*). The other two waves of immigration came from the former Spanish colonies of Hispaniola and Louisiana, both surrendered to France, in 1795 and in 1803, respectively. As a consequence, many enterprising and bright Spanish and French people emigrated from those colonies to Cuba, who contributed to raising the economic and social level of the island and began to grow coffee in Cuba. Moreover, entire families immigrated to Cuba from the Canary Islands, and this was also championed and promoted by governor Las Casas.

Growth of Havana's population

The history that followed, up to the beginning of the period we are interested in, was marked by Spain's constant concern not to grant too much freedom to its colonies, for fear of fueling their spirit of independence. In particular, in 1820, governor *Cajigal* was prohibited from ratifying the Spanish Constitution in Cuba. His successor, *Don Francisco Dionisio Vives*, was entrusted with special powers, in 1823, to the aim of maintaining order in Cuba, as did, in 1830, the governor that came after him, *Ricafort*, in derogation of the laws in force in Spain. Notwithstanding, such measures did not prevent most Spanish colonies—with the sole exceptions of Cuba and Puerto Rico—from gaining independence from Spain in the period between 1810 and 1824.

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DON MIGUEL TACÓN Y ROSIQUE

Visconde de Bayamo, Marqués de la Unión de Cuba, Caballero Insigne, Orden Toisón de Oro

Don Miguel Tacón y Rosique was born in 1775 and died in 1855. Prior to taking office as the eighty-eighth governor of Cuba, on 1 June 1834, at the age of fifty-nine, he had served in the Spanish army and had taken part in the military operations in Latin America, which preceded the independence of most of the Spanish colonies. On account of his past experiences, he tended to mistrust Creoles and was against any type of political concession that might have compromised absolute Spanish sovereignty over Cuba. Indeed, only pure Spaniards belonged to his *camarilla*. In this regard Jacobo de la Pezuela relates: *"… Tacón did not add, to Las Casas' great talent for government, flexibility and rectitude and to Cienfuegos' ardent love for law and order, the mediation ability of Vives … "* However, Pezuela implicitly compared him to the best Spanish governors of the island. In fact, owing to his biased attitude, Tacón was despised by the Creole aristocracy (which he did not invite to the great balls given at the Governor's Palace) as well as by the *'sugarocracy'* and the Church, which had many powerful friends as well as its own strong economic interests in the sugar industry. Tacón attacked the latter so vehemently that he earned the reputation of being anticlerical. However, by supporting clandestine slave trade - from which he is said to have earned huge profits - he ended up favoring the sugar industry, supplying cheap labor and thereby contributing to its economic growth.

Tacón maintained the censorship imposed by his two predecessors Vives and Ricafort, adding a third, military censor to the two civilian ones, with a final right of veto. He also suppressed the *Revista Bimestre Cubana* because he considered it to be too anti-conformist. He was very hard on the Creole and colored people, for fear of separatist movements such as the ones that had occurred in the rest of Latin America. In fact, Tacón resorted to all means of dissuasion, including jail and deportation.

According to Pedro José Guiteras (see bibl.), General Tacón *"was tall, lean, with a serene and solemn face and steadfast countenance, which, however, was dissimulated in his general physiognomy. He was careful to keep a dignified attitude and to appear well-groomed, and had the virtue of being methodical and industrious in his government tasks. The exaggerated notion that he had of his authority enhanced his arrogance and extreme reserve… His moodiness led him to be often overwhelmed with anger and he was extremely strict in exacting obedience."* Ramón de la Sagra (see bibl.) added on Tacón's commitment to building: "… *He kept watch like Argus… he read the reports on the work progress which he asked for daily and controlled the supply of materials to the different sites, visiting them in the evening …*"

Tacón went down in history because of his exceptional building activity: indeed, another period of large-scale urban constructions matching that of Tacón was only registered ninety years later, in 1925, when a new master plan of the city was entrusted to the Frenchman *J. C. N. Forestier*.

Another Tacón's equally important merit was that of keeping public order and enforcing the law. He repressed opposing political parties ruthlessly and marginalized affluent Creoles from the centers of power (making them his enemies), resorting to deportation to get rid of his opponents. He also put an end to gambling and to the licentiousness that had gained ground under the various governors who had come before him. Conversely, Tacón was not blood-thirsty: indeed, the number of people put in prison and sentenced to death under his government was much lower with respect to the previous Vives and Ricafort governments, or the O'Donnell, Roncali and Concha governments that followed.

Briefly, Tacón achieved the following objectives: he improved public services and hygiene, fought the environmental pollution, he was an inflexible censor of customs, improved public order and, above all, he created an urban structure suitable for recreation and leisure, in tune with the changes that had taken place in the lifestyle of the town, which, thanks to him, became a modern city. In particular, he repaired the streets and introduced street lighting, built a theater in the capital that turned out to be the best in America, and left the island with a population that had grown to more than one million people and an income estimated at over ten million pesos *fuertes.* Finally, Tacón went out of his way to ennoble and reassert the power of his motherland in Cuba. According to Pérez de la Riva (see bibl.), Don Miguel Tacón was the greatest town builder of the past century: "… *His name echoes in all the districts: Calle de Tacón, Teatro de Tacón, Paseo de Tacón, Mercado de Tacón, Puerta de Tacón …*"

During his government, Tacón avoided using the *Royal Revenues* administered by the (Creole) *Conde de Villanueva* to finance the public works that he approved, resorting as much as possible to donations, taxation, the private capital of contractors and the sale of *bozales* (slaves born outside of the island) and emancipated slaves. Public works employed emancipated slaves, prisoners and even Carlist exiles[1], with various expedients, including long extensions of their detention terms.

[1]Supporters of *Don Carlos*, the pretender to the Spanish throne, or his heirs.

Public Order and Military Structures

About one month after having taken office, Tacón adopted a series of measures to enforce law and order on the island. First of all, he regulated the use of weapons and forbade people to circulate armed. He introduced strict regulations for the disembarking of passengers traveling on ships arriving in the port. He also ordered that dog owners use leads and muzzles and that stray dogs be killed. On 15 July 1834, he set up an efficient night patrol corps for the sixteen intramural neighborhoods, known as the *Cuerpo de Serenos*, for which he himself drafted detailed regulations. Prior to this, night guards, which had existed in theory ever since the early 1800s, were few and inefficient, also because they were paid with the voluntary contributions of the citizens.

Tacón worked hard on the moral and social rehabilitation of the island, and the effects of his endeavor were long-lasting. In particular, he prosecuted thieves, murderers, tramps and gamblers, he closed illegal gambling houses and reproduced the announcements of the *Buen Gobierno* which were displayed on street corners. Up until then, the situation had been such that the lives and property of the people were not safe even during the day or in well-lighted areas. After sunset, no peaceful citizen would venture to walk the streets. The city teemed with gamblers and thieves, whereas the countryside was infested with gangs of outlaws. As soon as Tacón became governor, he changed this state of affairs and persecuted all criminals regardless of rank or category. Indeed, it is said that he had one of his officers, accused of embezzlement, locked up in jail. After exiling gamblers, he ousted the gangs of outlaws from the city and countryside. In particular, he purged the city of the various bands of pirates, smugglers and robbers whose favorite haven had been the *Regla* neighborhood (south of the Havana bay) and which had previously infested the roads that led to the city, engaging in their criminal activities right under the city wall, in defiance of customs officers and the fortress military. Following Tacón's energetic measures, Regla became a calm neighborhood, if poorer and deserted. Even its *Plaza de Toros* - previously patronized by the gangs of outlaws - was abandoned by the public, whose interest in violent spectacles had declined, and the amphitheater fell into ruin, as did many of the houses in this neighborhood that were linked to crime. Many years later, in 1845, tales of the incredible and daily criminal feats of the past were recounted in Regla like legends. Indeed, ever since Tacón became governor, guards on horseback patrolled the streets of Regla every night, reassuring pedestrians and discouraging criminals.

Tacón's drastic measures won the approval of foreigners, who had steered clear of the island up until then, knowing that in that land thieves and bandits had the upper hand. Thus, as a result of Tacón's provisions, a remarkable number of tourists flocked to the island, especially from North America. *Eduard Otto*, a German writer, reported that during his stay in Havana, around 1836, the entire city was perfectly safe.

Tacón also turned his attention to the military and command structures, and had the Palace of General Captains or *Casa de Gobierno* remodeled between 1835 and 1836. The jails were removed and prisoners were temporarily detained in the Cabaña fortress. The task of restructuring the building was assigned to chief engineer Don Manuel Pastor. The rooms of the former jail were restored and used as offices by the Captain General and the Municipality (*Ayuntamiento*); eight elegant shops and two public notary offices were also obtained. The roof was renewed and a large neoclassical marble portico was added to the façade that overlooked the Plaza de Armas, which has remained unchanged to date.

Tacón built a *Campo Militar* better known as *Campo de Marte*, which was to serve for the training and exercises of his troops, keeping them at the top level of efficiency. In later years, however, it was also used for parades and other events. Among them, it is worth mentioning some famous aerostatic lifts, such as that of the Cuban *José Domingo Blinó*. The *Campo* (field), which was located near the crossroads of San Luis Gonzaga and the Paseo Extramural, was two hundred meters long and one hundred and fifty meters wide and was surrounded by a tall iron fence, three meters high, with large gates on the four sides: the *Puerta de Tacón* to the east (right in front of the city-wall), the *Puerta de Hernández de Cortés* to the north, the *Puerta de Pizarro* to the South and the *Puerta de Colón* to the West. Each gate had two pillars supporting an arc with the coat of arms of the city and an inscription with the year of construction and name of the gate. Otto Eduard wrote that there were large *alamedas* around the square with very beautiful buildings from which the population could admire the exercises, and that, on the northern side, the Campo de Marte was adjacent to the old Botanical Garden (*Jardín Botánico*). Furthermore, Otto reported that he was very much impressed by the excellent bearing of the military. The Campo de Marte was built with public funds, and total expenditure amounted to 181,053 pesos. Today it no longer exists. Part of the area is currently occupied by the Plaza de la Fraternidad.

Around March 1835, Tacón began to build a new prison called *Nueva Cárcel* or *Cárcel de Tacón*. By September 1836, all of the prisoners who had been transferred temporarily from the basement of the *Casa de Gobierno* to the Cabaña fortress were moved there. The project for the jail was a modern one indeed for that time. As a matter of fact, Tacón sent his friend Ramón de la Sagra off to Europe for a couple of years to study the most efficient jails as well as to the United States to take stock of their modern penitentiary theories. Don Manuel Pastor directed the works and another friend of Tacón's Joaquín Gómez, was in charge of raising public funds. The building, which was situated at the beginning of the Paseo Extramural, facing the ocean, was sixty-seven meters long and one hundred and seventy meters wide, and could hold up to two thousand prisoners, distinguished by sex, social class, color and type of crime, and over one thousand two hundred military men. For this purpose, the ground floor of the building was used as a jail, while the upper floor was used as barracks for the troops and as officers' residence. The ground floor featured two workshops where the prisoners were put to work, according to the United States' system, as well as large courtyards for the hour of recreation. Moreover, the prisoners were kept in large rooms, instead of locking each one in a separate cell, with the exception of those imprisoned for serious crimes. The second floor was completed in 1839, after Tacón had already left office. The final cost of the *Nueva Cárcel* amounted to 480,640 pesos and 4 reales. In the subsequent years, the terrain, which was part rocky and part sandy, began to yield, therefore a number of measures had to be taken. The building was torn down in 1930, although the chapel - which still exists - was left as a Memorial of it.

Another military building was the *Barracks of Carbineers* (*Cuartel de Carabineros*) of the Castillo de la Real Fuerza. It was begun in 1837 and completed in 1839 under the government of *Don Joaquín Ezpeleta.* The building was set up in order to avoid having the garrison reside outside the walls, whence, in case of need, it could not rush to the fortress during the night, when the gates of the wall were shut.

Between 1836 and 1837, Tacón also built a villa to be used by the Captain General - which was used also by his successors - as a private residence or *de recreo* (for recreation), so as to separate the place of work from the private residence. To this end, Tacón decided to use an area along the *Paseo de Tacón* (or *Paseo Militar*), under construction at the time, called *Los Molinos del Rey*. There was also an old house there, which was restructured and then used to lodge the servants of the villa. The garden (which was called *Jardín de Tacón*) presented many precious plants and bushes that were taken from the nearby botanical garden (*Jardín Botánico*), which had to be moved also to make room for the railway. The villa was built by Don Manuel Pastor. It had only one floor, with a terrace and galleries and shutters on the windows. Materials left over from the other constructions were used and labor was provided by the prisoners of the *Nueva Cárcel*. The villa is currently known as the *Quinta de los Molinos* (Villa of the Mills), and a few remains of the railing of *Campo de Marte* are displayed there today. Its total cost amounted to 25,062 pesos.

Map of the island of Cuba of 1874

Public Works and Public Services

Tacón devoted much attention to organizing public services. On 12 December 1835, he founded the *Cuerpo de Bomberos* (the Fire Brigade), comprised of one hundred and eighty men (six thirty-men units), of which one third were white, one third mulatto and one third black. Half of the men were allocated to the extramural neighborhoods while the other half was assigned to the intramural quarters. Each unit had men who were brick-layers, carpenters or blacksmiths, guided by a commanding Lieutenant who was assisted by a Second Lieutenant and a Sergeant. The barracks were situated next to the San Felipe convent, on the corner of Obrapía and Aguilar. This unit reported to the engineer Manuel Pastor, who, in turn, reported to Tacón, who held the office of Inspector. Also in this case Tacón no longer resorted to the voluntary contributions of citizens to pay the salaries of said firemen and levied a small but fixed tax, in order to ensure that the service wouldn't be inefficient as it had been in the past. Another innovation consisted in installing fire hydrants on the walls of corner buildings, where the hydraulic network pipes of the very recent Fernando VII aqueduct passed. Said hydrants were also used to sprinkle the streets during the dry season.

In the same year, Tacón took away the contract for garbage collection from the previous holder, who had proved to be inefficient, and called a public tender, the first condition being that the roads had to be swept on the same day that garbage was collected.

Between 1834 and 1835, Tacón tore down and rebuilt several markets and the city's slaughter house. In the new markets he introduced modern hygienic criteria such as running water to keep counters and utensils clean, big marble slabs on which to display the produce, good air ventilation and lighting, large roads for traffic and porticos to shelter people from sun and rain. Previously, the markets had been held in open squares and were often unbearably reeking. He also introduced the *Councilor responsible for the Police and for weight rectification*, despite the fact that most of the buyers were slaves or colored people. One of the new markets, called *Mercado de Cristina* (or *de Fernando VII*) was within the walls, in the Plaza Vieja (or de Fernando VII). It was built by a private contractor (Manuel Pastor) and cost 115,521 pesos. It no longer exists, although the Plaza Vieja still stands. The other intramural market was the *Mercado del Santo Cristo*, on Plaza del Cristo (or Plaza Nueva), next to the *Iglesia del Santo Cristo* situated on Calle Teniente Rey, between Villegas and Bernaza. It also was built by a private contractor (Manuel Pastor) and cost 67,876 pesos. Today, no traces are left of this market. The *Pescadería* (or *Boquete de la Pescadería*) built by another private contractor (Don Francisco Marty) has been described in detail in the foregoing, as was the market built outside the walls, called *Mercado de Tacón* (or *Mercado del Vapor*) which was also built by a private contractor (Don Manuel Pastor).

As regards the slaughter house, the *Matadero-Carnicería*, Tacón tried to make the procedures more hygienic and he summoned technical experts from the United States for this purpose. The old slaughter house, situated within the walls, was dirty as well as irrational. The new slaughter house was erected outside the walls, to the right of the *Chávez* bridge, near the *Calzada del Monte* (in the *Horcón* neighborhood), also called *Calzada del Horcón*. He also ordered that the meat be transported in closed wagons and as of l October 1835, heavy fines as well as jail sentences were given to the many butchers who failed to comply. The slaughter house cost 47,780 pesos.

As for public works, Tacón paved with *macadam* (after the name of the Scottish engineer *John McAdam*, who developed this method in Bristol, GB in 1815) as many as twelve intramural roads and several extramural roads, for a total of twelve kilometers. More specifically, it was estimated that, between 1834 and 1837, over 120,756 square meters of roads were macadamized. The method consisted in laying a roadbed of gravel and crushed stone, rolling the surface with the addition of binders, sometimes merely consisting of water sprayed prior to rolling, which helped to cement and flatten the surface. Tacón developed a method which was tried out for the first time on Calle de O'Reilly in 1834. After the experiments he decided to do without the final layer of gravel and sand because torrential rain simply washed it away and dragged the material down to the bay, raising the level of the sea bottom. Instead, he had a pounding machine with six hammers (served by six men) built, which crushed the hard flint-stone into small fragments; the latter were then rolled with a heavy compressor, thereby achieving a sort of dry compacting of the roadbed. The advantage gained by paving the roads according to this method was that the noise produced by carriages and wagons was greatly reduced, as the surface was smoother; moreover, it was possible to give the roadbed a convex shape to help rainwater flow down to the side of the road. The method, however, had to be reviewed because when very heavily-loaded wagons passed, pulled by oxen, they would destroy the road, therefore harder and more compact materials had to be used.

While he paved the roads, Tacón also provided for the construction of a sewage network. He ordered that homeowners equip their houses with cesspools for the disposal of waste water, to avoid water used for household purposes and personal hygiene being stealthily discharged into the streets, contrary to regulations. Indeed, the sewers were to serve almost exclusively to convey rainwater only into the sea. Instead, all sorts of wastes and filthy water ended up being discharged. The sewage system received water from the *Zanja* to dilute the waste. The umpteenth controversy between Villanueva and Tacón arose on this subject, because the works for the railways made it necessary to cover a stretch of the *Zanja*, damaging the connection with the sewers (according to Tacón), while, according to Villanueva, said inconveniences were caused by the excessive difference in level of the Calzada de San Luis Gonzaga. The works for the sewer system were begun by Tacón in 1835 and by 1837 more than 2,730 meters had been built.

Tacón also had bronze plates bearing the street names placed on street corners, and introduced numbering for the houses, with even numbers on one side of the road and odd numbers on the other, as is done in modern cities.

In the years between 1836 and 1837 other civil constructions were launched, including the extension of the *Paseo Extramural*, the construction of the *Paseo de Tacón* and the refurbishing of *Calzada de San Luis Gonzaga* and of the *Puente Galiano*. The latter, which initially stretched across the *Zanja* on an acute angle, was rebuilt at a right angle, so as to leave a larger underpass for the railways. Later, when the *Zanja* was covered over and paved, the bridge was no longer of use and was thus dismantled.

In that same period (1836 1837), Tacón restructured the main wharf, situated opposite the harbor office, which was called *Muelle del Comercio* (later denominated *Muelle de Caballería*). He imported granite stone from Barcelona and paved the entire area, where he later placed the *Fuente de Neptuno* or *Fuente del Comercio*, which was brought from Genoa specifically for this purpose. The fountain was moved several times. First it was placed at the crossroads of *Paseo del Prado* with *Calle de Neptuno*, which was named after the fountain. Then it was taken to the *Parque de la Punta* and finally it was moved four kilometers west, near the coast (*Malecón*), and was placed in the *Parque Gonzalo de Quesada* (in the new *Vedado* quarter), which is formed by four roads - *Calzada*, *5ª*, *C* and *D* - where it has remained to this day.

The *Paseo de Tacón* was built as an extension of the *Calzada de San Luis Gonzaga.* It was 1.17 kilometers long; the central section reserved for carriages was 16.7 meters wide, whereas the two side lanes for pedestrians where half as wide, the total width being 37.6 meters, including the four rows of trees that adorned it. The old criterion that was previously adopted for the *alamedas*, according to which the road section for the pedestrians was elevated and placed in between the side lanes to be used exclusively by vehicles, was reversed. The Paseo de Tacón replaced it with the modern criterion which envisages vehicle traffic at the center of the road and sidewalks for pedestrians on either side of the latter, the road and sidewalks being on the same level. Every three hundred meters, the Paseo opened onto lovely squares with seats, steps, columns, fountains, cascades, lakes and other decorations; there were five such squares on the whole. It was also known as *Paseo Militar*, for the troops permanently transited through it on their way uphill to the *Castillo del Príncipe*. *Ramón de la Sagra* selected the plants and vegetation, as he was a botanical expert and had a good understanding of the island's weather conditions. Despite its magnificence, it was only in the first years of its existence that the Paseo de Tacón was chosen by the aristocracy of Havana as a place where to idle the hours away, enjoying its coolness, bubbling fountains and fresh air laden with the scent of flowers. A few years later, however, it was mainly frequented by military men on their way to the Castillo del Príncipe and by the students of the *Colegio* (boarding school) which was built shortly thereafter near the banks of the *Zanja*. The reason why the population abandoned this paseo was because it was very far away from the center of the city.

Moreover, as of 1840, there was also the inconvenience that transit had to be interrupted at certain hours of the day on account of the railway to *Güines*, which crossed the Paseo.

Another project, which was important for many reasons, was the *Calzada* (or *Malecón*) *de San Luis Gonzaga*. It is worth highlighting that *Malecón* literally means embankment for protection from water, namely dam, or elevated walk, like the current *Malecón*, which runs along the north-west coast of Havana. This road, *San Luis Gonzaga*, had existed for a long time (at least since the beginning of the eighteenth century) and it was the main road that led from the city to the countryside. It was once called *Camino de San Antonio* because, after a winding path, starting from intramural *Calle Real* (or *Calle de la Muralla*), and after crossing the area of *Campo de Marte*, it led to the farm of *San Antonio el Chiquito*. In 1751, a Jesuit hermitage (*Ermita de San Luis Gonzaga*) was built at the corner of said *Camino* with *Calle de la Beneficencia*, and, since then, the *Camino* was named after the hermitage, i.e. *Calzada de San Luis Gonzaga*, also because the Jesuit fathers - who were involved in the *San Antonio el Chiquito* plantation - had paved the road. At its crossing with *Águila* there was a circus with seats, called *Mentidero*, where old people and politicians met to chat.

The Fuente de Neptuno, today at Vedado

In 1836, Tacón had the *San Luis Gonzaga* rebuilt, endowing it with a long fly-over bridge (the first of its kind in the world), which was three hundred meters long and ten meters wide, in order to eliminate much of the difference in level and the winding course of the previous road, so as to connect it with the Paseo de Tacón in as straight a line as possible. From then on, the road became animated and crowded, and it could finally be used also during the rainy season, to climb easily up the hill to the *Castillo del Príncipe*. The boundary between the Paseo de Tacón and San Luis Gonzaga was precisely at the intersection with *Belascoaín*, called *Campo de Carmona* at the time, while San Luis Gonzaga began at Campo de Marte. Its total length was 835 meters and it was fifteen meters wide. Some streets passed under the fly-over bridge. Two narrow side lanes were also built on both sides of the bridge to deviate heavy vehicles and facilitate circulation. However, the owners of the houses set next to the fly-over bridge, which were left in the shade and subject to flooding, turned to the *Juicio de la Residencia* (the Court for inquiring public officials) to protest, and complained that the city had been split in two by the embankment. Instead, the *Ayuntamiento* took a stance in favor of Tacón, complimenting him on his project. The sentence of the court was also in favor of Tacón. Only when Tacón returned to Spain did his enemies attack the *horror* of San Luis Gonzaga and saw to it that the embankment be destroyed in 1844, after which the road was rebaptized *Avenida de la Reina* (currently *Avenida Simón Bolívar*).

Tacón had another gate opened in the wall, next to the *Puerta de Monserrate*, as the latter was too small for the two-way traffic to and from the intramural city. Hence, the *Puerta de Monserrate* was doubled, serving the two one-way streets, *Calle del Obispo* and *Calle de O'Reilly*, which linked the Plaza de Armas and the *Casa del Gobierno* directly with the area outside the walls. In particular, the new gate served Calle de O'Reilly to exit the city, while the old gate served to enter the city, towards Calle del Obispo. Since a hermitage (*Ermita de Monserrate*) stood between the two gates, Tacón had to have it torn down and subsequently rebuilt in the *Colón* neighborhood, naturally coming up against yet other problems with the *Juicio de Residencia*. The new doubled gate of Monserrate made it much easier for the garrison to transit to Campo de Marte, the Castillo del Príncipe or the Nueva Cárcel. Tacón himself used it to go with his characteristic black carriage to the Gran Teatro de Tacón, which is described in the next appendix. Building the new gate also entailed the need to build a new stone bridge, with eleven arches, which was necessary in order to cross the moat surrounding the city wall. The main arch was supported by four pillars. Stone parapets and sidewalks were placed on either side of the bridge, while on one side of the gate (to the left exiting the city) lodgings for the guard corps were erected. This gate is an important example of Tacón's constructive vision.

Overall, Tacón's construction projects cost more than three million pesos, according to the figures officially registered and to an estimate of the missing items (Chateloin, see bibl.).

On 21 April 1838, after almost four years of government, Tacón left Havana and his office and returned to Spain *"on account of his poor health,"* it was said. He died there seventeen years later.

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GRAN TEATRO DE TACÓN

History and description

Anyone wishing to walk around the entire block where the *Teatro García Lorca* currently stands and where the *Gran Teatro de Tacón* stood in the last century, should begin at the façade, which overlooks the big *Parque Central*. Here, in this enormous square, ended the *Paseo Extramural*, now *Paseo de Martí*, stretching almost from the sea, near the *Castillo de San Salvador de la Punta*. *Calle de Monserrate* (currently *Avenida de Bélgica*) also began here, though it headed in the opposite direction. On the right, facing the theater, one can enter the narrow street of *San Rafael*, then turn left on the street of the *Consulado*, which runs along the back of the theater and, lastly, left again, along the wide street of *San José*, to complete the tour at the *Parque Central*. Returning to the point of departure along *San José*, one cannot miss, to the right, the large garden where the *Antiguo Capitolio Nacional* (built in 1928) is located, now housing the *Academia* and *Museo de Ciencias*. This tour takes one round the edge of the plot of 6176 square *varas* that *Don Francisco Marty* obtained from the old botanic gardens in order to build the *Gran Teatro*. The agreement was concluded in two stages, the first on 21 July 1836, when payment was made for 5678 square varas at 14 reales each, and the second on 18 November 1839 when the remaining part of the total 6176 square varas was settled at 18 reales each[2], for a total of 10,932 pesos and 4 $\frac{1}{4}$ reales. A fairly low price was granted because the land had been described as *"… soft and sunken ground, flooded by rainfall, which makes construction expensive."*

According to Pezuela, the plot of land measured 77 varas along the Paseo and 80 varas across, along the streets of San Rafael and San José. However, a precise measurement of the area was made in 1853, during legal proceedings instituted by Marty. It was calculated (see further on) that the two sides averaged (the plot not being perfectly rectangular) 74.5 and 81.3 varas respectively, corresponding to approximately 63.2 and 69.0 meters. The area was divided almost equally between the actual theater, which occupied an area of 37.7 x 81.3 varas towards the street of San Rafael, and a large courtyard containing the (Meucci's and Marty's) residence building as well as the protruding building for the theater's prop rooms and laboratory, which covered the remaining area of 36.7 x 81.3 varas next to the street

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[2]The additional area consisted of two strips of land adjoining the first plot, one along the street of *San José* and the other along the street *del Consulado*, together totaling 500 square varas. Moreover, *Marty* did not use a small area of about 120 square varas in order to let the building be perfectly rectangular and of the appropriate dimensions. The measurements quoted below refer to the final calculation as recorded by the official surveyor in 1853 (see further on).

of San José. The theater portico extended over the plot by 8.4 varas (about 7 meters) towards the Paseo so as to allow the carriages heading for the theater to transit freely along the Paseo itself.

The city wall and the two gates of Monserrate which stood opposite the Gran Teatro, on the other side of the Paseo, were demolished in 1863, therefore today's tourists will be unable to see them.

A description of the large courtyard and annexes is given by Pezuela, later quoted by Fernando Ortiz (1941, see bibl.) as follows (translation): *"… Adjacent to the right side of the nave of the theater there is a low building with the façade facing the avenue* [i.e. facing the Paseo Extramural, Editor's note] *and the side facing Calle de San José, which is comprised of two floors from the road-bed, where most of the theater's apartments and laboratories are located; thus the far-sighted Marty, who owned the building, had all that was required in terms of sets, machinery and structural work prepared there, without going out of the enclosure, for that was the stable residence of his employees and most experienced workers …"* These *most experienced workers* included Antonio Meucci, as he himself testified during the Bell/Globe case in 1885. Moreover, *N.E. Baguer* (1983, see bibl.) confirms that the family of Don Francisco Marty also lived in the annex. Indeed, he writes that (translation): *"the whole block … was owned by Don Pancho and that is where his family, the theater workshops and the lodgings of the workers were …"*

According to Pezuela, there were, inside the portico, three wrought-iron entrances to the theater. He relates as follows (translation): *"… they were located inside a portico, of simple and elegant design but sufficiently large to accommodate quitrines and volantas on rainy evenings. There were three inlaid arches along the front of the portico facing the Paseo and one on each of the two sides. The front arches were supported by solid marble Doric columns, while along the sides and at the corners the columns were in relief. Above the portico ran a terrace, and on performance evenings the military band of the artillery regiment used to play national and foreign pieces there, beneath six tall poles from which fluttered huge Spanish flags … When the Governor's coach was sighted from the Gran Teatro through the Monserrate gateway, coming from the Calle de O'Reilly, the military band would immediately strike up the royal march under the light of thousands of Bengal lights, while inside the last touches were put to the royal box …"* The three wrought-iron entrances did not lead directly to the theater hall but to a large patio paved in marble, flanked by two covered corridors leading to the actual doors towards the stalls and boxes. The patio was divided lengthwise into two sections, each with its own

Prices at the Teatro Tacón in 1838 (the inauguration)

coffee bar, in place of the *buvette*, which was common in European theaters. The bar on the right of the patio was reserved for white women and served mostly ice-creams, while the other, open to both sexes, served wine and liqueurs; they offered a combined seating capacity of 570. Part of the patio was covered at the level of the second floor by a terrace that communicated with the terrace over the portico and in the center of which was a large skylight.

The theater itself contained five tiers of boxes, about 3.30 meters above each other, with separate staircases for each tier. The first three tiers each contained fifty boxes, the fourth tier housed the circle (*tertulia*) and on the fifth level was the gallery (*cazuela*). It is astonishing how closely the inside of the Teatro Tacón resembled the Pergola in Florence, which might be due to the fact that Antonio Meucci contributed to designing as well as building the theater.

Lighting was provided with candles, which were placed in front of the railings that ran along the five tiers of boxes, presenting fairly wide meshes to allow the passage of air. There were no vestibules in front of the boxes, as in European theaters. One entered directly from the corridors through half-doors, open at the top to help the air circulate, a necessity in the climate of Havana. For the same reason, the boxes were not separated like ‘confession boxes’ as in Europe, so that all the spectators could see each other. *“At the Teatro Tacón* - one reads in Eguren (see bibl.) - *nothing was hidden from the sight of the multitude.”* This pleased the women most of all as it allowed them to show off their clothes, hairstyles, jewels and delicate satin shoes, certain of being admired from top to toe.

All seats and chairs were in the Viennese style (that is in cane), very appropriate for the circulation of air, and they were both large and comfortable. Indeed, velvet would have been most ill-suited for that climate.

The first three tiers of boxes were reserved for the Creole and Spanish aristocracy and were accessed through the central door, at the end of the patio. The circle was occupied by the white middle class while the gallery was for blacks, mulattos and Chinese laborers (*chinos de la tierra*), whereas Chinese tourists were grouped with the whites. It is interesting to note that no-one was automatically excluded from attending theater performances. Subscription prices for the season were $36 (for 60 performances) for the first and second tiers of boxes; $8 (for 15 performances) for the stalls (*lunetas*); $5 (for 15 performances) for the first row of the circle, and so on (see picture on p. 363, taken from Diario de La Habana of 14 April 1838).

The royal box was raised slightly above the stalls, and it stood out first of all because it was much larger than the other boxes and also because it was draped with a band of red silk, decorated in the center with a bunch of Spanish flags, the military coat of arms and the royal crown. Inside, the royal box contained a small drawing room and a boudoir, papered throughout in American oil-cloth (no velvet!) and furnished with cane seats and armchairs in black and gold. The royal box was accessed through a private entrance on the street of San Rafael. Next to the royal box were the boxes reserved for the President of the Court (*Regente de Audiencia*), the Commander-in-Chief of the Navy and the *Intendente de Hacienda*, who at that time was the Conde de Villanueva.

According to Pezuela, the proscenium was 69 Castilian feet deep, that is roughly 19.2 meters, and 58 feet wide, namely 16.2 meters. The auditorium (considered to be the largest in the world) was approximately 20 meters high and could hold up to 3000 people, although it is estimated that at the inauguration ball there were seven thousand people inside the theater. However, as is related by Eguren, Don Francisco Marty created this enormous auditorium, somewhat at the expense of the performers' dressing rooms, which were quite cramped and uncomfortable, the only flaw in the building.

The interior of the theater was luxurious and abundantly lit by a total of 1034 candles. In particular, the *araña*, an enormous chandelier hanging from the ceiling (and so large as to block the view of those sitting in the upper tiers) boasted several hundred candles, each surrounded by a beautiful sphere of cut glass. It was regarded as a masterpiece of jewelry and was so famous as to be listed among the three marvels of Havana:

Tres cosas tiene la Habana
que causan admiración:
son el Morro, la Cabaña
y la araña del Tacón.

The interior's decorations featured two basic colors, white and gold, and they were entrusted to French and Italian artists.

Pezuela claims that the Gran Teatro Tacón boasted much the same facilities and capacity as the *Teatro Real* in Madrid and the *Liceo* in Barcelona and was no less elegant, the difference being that in the Tacón theater more thought had been given to the problem of ventilation and the chairs were more suitable to the climate of Havana. Interestingly, the *Condesa de Merlín* stated that only the major European capitals possessed theaters that could rival the beauty, the magnificent lighting or the elegant audience of Gran Teatro Tacón, adding that in London or Paris the Tacón theater, given the size of its auditorium, would have been mistaken for an immense aviary. Lastly, the German author, Otto Eduard, wrote that "… *The Teatro* [Tacón] *has been built to the same design as the theater of Hamburg - but on a larger scale …*"

Except for the façade, the outside walls of the Tacón theater had absolutely no artistic embellishment, as indeed was true of many important European theaters, since the main concerns were functionality and interior decor. In order to provide good ventilation, the theater was built with eighty outside windows. As many as twenty-two were the emergency exits (nine on each side of the auditorium and four at the front towards the Paseo) leading directly onto the street and enabling rapid evacuation in the event of fire or any other emergency. The roof of the theater, when it was firstly built, was a normal four-pitch roof, but it was extremely high and provided with several openings for ventilation.

Performances usually began between seven and eight o'clock in the evening while plays occasionally started as early as four in the afternoon. In the four months of July, August, September and October, namely during the rainy season, the theater generally stayed closed. During the so-called *dry season* (November through March-April) Cuban theatergoers were joined by large numbers of North American tourists who came to Havana to flee their winter.

The cost of building the theater was around 400,000 pesos, in addition to labor (free) and other assistance which the governor gave to Don Francisco Marty.

The Gran Teatro Tacón was officially opened on 15 April 1838, although on preceding 18 February (carnival night in Havana) the theater, which was nearly finished, opened its doors for a series of huge masked balls.

The Tacón theater was restored and renovated a number of times. The first recorded occasion was after the terrible hurricane of 10 and 11 October 1846. Work to repair the damage began immediately (on 27 October) and the opportunity was taken to introduce the new system of gas lighting imported from the United States and to renew equipment, furniture and costumes. It appears from a number of contemporary lithographs that the roof structure was also altered from four to two pitches (possibly to prevent it being so easily blown away by hurricanes). On 18 November 1846 the Tacón theater opened again with Verdi's *Ernani*. A few months later, when the season ended, on 18 April 1847, the theater was subjected to further, more extensive renovation. Antonio Meucci was placed in charge of the work. Five months later, on 25 September 1847, the theater opened once again. The decor was changed and there was new technical equipment. The ceiling was painted in plain white with gold relief work; at the center of the proscenium arch was placed a clock supported by two putti, which had been imported from Paris; a new system of curtains was put up and a new ventilation system designed by Antonio Meucci was installed; a new machine was imported from the United States, which could raise or lower the stage in a matter of minutes; lastly, a novelty in

Havana, ladies' cloakrooms were added, a facility not previously present in the city's theaters.

Two years later, between May and June 1849, a large hall was built next to the theater, taking up part of the courtyard in front of the annex building, between the street of San José and the Paseo Extramural. On that occasion, the porticoes along the front toward the Paseo were extended to their present length.

As for the performances, immediately after the inauguration, with the purpose to gradually abandon the *Gran Diorama*, which also was administered by Don Francisco Marty, the Tacón theater for the most part put on prose plays, notably by Spanish and sometimes Cuban authors. Later, particularly after the *Teatro Principal* was destroyed in October 1846, Italian opera was transferred to the Tacón theater.

After 1848, however, the fortune of the Tacón theater slowly declined. Don Francisco Marty was vexed by the public's lack of appreciation for his huge and expensive *gift* - the theater - to the people of Havana and by public accusations concerning his *turbid* past and so he closed the Tacón theater, thus completely depriving the people of Havana of all theatrical performances for two years, from 31 January 1848 (the last performance being the première of *Colombo a Cuba*) until 12 January 1850, when the opera returned to the Tacón theater with *Lucia di Lammermoor*. During those two years, oddly enough, the theater continued to operate behind closed doors for a small circle of people, including Don Francisco, who, it is said, acted as audience, critic or supporter of this or that artist. Moreover, from 1847 Don Francisco led the Italian opera company of Havana in a series of North American tours under the name *The Havana Opera Company*, visiting almost each year (and not only during Havana's dead season) New York, Philadelphia, Boston (where he introduced Italian opera) and other cities.

The closure of the Tacón theater coincided, more or less, with the government of Federico Roncali, who was appointed governor immediately after Leopoldo O'Donnell. In fact, Roncali took office on 20 March 1848 and governed until November 1850, through a turbulent period of riots, revolutions, invasions and consequent repression. In all likelihood, Don Francisco did not get from him the same support that he had received from previous governors. Under the governor José Gutiérrez de la Concha, who succeeded Roncali in November 1850 and was described as *'a lover of art and an opera connoisseur,'* things might have improved but, in the meantime, Don Francisco had left Havana. On 23 March 1850, to be exact, all ninety members of the Italian Opera, as well as the family of the impresario, left for Charleston, SC on board the *Vapor Isabel* and then moved to

New York for a series of performances at the *Castle Garden*. We have found nothing to confirm the story reported by a number of authors according to which Antonio Meucci and the other members of the Italian Opera were forced to leave Havana because a fire destroyed the Teatro Tacón. No fire is mentioned in the detailed chronological history of the Teatro Tacón drawn up by Francisco Rey Alfonso (see bibl.) or in the three years of the Diario de la Marina around 1850 which the author has consulted for that purpose.

The Gran Teatro Tacón, today, renamed ‘Teatro García Lorca’ or ‘Teatro Nacional’

On 28 November 1850, the opera returned to Havana for the local première of *Maria di Rohan*, starring *Lorenzo Salvi*, *Federico Badiali*, *Balbina Steffenone* and others, on 13 December with *The Huguenots* and on 21 and 26 December with *Lucia di Lammermoor*. On the second night of *Lucia*, however, Lorenzo Salvi, singing the part of *Edgardo*, was replaced by another Italian tenor, *Geremia Bettini*, reportedly on account of a disagreement with Don Francisco Marty. On 8 January 1851, the famous soloist *Jenny Lind - the Swedish nightingale -* arrived in Havana, heralded by a massive publicity campaign organized by her agent, the famous P.T. Barnum.

Don Francisco Marty gradually moved away from the theater. As was already mentioned in the main text, his company broke up in New York after a last performance at the *Astor Place Theater*. Although he continued to own the Teatro Tacón he let others run it. Among these managers was the Austrian impresario, living in New York, *Max Maretzek*, who staged operas at the Tacón theater in 1856 and 1857. During that last year (1857), on 6 May to be precise, just before his twenty-year concession ended, Don Francisco sold the Gran Teatro Tacón for the sum of 690,000 pesos to a group of Havana notables who wished to set up a literary circle there, later called *Gran Liceo*. Several years later, the complex was purchased by a foreign company, the *Tacón Realty Company*, and finally, in 1905, by another company, called *Centro Gallego* (*Gallego*, in Spanish, means *Galician*), which built a magnificent palace for its head offices.

In its approximately twenty years of activity (precisely from 1838 to 1857) the theater put on 108 operas, 1108 tragedies and plays and 48 operettas. It had 211 sets and wings and 13,787 theatrical costumes.

Information and Planimetric Surveys of the Tacón Theater

REAL AUDIENCIA PRETORIAL
DE LA HABANA
Escrituras varias, medidas y planos del Teatro de Tacón
[dated: 21 July 1836;
18 November 1839; and
October-November 1853]

Teatro de Tacón, 1853

Primera Escritura
del 21 de Julio de 1836

En la siempre fidelísima ciudad de la Habana en veinte y uno de Julio de mil ochocientos treinta y seis años [21 July 1836, Editor’s note], ante mí el Escribano [Notary, Editor’s note] y testigos, D.^{n} Fran.º Marti y Torrens, Alférez [sub-lieutnant, Editor’s note] de fragata de la Real Armada vecino de esta ciudad a quien doy fe conozco dijo: que á consecuencia del expediente [file, Editor’s note] Nº 411, cuaderno quince de ministraciones promovido por el exponente solicitando una porción de terreno de una parte del Jardín Botánico para la formación de un Teatro en decreto proveído á los siete de Marzo último recaído [7 March 1836, Editor’s note] á instancia del expresado Marty en que hacía dicha solicitud se mandó pasar á informes de la Administración general de ventas R^{s} terrenos y por que ministro otra oficina en ocho del expresado mes, expuso entre otras cosas, era de parecer que podía accederse a dicha solicitud atendiendo á la recomendación que hace el Excelentísimo Señor Gobernador y Capitán General, cediendo cierto número de varas así de frente como de fondo que no dañan al establecimiento de su destino, y procurando ligar dicha sección de modo que en lo sucesivo no se convierta la obra en beneficio privada, aunque en el presente Gobierno no es de tenerse semejante distracción, y que si Su Excelencia la dispone así podrá pasar el agrimensor interino de la Real Hacienda Don Juan Lobo á medir á acotar y justipreciar el terreno que se considere necesario para el efecto que se solicita, por lo que en el proveído el día nueve se manda contestar el Excelentísimo Señor Capitán General de conformidad con lo sustanciado del informe precedente pero con la condición de que el interesado ha de presentar en esta Superintendencia el plano del edificio de que se trata, para saber el espacio de terreno que ha de ocupar, pues no podrá construir sino lo que precisamente pertenezca al Coliseo en convertir en tiempo alguno para distintos usos porque en tal caso lo resumirá la Real Hacienda para los suyos preferentes á que estaba destinado. = Y en el que se proveyó á los veinte y uno se dispone, que estando ya presentado los planos del Coliseo sobre que se instruye este especificamente vuelva á informe de la ministración General de Rentas Terrenos. En vista de los cual dispuso el Señor Administrador General con fecha del veinte y tres pasar los planos adjuntos al Agrimensor interino de la Real Hacienda para que en cumplimiento de los anteriores decretos mida señale y avalúe el terreno de que se trata que deberá computarse en setenta varas de frente y ochenta de fondo y practicada dicha mensura por el expresado agrimensor resulta de ella, que habiendo pasado al Barrio de San Lázaro á la esquina Nordeste del Jardín Botánico, formadas por las calles occidentales del Prado y la del Monserrate, midiendo por su acera meridional ochenta varas por cada costado, el del oriente hace frente á dicha calle del Prado, y el de occidente deslinda con terreno del Jardín que media entre del Diorama: por el fondo linda con el mismo Jardín y desplaza entre las cuatro dimensiones lineales relacionadas cinco mil seiscientas varas cuad^{s} que en razón de ventajoso local aunque bajo de suelo flojo y profundo, inundado con las lluvias hace la construcción costosa, estimo por cada una de otras varas á catorce reales ó en nueve mil ochocientos pesos, el todo de ellas[3], advirtiéndose por nota: \/ cuando se tuvo la anterior medida se principió por la de ancho de la Calle del Monserrate, no obstante la fabrica de su costado ser de tablas tiene las doce varas de ancho que señala el plano aprobado de los suburbios, por abuso no se hizo el mismo examen en el costado que hace frente al prado y en este resulta \/ el cercado de tablas del Jardín esta internado en la calle Occidental del Prado, para llevar al verdadero local, al punto en que debe levantarse cualquiera fabrica tomo desde la fachada mas próxima del pretil de mampostería del tramo del medio del Prado, las veinte varas que marca dicho Plano y desde su extremo midió las ochenta varas p^{r} la calle del Monserrate finalizaran á una vara y cuatro pulgadas, antes de la acera Este de la proyectada Calle del Consulado. Por el costado del Paseo requirió las setenta varas que hallo exactas con la diferencia de haber pasado el punto que las marcaba fuera del cercado del Jardín para dentro de el, en el extremo de las veinte varas del mismo pretil de cuyos traspasos no alteró el área de las dimensiones señaladas, y sí se disminuyendo la paja sobrante entre el costado Oeste y la acera Este de dicha Calle del Consulado, ahora solo le queda setenta y siete varas y siete décimas de otra cuad^{s}. = También se nota que á las setenta y cuatro varas y una tercia de la Calle de Monserrate, se halla un punto fuera de otro cercado con marca del Camino de Hierro. Y desde el punto extremo de las setenta varas hasta la proyección que según el dicho Plano traería la acera Este de la Calle de S.^{n} José, hay un trecho de veinte y ocho varas, resultándose lo expuesto que las varas designadas para el edificio son *cinco mil seiscientas setenta y siete varas y tres cuartas de otra* cuadrada que á razón de catorce reales cada una impostan todas, *nueve mil novec^{s} treinta y seis* pesos *medio r^{ls}*, según consta del certificado y notariado por el expresado Agrimensor en veinte cuatro de Marzo último. En su consecuencia manifestó el S.r Adm.^{or} Gen. en su informe de ocho de Junio próximo pasado:

[3]The 5,600 square varas come from 70 x 80. It is confirmed that the peso was divided into 8 reales, since the 5,600 square varas, priced at 14 reales each, were sold for 9,800 pesos (5,600 x 14 = 9,800 x 8). The exact surface turned out to be (see below) 5,677.75 square varas, hence the final price paid was 9,936 pesos and half a real.

que estando practicada la medida del terreno destinado para el Teatro de que trata el Exped.^{te} puede su Exc^{a} servirse disponer conforme[?] la correspondiente Escritura de venta a censo á favor de D. Fran^{o} Marty y Torrens que con lo informado por la Contab^{d} Gen.^{l} de Ejército, V^{o} Trib. de Cuentas, y ministe… [interrupted here]

Segunda Escritura
del 18 de Noviembre de 1839

En la siempre fidelísima ciudad de la Habana en diez y ocho de Noviembre de mil ochocientos treinta y nueve años [18 November 1839, Editor’s note] ante mí el Escribano y testigos D.^{n} Fran.^{co} Marty y Torrens vecino de esta ciudad á quien doy fe conozco y dijo: Que por disposición del Sr. Adm.or g.ral de Rentas … de veinte y ocho de Septiembre ultimo consiguiente á decreto del Ex.mo Sr. Int^{te} de Ej^{to} Sup^{te} Gen.l Delegado al Hac^{da} del día veinte y cinco se manda que al Ex.mo de R^{l} Hacienda forme escritura de venta á censo á favor del exponente del terreno de que trata el exped.^{te} y estando pract^{da} la mensura por el Ag^{or} int^{o} de Rl Hac^{da} D^{n} Juan Lobo, resulta de ello: que habiendo pasado á extramuros barrio de San Lazaro á la esquina que el teatro de Tacón forma á las Calles Occid.^{l} del Prado y á la de Monserrate, desde ella por la primera que hace frente al paseo publico midió setenta y cuatro varas y media [74.5 varas, Editor’s note] doblando hacia el Oeste midió ochenta y cuatro varas y veinte pulgadas [84.556 varas, Editor’s note], destinando con el terreno del ante dicho Jardín Botánico y llega á tomar el espacio yermo [untilled, Editor’s note] dejado para la prolongación de la Calle del Consulado; por la acera Este ó costado Oeste del relacionado Teatro midió setenta y cuatro varas y media [74.5 varas, Editor’s note] hasta la acera Sur de la del Monserrate y por esta hasta la esq^{a} punto de origen de este apeo [limit, Editor’s note], midió ochenta y una varas y una cuarta [81.25 varas, Editor's note]; ocupa entre las cuatro relacionadas dimensiones lineales seis mil ciento setenta y seis varas cuad^{s} de las cuales, cinco mil seiscientos setenta y siete fueron avaluadas á razón de catorce reales cada una ó en nueve mil novecientos treinta y seis pesos y medio r^{l} según la escritura que se le otorgó en veinte y uno de Julio de mil ochocientos treinta y seis; y el exceso que tomó de *cuatrocientos noventa y ocho varas y una cuarta más* de superficie externa á razón de diez y seis reales cada una ó *novecientos noventa y seis* pesos *cuatro reales* que agregada á la cantidad que reconoce suman unidas diez mil novecientos treinta y dos pesos cuatro y medio reales [10,932 pesos and 4.5 *reales*, Editor's note] de los cuales debe de reconocer el censo según aparece del certificado dado por el

Ag.or en diez y nueve de Set. próximo pasado[4];

[Here a map is shown of the area around the theater (see a partial view on p. 253) which surely dates back to the period 1836-1838, since the *Depósito de Villanueva* is mentioned which no longer existed in 1853, and the houses of Marty and Meucci are not indicated, which existed in 1853 - with the following indications, from top left to bottom right:]

Depósito de Villanueva, Calle de San José, Diorama y cuartel que fue ultimte de Serenos, Calle de San Rafael, Calle del Consulado, Salón, Escenario, Teatro de Tacón, Patio, Pórtico, Antiguo cuartel de Serenos, Plaza, Paseo de Isabel 2ª, Estatua de Isabel 2ª, Casa del telégrafo; Puertas del Monserrate. [In addition, several trees, numbers and reference letters are indicated, as well as the following note and inscription:]

[4]There was therefore an addition of 498.25 square varas to the 5,677.75 of the first *Escritura*, adding up to a total of 6,176.00 square varas, which is exactly the figure referred by Pezuela. Such a surface, however, would be represented by a trapeze with two opposing sides 74.5 varas long, and the other two, respectively 84.566 and 81.25 varas long, therefore with an average of 82.90 varas. (see page 373).

Since this addition was paid at 16 reales instead of 14 reales per square vara, the total price of the land turns out to be 10,932 pesos and 4.5 reales, equivalent to about $150,000 in 1990.

Nota. Los arboles comprendidos en la parte a b c d no existen en la actualidad.

Inscription:

Es copia del que existe en el cuaderno de audiencia del recurso interpuesto por D. Franco Marti y Torrens sobre cierta ocurrencia habida en el Teatro con el Alcade Mor[?] *3°. D. Vicente de la Torre de Trasierra*
Habana y Octubre 20 de 1853
Mariano Carlés

[above the inscription is a scale with six graduations of 20 Castilian varas]

Real Audiencia Pretorial
Sala 2ª de Justicia
ESCRIBANIA DE CAMARA
de
D. José Soroa

De orden del Sñr. Oidor comisionado a consecuencia de las diligencias formadas gubernativamente sobre si deben ó no los Alcades mayores Presidentes del Teatro Tacón colocar sus carruages dentro del patio anejo al mismo, cito á U. á fin de que á las diez de la mañana del 18 del actual comparezca en el Edificio de esta Rl. Audiencia á evacuar cierto acto de justicia

Dios que á U. m. a. Habana
17 de Octubre de 1853
José Soroa
Sñr. Agrimensor
D. Mariano Carlés

Denoten = Del punto **A.** ángulo de la Calle de San Rafael y paseo de Isabel 2ª. nos dirigimos al S. 16°. E. y medimos el frente del frente del Teatro de Tacón que se compone de 37 varas y 24 pulgadas hasta **B.** división de dicho Teatro y el patio anexo de este punto á la entrada del expresado patio medimos en la misma dirección 3 varas y seis pulgadas y tres varas que tiene de ancho la expresada entrada de esta á la puerta del antiguo Cuartel de Serenos medimos 26 varas 2 pulg.s siendo la latitud de la puerta de 2 varas 7 pulg.s y la misma distancia de esta á la esquina de la Calle de San José en **C.** cuyas distancias parciales desde **B.** á **C.** constituyen el frente del mencionado patio que se compone de 36 v.s 22 pulg.s y doblando hacia al O. por la Calle de San José medimos 81 varas 19 pulg.s hasta **D.** esquina de esta calle con la del Consulado y volviendo por esta hacia el N. medimos 35 varas 32 pulg.s hasta **E.** que es la división del expresado Teatro y patio anexo y continúan de la misma dirección medimos 37 varas 28 pulgadas hasta **F.** ó sea el frente del fondo del Teatro y continuando por la calle de San Rafael hacia al E. medimos 81 varas 3 pulg.s hasta el punto **A.** que fue de partida. De modo que la linea **A.C.** consta de 74 varas 10 p.s [5].

El lado **C.D.** de 81 var.s 19 pulg.s. La **D.F.** de 73 varas y 24 pulgadas y el fondo **F.A.** de 81 varas tres pulgadas quedando por lo tanto el citado patio dentro de los limites concedidos por la Real Hacienda y vendidos á censo al Sñr D.n Francisco Marty y Torrens á que se refiere la primera escritura de [17…] del Expediente de la materia.

Referencias

El espacio comprendido entre las letras **A.s.x.z.** indica la concesión de la Real Hacienda de 70 varas de frente y 80 de fondo á que se contrae otra primera escritura.

El espacio comprendido entre la letras **z.x.s.F.D.C.z.** manifiesta el terreno á que alude la segunda escritura[6].

Se notan que hemos encontrado en el tamaño de los lados menos cantidad que las designadas en las escrituras lo que atribuimos á la delineación del edificio con las Calles cuando se construyó pero no son de gran consideración - Habana y Octubre 24 de 1853 = D.n Fran.co Camilo Cuyás =

Mariano Carlés =

Dros[?] cuatro asistencias
para cada facultativa

Es copia Habana y Noviembre 5 de 1853

Mariano Carlés, Agrim.r público

PLANO

[scale graduated in Cuban varas]

De un paño de tierra de una parte de lo que fue Jardín Botánico que

[5]This confirms that a *pulgada* (by definition, 1/12 of a foot) equaled 1/36 of a vara. In fact: **AB** = 37 varas, 24 pulgadas; **BC** = 36 varas, 22 pulgadas; **AC** = 74 varas, 10 pulgadas, hence 1 vara = 36 pulgadas.

[6]The plot indicated in the *Segunda Escritura* is essentially the sliver towards San José, occupied by the *Cuartel de Serenos*, plus another sliver towards the Calle del Consulado.

solicitó el Sñr. D.^{n} Fran.^{co} Marty y Torrens para la formación de un Teatro en cuyo espacio se encuentra hoy construido el Gran Teatro de Tacón y patio anexo.

Other Quotations

[Baguer, 14 Aug. 1983, see bibl.]

"… la manzana completa …era entonces propiedad de Don Pancho y allí estaban su hogar, los talleres del teatro y habitaciones para los trabajadores …"

Plan of the Gran Teatro showing points A, B, C, D, E, F of the land surveyor's report

[Chateloin, p. 196, see bibl.]

"… El teatro se construyó en extramuros, en la parte nordeste del que había sido Jardín Botánico, en los terrenos contiguos a la Estación de Villanueva …"

[Chateloin, p. 197; Ortiz, 1941, both quoting Pezuela, see bibl.]

"… El teatro propiamente dicho compónese de un cuadrilongo de unas 40 varas de anchura y cerca de doble longitud, cubierto de una simple techumbre con varios ventiladores. La entrada principal es un pórtico de elegante sencillez, con tres arcos al frente, y uno de los costados, con columnas de mármol intermedio y tres de relieve sobre obra de piedra en ambos ángulos. Cúbrele una azotea que sirbe de techo al espacio de la entrada principal. Contiguo a la derecha de la nave del teatro, corre un edificio bajo con el frente a la Alameda y el costado a la calle de San José y de dos pisos para el fondo, donde están establecidos casi todas las dependencias y los talleres de la empresa; porque el perspicaz Marty, mientras fue suyo el edificio, se hacía preparar por cuenta propia, sin salir del recinto, todo lo concerniente a decoración, maquinaria y carpintería, teniendo residencia fija en él sus dependientes y más precisos operarios. … Después del pórtico había un patio enlosado con dos corridores cubiertos que conducían a las tres entradas del teatro …"

Note

Pezuela's indication of the side's length is not altogether accurate, first of all because he indicates 80 x 77 = 6160 square varas instead of 6176. And then because the measurements made by the official land surveyor in 1853 gave values for the various sides (see the picture and table below) different than the ones indicated by Pezuela. We report in the table below a comparison of actual measures with those given by Pezuela:

Sides —>	AB	BC	AC	CD	DE	EF	DF	FA
1839 (varas)			**74.5**	**84.56**			**74.5**	**81.25**
1853 (varas)	37.67	36.61	**74.28**	**81.53**	36.89	37.78	**74.67**	**81.08**
1853 (meters)	31.45	30.57	**62.02**	**68.08**	30.80	31.55	**62.35**	**67.70**
mean (varas) (*)	37.725	36.75	**74.5**	**81.3**				
mean (meters)	31.5	30.7	**62.2**	**67.9**				
Pezuela (varas)			**77**	**80**			**77**	**80**

(*) Length of the sides of a rectangle with an area equivalent to that of the actual quadrilateral.

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THE HISTORY OF CUBA FROM TACÓN TO INDEPENDENCE

The Tacón government, which ended on 21 April 1838, was succeeded by the governments of Don *Joaquín de Ezpeleta*, which lasted only one year and a half, and of Don *Pedro Téllez Girón*, which lasted little more than a year, both being of minor importance. On the other hand, the government led by Don *Gerónimo Valdés*, who took office on 6 March 1841, and stayed in power for just over two and a half years, had a major impact on the life of the island. Indeed, Valdés was described even by the historians of Castro's revolution as a "*man of clear intellect, remarkable intelligence, honest intentions, worthy and punctilious as a military man. Rigorously adhering to the rules, like Tacón, whom he excelled in all other qualities*" (*Libro de Cuba*, see bibl.). He is also remembered for his generosity, as he donated one thousand pesos of his personal assets for the construction of the new *Jardín Botánico*. Furthermore, he made a considerable effort to curb the illegal slave trade, in compliance with a new agreement signed with England in 1842. However, Valdés had trouble with the English consul in Havana, *David Turnbull*, who advocated the abolition of slavery, for the latter was on good terms with the Creole fighters for independence and claimed that they should fall within the litigation pertaining to racial problems rather than to the one concerning independence. In the end, Valdés was forced to expel Turnbull from Cuba.

In Madrid, however, it was felt that a firmer iron hand was needed to govern Cuba and, on 21 October 1843, Valdés was replaced by *Leopoldo O'Donnell y Jorris, Conde de Lucena, Duque de Tetuán*, one of the youngest generals of the Spanish army. He went down in history as the most cruel, predatory and bloodthirsty governor of Cuba. One of the first things he did was to repress a racist conspiracy attributed to a number of white notables, known as the *conspiración de la escalera*, in which it was said that some three thousand people took part. Seventy-eight of them were executed, nine hundred were sent to jail (four hundred died as a consequence of the tortures endured during imprisonment) and, lastly, five hundred were exiled. Among the conspirators there were many whites whom O'Donnell disliked, hence it was rumored that the conspiracy was actually inspired by O'Donnell himself with the purpose to eliminate his personal enemies.

During the O'Donnell government, a number of important public works were implemented. In October 1844, the *Liceo Artístico y Literario* was founded which, in a year's time, was endowed with equipment and physics and chemistry laboratories, an art school, a chair of agriculture and perspective and a musical archive, thus resembling

Regla and first railroad

Florence's Accademia di Belle Arti. In 1845, the *Faro O'Donnell* (*O'Donnell Lighthouse*) was completed, which was located at the entrance to the port, on top of the *Castillo del Morro*, and was surmounted by an elegant dome. The lighthouse was approximately 30 meters tall. Its fixed beam had an intensity equivalent to some 550 *cárcel*[7] and could be clearly seen from a distance of up to thirty-five kilometers. The light given off by the directional revolving beams was four times greater (two thousand *cárcel*) The new lighthouse, which was much more powerful, made navigation around the port considerably safer than before.

Likewise interesting was the construction of the new *Palacio Aldama* at the end of the *Campo de Marte*, which became famous as it was the first to have a private bath. In 1847, upon O'Donnell's request, a commemorative column was erected in the *Alameda de Paula* in homage to the Spanish Navy. The column, known as *Columna O'Donnell*, still exists. Always in 1847, it is worth mentioning the arrival in Cuba of six hundred Chinese, who had been recruited to work the land but were subsequently forced to stay and were treated as semi-slaves.

Interestingly enough, it was actually the bloodthirsty repression of the *conspiración de la escalera*, in 1844, that fostered a more effective opposition to the colonial government. Indeed, it resulted in large-scale migration (both forced and voluntary) of Cubans to the United States, and, at the same time, it increased Cuba's political isolation. Furthermore, the exiles soon established underground contacts with their fellow-countrymen in Cuba, keeping the ideal of independence from Spain alive. However, it is important to recall that two very different movements emerged whose aim was to achieve independence from Spain. The first was the *annexation movement*, which wanted Cuba to become one of the United States of America, and the other was the *autonomist movement*, which strove for total independence from both Spain and the United States. On 10 January 1848, the first edition of the annexation movement's newspaper, *La Verdad*, was printed in New York; it was distributed for free and secretly made its way into Cuba. The paper's editor was *Gaspar Betancourt Cisneros*, also known as *El Lugareño*. Although he supported the ideal of annexation, which most Cubans did not appreciate, he contributed to boosting patriotism and the desire for freedom.

O'Donnell governed the island for about four and a half years, that is until 20 March 1848, when he was replaced by *Federico Roncali*, *Conde de Alcoy*. The latter was succeeded by Don *José Gutiérrez de la Concha* on 13 November 1850, when Antonio Meucci had already left Havana.

[7]The standard unit of light intensity, or *cárcel*, was that given by a lamp that consumed 93.26 grams of colza (or oil-seed rape) oil per hour.

Roncali went down in history as an absolute despot. Reportedly, disputes of every kind (even divorces) were settled at his table, and he would pronounce acquittals or sentences in a matter of minutes, without consulting anyone. From a political point of view, Roncali and Concha were no less terrible than their predecessor, also due to the fact that both were angered by repeated US threats to Spain's sovereignty over Cuba.

Indeed, already in 1847 the United States army, led by General *Winfield Scott*, had invaded Mexico and with the Treaty of 2 February 1848, had annexed the territories of Texas, Upper California, New Mexico and part of the states of Chihuahua, Coahuila and Tamaulipas. Fear grew in Cuba; nor did the Monroe Doctrine, nominally in force for twenty-five years, ensure security to the surviving Spanish government of Cuba. In fact, under Roncali's government, as many as three expeditions from the United States in support of the annexationists were organized in 1848, 1849 and 1850, respectively, which were led by the famous commander Narciso López, a native Venezuelan. On 20 April 1848, in particular, an underground pamphlet was circulated in Havana which described how a Cuban was seen by Spain: "*A slave without the right to speak or write; he may not criticize the government; he may not complain when ill-treated; he may not leave the country without a permit; he may be arrested and buried in a cell without explanation; his family may be threatened; the government may freeze or confiscate his property.*"

On 20 October of 1848, the famous Cuban writer, *Cirilo Villaverde*, was arrested in his home in the middle of the night, by order of Roncali. After six months of imprisonment in a damp and dark cell, where he was treated like an animal, he was sentenced to life imprisonment for treason against the Crown of Spain. However, he managed to escape on 4 April 1849, with the help of a guard and of another convict sentenced for petty crime, and took refuge in Florida.

In the United States, the *Junta Cubana* was established in September 1849 with the purpose of instigating a revolution to liberate the island. The president of the *Junta* was Narciso López, while the secretary was Cirilo Villaverde. Meanwhile, Havana was celebrating the birthday of the Queen Mother of Spain and the city engaged in festivities. On 11 May 1850, the Cuban flag, designed by Narciso López, flew for the first time in New York, at the Head Office of the newspaper *Commercial Advertiser*, on Fulton St. and Nassau St.. On 19 May López organized a military coup at Cárdenas (150 km east of Havana, just beyond Matanzas) where he landed with a legion of volunteers. He was joined by twenty-four Spanish soldiers and a sergeant (who was shot, on 25

May together with 4 Americans), but not by the citizens of Cárdenas. Nevertheless, the town was in his hands for forty-eight hours, after which he was forced to sail back to the United States. On 10 August a man by the name of *Bernardino Hernández* was garroted for having supplied a horse to Narciso López. In September, the Spaniards reinforced the fortifications for fear of further invasions.

In November 1850, *José Gutiérrez de la Concha* took office as governor. During his term of government another expedition was organized by Narciso López, who once again set off from New Orleans, LA, in the United States, and landed on 12 August 1851, on the northern coast of the island, close to today's Bahía Honda. The expedition also included one hundred and fifty Americans, under the command of Colonel *Crittenden*. However, the Spaniards had received advance warning of the expedition and easily defeated the invaders, executing and mutilating Colonel Crittenden and fifty of his men in Havana, at the castle of *Atarés*, on 16 August. López was captured on 29 August and garroted three days later. During the same period, other insurrections organized by non-annexationists took place, but all were quelled by the Spaniards.

In 1868, a revolution broke out under the leadership of *Carlos Manuel de Céspedes*, who freed the slaves on his estates and declared war on Spain, known as the *Ten Years' War*. A peace treaty was signed in 1878, after which thousands of Cubans emigrated to the United States, where they established a large colony. A second war of independence began in 1879 and failed in less than a year.

Finally, in 1895, the so-called *Necessary War* began under the command of *José Martí*. On 15 February 1898, the United States declared war on Spain after a US cruiser was destroyed in the port of Havana (causing the death of two hundred and eighty-eight American sailors) and landed in Santiago de Cuba. On 1 January 1899, a peace treaty was signed with Spain; no representatives of the Cuban rebels were present despite the fact that they had done much to weaken the resistance of the Spanish army on the island. Under the treaty, the Spaniards left Cuba, after 407 years of colonial rule. The treaty also marked the final ousting of Spain from the Americas, since also the island of Puerto Rico (located slightly west of Hispaniola) was lost and annexed to the United States under the same treaty. Moreover, the island of Cuba, if officially independent, fell under the political and economic influence of the United States and the situation remained such practically until the success of *Fidel Castro*'s revolution, in 1952. Indeed, in the years following the treaty up until Castro's revolution, Cuba was ruled by a series of governments that were loyal to the United States. Instead, it is worth highlighting that relations between Cuba and Canada were, and continue to be, on friendly terms.

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THE SLAVES

Slaves played an important part in the economic development of the island of Cuba, just as they did many centuries before in the ancient civilizations of the Mediterranean and of the East. It is worth highlighting that the first two cargoes of slaves from Africa to Cuba, in the years 1523 and 1525, respectively, were drawn with the specific aim to enhance agricultural activities. Conversely, the natives of the island, namely the *indios*, were given their freedom in 1529, provided they withdrew to special reservations, the *comunidades indias* (as was done much later in the United States). Within a matter of decades, such isolation practically resulted in their extinction. In 1580, the town council of Havana (*Cabildo*) ordered to go and fetch one thousand slaves to be used in the mines of *Baracoa*. In 1595, Spain signed a contract with one *Pedro Gómez Reynol* for the supply of three thousand five hundred slaves a year for nine years. It may be recalled that, in the United States, the trade of black slaves began later, in 1619.

There were *Creole* slaves, that is to say born in Cuba, or *bozales*, born elsewhere (generally in Africa). It was often the African tribe chiefs who supplied slaves to the white slave-traders.

In March 1812, a revolt against slavery broke out in Cuba, led by *José Antonio Aponte*. On 9 April 1812, the main conspirators were hanged.

The free trade of slaves, sanctioned by the *Las Casas* government in 1789, was supposed to end in 1821, under the treaty signed by England and Spain in 1817. Nevertheless, it continued as an illegal and fraudulent business almost until the revolution of 1868. On the other hand, the English Parliament itself abolished black slavery in the British Empire only in 1833. In Brazil, slavery was abolished as late as in 1885 by Emperor *Pedro II*. In Cuba, slaves transported from Africa on ships that had been captured by the English were regarded as *emancipated*.

1835 was the year in which the largest number of black slaves arrived in Cuba, and that was under the government of *Don Miguel Tacón*. The United States refused to allow the English to inspect their ships (whether carrying slaves or otherwise) and in 1838 arranged through the United States consul in Havana, *Nicholas P. Trist* (a friend of Tacón's), to provide documents for sixty-one of the seventy-one slave ships entering the port of Havana during that year. Moreover, on 15 July 1840, *John Forsyth*, the US Secretary of State, assured the Spanish government that it could rely on military and naval assistance from the United States in the event of any attempt (by the English) to take Cuba away from Spain on the pretext of preventing the slave trade.

Tacón gave orders not to kill the fugitive slaves (*cimarrones*[8]), as had previously been the habit; instead, they were to be gathered at the *Depósito de Cimarrones*, whence they were taken to labor on government works until they were reclaimed by their owners. Needless to say, no attempt whatsoever was made to notify the presumed owners, with the result that years often went by before the captured slaves were released. To prevent disputes, the slaves were almost always branded.

Large numbers of blacks were also brought into the island in 1840-41, under the government of Don *Pedro Téllez Girón*, with the purpose to boost the growing of sugar cane crops.

According to the 1841 census, in Havana out of 184,508 inhabitants, 21.7% were slaves and 19.1% were free or emancipated colored people. In the hinterland, and in other towns in Cuba, the percentages were much higher.

The only governor of Cuba who made some effort to curb the illegal slave trade was Don *Gerónimo Valdés*. In 1842, he signed a new agreement with England whereby England acquired (partly by virtue of certain clauses embodied in the reform of the *International Tribunal of Weights*) the right to appoint an official responsible for protecting the Africans and to build in Havana's port a pontoon that would serve as a depository where people would await decisions concerning their freedom, but which was actually used as a shelter by slaves who had fled from their masters. Nevertheless, although Valdés was against the slave trade, he expelled the British ambassador in Havana, David Turnbull, a renowned abolitionist, for he actually encouraged the supporters of Cuban independence.

In 1847, six hundred Chinese arrived in Cuba under an eight-year contract envisaging the miserly wage of $4.00 per month. They were semi-slaves who were sold to the colonials and were sometimes treated worse than the *bozales*. When their contract expired, as they did not have enough money to return to their country, they ended up working like prisoners on public works, like the convicts. Between 1852 and 1859, 48,500 Chinese landed in Cuba.

The extent to which slavery was practiced in Cuba following the 1817 Treaty can be deduced from the following extract taken from the regulations relating to fugitive slaves (*cimarrones*), issued on 2 December 1845:

Art. 1. *He shall be regarded as a fugitive (cimarrón) any slave who sleeps outside his own home without the permission of his master, or who is found in the fields without permission, at one league's distance from the edge of the*

[8]The word *cimarrón* implied the flight to the mountains, applicable to both animals and slaves, to denote the wild nature of the fugitives.

property to which he has been assigned.

Art. 2. *Any person, whether he be from the place in question or elsewhere, shall have the right to capture fugitives and shall be rewarded, upon their consignment to their master, to the general Depósito or to the local court and special delegations, with the capture fee of 4 pesos fuertes. …*

Art. 35. *They shall be regarded as associates (apalencados) six or more fugitives found together.*

Art. 36. *The local courts shall notify the higher civil government of the existence of any band (palenque) rumored to exist within their jurisdiction and shall proceed without delay to take priority action to destroy that band, using whatever armed force shall prove necessary.*

Art. 37. *When attacking a band, no means shall be withheld to bring about the submission and punishment of the guilty parties; however, when the slaves have surrendered and been disarmed, no ill-treatment shall be allowed. …*

Art. 40. *For each fugitive slave captured with a band the following capture fees shall be paid: 20ps if no resistance is offered during the attack; 35ps when resistance is offered with steel weapons; 50ps if resistance is offered with fire-arms. In addition, 40ps shall be paid for each bandit captured unwounded or without serious contusions; 70ps if captured in the above condition after resistance with steel weapons; and 100ps if he has used fire-arms. …*

Art. 48. *The capture of fugitive slaves singly or in bands shall be regarded solely as the action of the government and shall in no case have any judicial implications whatsoever.*

Still in 1850, the newspapers openly published advertisements for the sale of slaves in the column *Esclavos* and featured descriptions of fugitive slaves in the column *Esclavos prófugos*, more than thirty years after the treaty that abolished slavery in 1821. In the section *Puerto de la Habana - Entradas y Salidas*, these newspapers gave notice not only of goods transported but also of the number of passengers, divided into *passajeros* and *reclutas* (recruits), this latter including slaves.

As we have said in the following, in 1868, at the onset of the revolution led by *Carlos Manuel de Céspedes*, he freed his slaves and declared war on Spain (the *Ten Years' War*). The peace treaty that ensued, in 1878, envisaged the liberation of all slaves and Asian settlers who had fought in the Cuban liberation army. Finally, eight years later, Cuban deputies at the *Cortes* (the Representative Assembly of Spain) succeeded in obtaining the enactment of a decree that completely abolished slavery in Cuba.

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THE REFRIGERATOR

Natural cold

Man discovered the usefulness of cold, as a means of preserving food and of creating pleasant savors (particularly for the hot season), several thousand years before Christ. Since the first machines capable of producing artificial cold were not available on an industrial scale until after the first half of the nineteenth century, before then, man could only resort to natural cold, mainly ice or snow, whenever and wherever available. Two significant stages in the process of controlling cold were the discovery of how to preserve ice or snow from the cold to the hot season and of how to transport them from cold to hot regions. Another major step that preceded the production of artificial cold by machine, was the discovery of certain substances, such as brines, which could, by changing their state (by evaporation, liquefaction or other) absorb heat from surrounding bodies, thereby causing them to cool.

An ancient example of a cooling process which did not rely on the use of natural ice or snow can be found in an Egyptian fresco of the third millennium BC, showing a slave waving a fan in front of an earthenware jar. It is not known for certain whether the Egyptians knew that the evaporation of water oozing from the pores of the terra-cotta caused the water inside the jar to cool. The idea might have come to them simply as a result of the habit of cooling oneself by fanning. Even today, however, in the countryside of Southern Italy, peasants use a small, porous earthenware jar (called *búmmulu*), left in a shady spot and wrapped in wet jute canvas, for their cool drinking water. In this case, the water that evaporates is mostly the water in the canvas and the cooling effect is greater, even without any external ventilation. The evaporation of water also lowers the temperature in caves where food and especially game have been preserved since ancient times.

An equally effective, if less intuitive, method is that of cooling at night under a clear sky, obtained through the irradiation of heat from the earth into the atmosphere. As we know, in the above conditions, the temperature of the ground may drop to below zero at night, even in hot countries such as North Africa. The ancient Greek, *Protagoras*, narrates that in the fifth century BC, the Egyptians produced small quantities of ice in the Nile valley by placing recipients on the roofs of their houses at night and collecting, in the morning, the thin layer of ice that had formed on the surface, during the night. The same principle is adopted in Iran, still today, although on a larger scale, using wide tanks of several thousand square meters.

Certain cooling mixtures, notably those obtained by dissolving certain salts in water - called *brines* - have been in use for long time, before their physical mechanism was explained, which happened in the second half of the nineteenth century. Some of them have been known since ancient times. For example, as early as the fourth century, in India, sodium nitrate was added to water to lower its temperature. In Italy, between 1530 and 1550, saltpeter (potassium nitrate) was usually added to water to obtain a mixture for cooling wine and water. In 1589, in his book *Magia Naturalis*, Battista Porta in Naples described the phenomenon of lowering temperature by adding salts to snow. In 1600, a variety of mixtures were used, such as ammonium nitrate and water in equal parts, which produces a temperature of -16 °C, or one part sodium chloride (common salt) to three parts snow, producing a temperature of -18 °C. Experiments in cooling using various types of brine were carried out in Florence in 1657 at the *Accademia del Cimento*. In this connection, it should be recalled that the first thermometer (an air thermometer) was invented in Florence by *Galileo Galilei* in 1597. In 1760, in St. Petersburg, *von Braun* succeeded in freezing mercury (thus reaching -40 °C) using a mixture of snow and calcium chloride. Lastly, in 1865, *Toselli ice boxes*, based on the ammonium nitrate brine described above, achieved enormous success in both homes and restaurants. One of these ice boxes was used in 1869 to obtain a block of ice weighing 20 kilograms, which was sent from Paris to Algiers for demonstration purposes.

It was only in the second half of the nineteenth century that the laws governing the cooling effect of brine were discovered. Their cooling effect is a combined result of two processes: the fusion of salt - that is, its passage from a solid to a liquid state - and of its dissolution in water, that corresponds to its spontaneous passage to a more disordered state. To allow such transformations, heat must be absorbed from another substance, which is therefore cooled. Perhaps not all of us, even today, are aware that even by the very simple act of dissolving ice in water we obtain a much greater decrease in temperature than the mere difference in temperatures and relative percentage weights of the two substances, because, for the crystal structure of the ice to break down, an additional supply of heat is needed, which can only be provided by the surrounding water.

From the end of the eighteenth century, land-owners in the southern states of America encouraged the development of methods for preserving and transporting large quantities of natural ice collected in winter from the surface of northern lakes and rivers and hand sawed into blocks about thirty centimeters thick. A Maryland farmer, Thomas Moore, published an article in 1803 entitled: *"An essay on the most eligible construction of ice houses; also a description of the newly invented machine called the refrigerator."* The article was principally concerned with the construction of *ice houses*, which immediately became highly popular all over the United States. The *refrigerator*, quoted in the paper, was basically a tank cooled with salt and water, which Moore himself patented in 1793. The first ice house was built in 1799 in Charleston, SC, and was built using double walls of solid wood, additionally isolated by filling the hollow space between the two with sawdust. The ice houses proved capable of preserving large quantities of ice (up to 60,000 tons) for approximately two years, with a loss ranging from 10% to 25% of the amount stored.

In 1806, the American *Frederic Tudor*, later nicknamed the *ice king*, launched the international trade of natural ice, starting with a shipment of one hundred and thirty tons of ice from Boston, MA to Martinique, followed shortly afterward by another shipment to Jamaica, where ice was also needed to combat yellow fever. In 1815, Tudor undertook an expedition to Havana and in 1816 set up an ice house there which had been prefabricated in Massachusetts. Since Don Francisco Marty arrived in Havana in 1810, it is very likely that he bought said ice house from Tudor, for it has been ascertained that Marty was the owner in 1834.

From 1817 onward, Tudor organized a coastal trade to supply the towns in the south of the United States by sea. In 1820 he set up an ice store in New Orleans. It is estimated that in twenty seven years of activity, up to 1833 that is, Tudor shipped approximately 4500 tons of ice. In 1833, he turned his attention to longer distances: one hundred and eighty tons of ice were shipped to Calcutta (reduced to one hundred and twenty on arrival); in 1834 he served Rio de Janeiro and in 1840 Great Britain. Statistics show that, still in 1899, Britain imported one hundred and fifty thousand tons of natural ice from the United States and Norway, and that the United States alone consumed twenty five million tons of natural ice per year. Even after the advent of machines for production of artificial ice, there was still a vast trade in natural ice that continued for many years up to the present century.

Artificial cold

Creating cold was still regarded as a divine prerogative (or as magic) even towards the middle of the nineteenth century. In 1844, John Gorrie, a doctor and hospital administrator at Apalachicola in Florida, who had invented a refrigerating machine to produce ice for his patients, was obliged to delay the patent to 1851 because the press accused him of trying to make something (ice) as well as the all powerful God (and fortunately for him the Holy Inquisition no longer existed!).

The year 1755 is regarded as the ‘year one’ in the history of artificial cold. In that year, a Scotsman, William Cullen, professor of chemistry at Glasgow University, developed a laboratory machine that could produce small quantities of ice by evaporating water in a vacuum under a dome, therefore, without using natural cold. In 1748, Cullen himself had observed that another liquid, ethyl ether, decreased its temperature when it evaporated. The American Oliver Evans, in 1805, had the idea of alternating phases in which a liquid evaporated with phases in which the vapor obtained was compressed to restore it to a liquid state; in this way, he created a closed cycle that did not require to replace the liquid used for evaporation. Following Evans' suggestion, an American engineer living in London, Jacob Perkins, patented an ether refrigeration machine for the production of ice, in 1834. Unfortunately, in London, the machine was judged to be useless, since stocks of natural ice were considered more than sufficient to meet the city's needs. There was therefore no follow-up to Perkins' machine, which is nevertheless to be regarded as the forerunner of modern so-called *compression refrigerators*.

Only after Michael Faraday's research into the liquefaction of gas, in 1823, did inventors begin to think of using normally gaseous substances that could be liquefied by compression, in place of volatile fluids, that is substances that are normally liquid (such as water, ether and alcohol) that could be evaporated as in the Perkins' machine. The development of thermodynamic theories that began in 1824 with Sadi Carnot and culminated in the major debates between Julius R. Mayer, James P. Joule, Rudolf J.E. Clausius and William Thomson, certainly played a role in the invention of the new refrigerators during the decade from 1842 to 1852.

The machine mentioned above, invented by the American John Gorrie in 1844, can be regarded as the forerunner of what are called *air machines*, based on the well-known principle that a sudden expansion of air - that had previously been compressed - causes it to cool (one need only think of the rush of air from an inflated tire). To be more precise, the air was compressed to two atmospheres in a water-cooled cylinder with a twenty centimeter diameter and transferred into a tank. Salt water, conveyed to the outlet of the expansion tap, was cooled to -7 °C by the exiting air and then used to produce ice. It was an open-cycle machine, though there was no need to recover the air used. Gorrie's machine was perfected several years later by the Scottish engineer Alexander Carnegie Kirk, who produced in 1862 a closed cycle air machine capable of achieving a temperature of -40 °C. His machine functioned day and night at the Bathgate refinery, where it had replaced an ether compression machine (of the Perkins type) that was thought to be too dangerous, and remained in operation, without interruption, for ten years from 1864. In 1877, another air machine was patented, the *Bell-Coleman*, which was even more advanced than Kirk's machine and was used from 1879 on by British ships on ocean crossings to transport frozen meat.

Perkins' machine was not used for practical applications for over twenty years. The real industrial development of refrigerators occurred in the two and a half decades from 1850 to 1875, and was not only attributable to Kirk, but also to the Scotsman (living in Australia) James Harrison (1856) and the Frenchman Ferdinand Carré (1859). Another important discovery, that of thermoelectric refrigeration, which was made in 1834 by the Frenchman Jean Peltier, was not put to practical uses until after 1875.

Harrison's story is an interesting one. As a young man he worked in a printer's shop in Glasgow and then, in 1837, emigrated to Australia and took up residence in Geelong, a town not far from Melbourne, where he started a newspaper. Three considerations inspired his interest in refrigerating machines: firstly, Melbourne was very distant from any sources of natural ice; secondly, the beer industry needed ice; and thirdly, it would be possible to export Australian beef even to Great Britain, which was recovering from a severe food crisis, the so-called 'hungry forties,' if the freighters were equipped with efficient refrigeration systems. After several years' trials, Harrison obtained a patent in 1855 for an ethyl ether compression machine, similar to that of Perkins. He set out for London, where he obtained two English patents and began industrial production, which he immediately continued on his return to Australia. Harrison's machines were produced, with a number of improvements, for forty five years. Moreover, they were used in 1861 in Sydney to create the first industrial frozen meat factory.

One serious flaw of the ethyl ether machines, however, was that ether is highly inflammable and toxic and therefore very dangerous. The machines were also not perfectly airtight because ether evaporates at less than atmospheric pressure. These problems were at the root of the success of air and absorption machines (described below) during the three decades from 1860 to 1890. From 1880 onward, after experiments with a number of liquids, the ammonia compressor was introduced and within the space of ten years it had taken over from every other type of machine, a lead which it still maintains today. Although the first patent for an ammonia compressor was taken out by the Scotsman David Boyle in 1872, it was the German Karl von Linde in 1876 who perfected the machine so that it could be launched on the world market.

As for the absorption machine developed by the Frenchman Ferdinand Carré in 1859, it was based on a mix of two liquids, one denominated *frigorigenous* (ammonia) and the other *absorber* (water). It should not be forgotten that ammonia evaporates spontaneously at a temperature of -33 °C. The machine functioned in such a way that ammonia was alternately absorbed and released from the water. The production of cold occurred during evaporation of the ammonia. Two containers were used, one acting alternately as a boiler (heated on a wood fire) and absorber and the other alternately as condenser and evaporator. The advantage of this machine was that it possessed no moving parts, at least in the case of small models. Furthermore, the two containers were connected by a tube and could interchange functions with a suitable heat exchanger design.

The domestic machine, which Ferdinand Carré put on show in London in 1862, is preserved now at the *Musée National des Techniques* in Paris. It could produce two kilograms of ice in one and a half hours with a consumption of six hundred and fifty grams of wood. Carré's machine was exported and produced practically throughout the world. In the southern states of the United States (especially the gulf states) Carré's machines were imported even during the Civil War, despite the Yankee blockade.

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HISTORY OF ELECTRODEPOSITION TECHNIQUES

In the year following the discovery of Volta's battery, i.e. 1800, electrolysis was discovered by A. Carlisle and W. Nicholson. A new branch of electricity was thus born, electrochemistry, which gave rise, in particular, to such applications as electroplating, galvanoplastics, electrotyping and so on, which we will henceforth call *electrodeposition techniques*. It should be recalled that both the processes of electroplating and galvanoplastics consist in the electrodeposition of metals, except that galvanoplastics involves the reproduction of several copies of metal objects by first creating a mold, not necessarily of metal, and then electro-depositing the desired metal on the mold, thus leaving the original unaltered. Electroplating, on the other hand, consists in coating a metal object with a thin layer of another metal, generally a more precious one and/or more resistant to external agents. Lastly, electrotyping consists in preparing molds for printing, called *electrotypes*.

In order to give as accurate as possible a picture of the state of the art of these techniques during the last century, we have reprinted below (in summary form and/or with additions, as necessary) the treatise prepared by Savorgnan di Brazzà in 1908 (see bibl.). We begin, however, with a short chapter on electric batteries since electrodeposition techniques evolved at very much the same pace as the batteries. Indeed, until the invention of the dynamo, batteries played a crucial role in electrodeposition processes, partly because at first the objects were actually electroplated inside them.

Electric batteries

Volta's *battery* — The first electric battery (called 'pile') was, as we know, invented by Count Alessandro Volta, professor of experimental physics at the University of Pavia, and was the outcome of research he had undertaken throughout the decade up to 1800. The official document recording that major invention is, however, a letter dated 20 March 1800, in which Volta presented his results to the *Royal Society* in London (from which he had received the *Copley Medal* in 1796). The most reliable texts date the discovery of Volta's battery in 1799. It is a curiosity of history that a so-called *electric battery* which the Englishman John Cuthbertson created in Amsterdam in 1770 by joining 135 Leyden jars, is regarded by some as the forerunner of Volta's battery.

The voltaic battery, as it was called, in its simplest form (*voltaic element* or *cell*) consists of a succession (*pile*) of four conductors, three of which are metal, M (also known as *electronic* or *first class conductors*) and one is an *electrolyte*, E (also called *ionic* or *second class conductor*) according to the following scheme:

$$M_1 \mid E \mid M_2 \mid M_1,$$

where the first and last metals (M_1) must be equal, E is the electrolyte and M_2 is the second metal. A variation of Volta's battery is the *concentration battery*, in which a single electrolyte is used but in two different concentrations (being equivalent, therefore, to *two* electrolytes, E_1, E_2), according to the following scheme:

$$M_1 \mid E_1 \mid E_2 \mid M_1.$$

In the first Volta's battery, the following elements were superimposed, in that order: a silver disc (later replaced by copper), a disc of cloth soaked in a diluted solution of sulfuric acid, a disc of zinc, then again (up to several times) copper-cloth-zinc etc., ending with copper. The word *pile*, originally used in place of *battery*, originated from the pile of these discs. Its *electromotive force* (emf), or open-circuit voltage, was approximately 1 volt. Today, this type of battery is only of theoretical interest.

The phenomenon of polarization— In 1829, A.C. Becquerel gave an explanation for a serious shortcoming shown by the batteries of the time - *polarization*, as he defined it - which caused a rapid drop in their electromotive force some time after they had been connected to an external load. If the battery was then left to rest for a few hours, without any load, it would begin to work again. Becquerel showed that in the majority of cases polarization was caused by hydrogen ions produced by the passage of the current, which clustered around the battery's positive pole (which is also the cathode of the electrolytic bath) thereby reducing the battery's emf. When the battery was disconnected from the load - and therefore the current passing through the bath was broken off - the ions spread slowly through the electrolyte, freeing the cathode and restoring the battery's full emf. This type of depolarization, which occurred when the battery was left to rest, was termed *spontaneous depolarization*. If, however, a substance capable of reacting with the hydrogen (to form water, for example) is added to the electrolyte, one obtains an *accelerated depolarization* and the substance that causes the acceleration is called a *depolarizer*. An example of an accelerated depolarization battery is the Bunsen battery, which has an acid depolarizer (nitric acid), as will be discussed further on.

Daniell battery— A radical solution to the problem of polarization was provided by so-called *unpolarizable batteries* such as the two-liquid battery. This type of battery was invented in 1836 by an Englishman, *John F. Daniell*, professor of Chemistry in London, and it consists of an amalgamated zinc anode and a copper cathode immersed, respectively, in a solution of copper sulfate and in one of zinc sulfate, separated by a porous septum (which will be indicated henceforth by the symbol ≣), thus according to the following scheme:

copper | copper sulfate saturated solution ≣ zinc sulfate solution | amalgamated zinc | copper.

By this means, the reactions caused by the passage of current occur around the porous septum and so do not alter the electric potential around the electrodes.

Daniell's cell (i. e. one element of the Daniell's battery) has an emf of around 1.09 volts and has the advantage of being very constant. For this reason it is suitable whenever a weak but constant current is required. About once every two months the zinc amalgam had to be replaced and, moreover, it must always be monitored very carefully to ensure that the concentration of zinc sulfate remains constant. A variant on Daniell's battery that was much used in the Italian telegraph network from 1863 on was *D'Amico's battery*. Instead of using a porous septum, this battery used a special design to separate the two liquids, based on gravity.

Bunsen battery

Bunsen battery— The first model of the Bunsen battery was developed by the English physicist, William R. Grove, in 1839. He built a battery by bending a sheet of amalgamated zinc into a U shape around a porous vessel containing nitric acid, inside of which was a foil of platinum. The whole was placed in a glass vessel containing a solution of sulfuric acid, according to the following scheme:

copper | platinum | nitric acid solution ≣ sulfuric acid solution | amalgamated zinc | copper

In Grove's battery, the released nitrogen reduces the nitric acid, transforming it into nitrogen dioxide, which on contact with air becomes ammonia and nitric acid. This battery was the first to use an acid depolarizer (nitric acid). The problem with Grove's battery, though, was the high price of platinum, which prevented it from becoming widely used. In 1840, the German chemist, Robert Wilhelm Bunsen (see a short biography below under "Profiles"), had the idea of replacing platinum with retort graphite and so made Grove's battery practical. With this modification the battery became known as *Bunsen battery*.

Bunsen battery (also called *carbon battery*) consists of a china container containing a 10% solution of sulfuric acid, in which is immersed a thin sheet of amalgamated zinc bent into a slit cylinder; inside the zinc cylinder is a porous vessel containing a solution of nitric acid in which the graphite electrode is immersed. On top of this electrode there is a copper ring which acts as the positive pole, hence, according to the following scheme:

copper | retort graphite | nitric acid solution ǀ sulfuric acid solution | amalgamated zinc | copper

Bunsen battery produces an emf of approximately 1.9 volts, one of the highest of all voltaic elements, and can supply a very strong current, much greater than that obtainable from Daniell's battery. Its disadvantages are that it is difficult to keep the concentrations of the two solutions constant and that it emits nitrous vapors, which are both unpleasant and harmful, so that it must be kept in a suitable and well-ventilated location.

Bunsen battery was subjected to a number of modifications, that will be described briefly hereinafter. In 1842, Archerau exchanged the positions of zinc and graphite; in 1847, another Frenchman, Callau, replaced the graphite with a thin sheet of lead, the nitric acid in the porous container with a solution of potassium nitrate and the internal liquid with a mixture of sulfuric acid and concentrated nitric acid. With this last contrivance he managed to create a battery with more constant current. In 1865, Maike replaced zinc with steel, in water acidulated with nitric acid. At the end of the century, Niandet immersed the zinc in a solution of sodium chloride and filled the porous vessel with chips of graphite and calcium chloride. Tommasi closed the porous vessel hermetically to prevent the development of harmful nitrous vapors, but by doing so he greatly diminished the amount of available current. D'Arsonval replaced the positive electrode, consisting in a single piece of retort graphite, with a set of thin sticks of the same material and so greatly increased the surface in contact with the electrolyte; at the same time he made up the depolarizing liquid with a mixture of hydrochloric acid and sulfuric acid which fell drop by drop onto the battery. Lastly, Marie Davy replaced the acidulated water with pure water and the nitric acid with a mercury sulfate paste, which absorbed hydrogen by releasing mercury.

Dry batteries— The so-called *dry batteries* should more appropriately be called as *damp batteries*, since liquid is replaced by any solid support that is kept damp; in a certain sense, Volta's battery was also a damp battery. A so-called dry battery was presented to the *Royal Society* in London in 1809 by a Swiss physicist, Delue. It was a column battery consisting of 300 zinc discs placed on top of an equal number of paper discs, gilded on one side and dampened with acidulated water on the other; the column of discs was enclosed in a glass tube. The following year, 1810, Giovanni Zamboni, a physics professor from Verona, Italy, began constructing a dry battery, which he finished in 1812. This battery consisted of sheets of tin foil coated with a thin layer of finely ground black oxide of manganese, mixed with milk and gum. Several thousand tin foil discs were then put together and compressed in order to obtain a certain number of three millimeter thick sheets; these sheets were alternated with an equal number of metal sheets in which holes had been punched, traversed by silk threads. The whole was enclosed in a glass tube and dampened with acidulated water. In this battery, the electromotive force resulted from chemical reactions between the tin being oxidized and the black oxide of manganese being reduced. The paper merely acted as a damp conductor. This battery was of limited duration because it stopped functioning as soon as the tin had been completely corroded.

Leclanché battery— The Leclanché battery - also using black oxide of manganese as a depolarizer - was derived from the Zamboni battery, which should therefore be regarded as the forerunner of modern dry batteries, as those used in flashlights, radios, cameras and other portable electronic equipment. The Leclanché battery was developed by the French chemist Georges Leclanché many years after Zamboni, i.e. around 1868, and consisted in a glass vessel containing: an electrode in amalgamated zinc, acting as anode; a depolarizing mixture of black oxide of manganese and graphite in a porous vessel; a graphite electrode; and a saturated solution of ammonium chloride as electrolyte; according to the following scheme:

copper | retort graphite | mixture of graphite and black oxide of manganese | saturated solution of ammonium chloride | amalgamated zinc | copper

The average emf was 1.5 volts, like the majority of modern-day dry batteries, however, by using different depolarizing mixtures, it was capable of reaching 1.8 volts. The Leclanché battery gained an immediate commercial success and was particularly used, throughout the last century and in the first decades of this, for local battery telephones and household electric bells. The Leclanché battery, however, was only suited to intermittent use as well as at a moderate current intensity, because black oxide of manganese could easily be polarized and its concentration under load was highly variable. It was also sensitive to high room temperature.

Accumulators or storage batteries— In 1859, the Frenchman Gaston Planté invented what is known as the *storage* (or *reversible*) *battery*, later called the *electric accumulator*, based on sulfuric acid and lead. This battery only became of practical use in 1881 when grated lead plates were introduced.

Other important development in batteries have taken place during the present century.

The *Ruben-Mallory* battery used a solid depolarizer consisting of mercury oxide and was therefore also called *mercury battery*. It was developed during World War II and became commercially available around 1957.

The *zinc-air battery*, developed by the British company *Energy Conversion* in 1968, weighed only one kilogram and could provide a constant voltage of 12 volts for 12 hours. It was widely used in telecommunications equipment.

The *aluminum-air battery*, developed in 1987 by *Alcan International Ltd.* of Montreal (Canada) with a Canadian government subsidy, had a capacity of 1.68 kWh and could pull an electric golf buggy for eight hours running.

Dynamo — It is not inappropriate to recall how important the introduction of the dynamo was as a replacement for electric batteries in the electroplating industry. At the end of the nineteenth century, the replacement of batteries by dynamo reduced the cost of electroplating by at least four times (for instance, galvanic silver-plating dropped from 4 lire per kilogram of silver deposited to approximately 1 lira per kilogram)[9].

After Michael Faraday suggested, in 1831, that electric energy could be obtained from a conductor moving crosswise to the lines of force of a magnetic field, many attempts were made to create an electric generator based on that principle. In 1832, Hippolyte Pixii had already built a small machine using natural magnets and a switch to obtain direct current. Charles Wheatstone, in 1845, replaced Pixii's natural magnets with electromagnets fed by a battery. Apparently, in 1850, Charles Christofle in Paris also built a rudimentary electromagnetic machine for use in electroplating in his famous factories, but results were not satisfactory. In the same year, F. Nollet built another electromagnetic machine that was used to operate an electric lighthouse. In 1855, Søren Hjørth, a Dane, patented another electromagnetic generator. Again, Charles Wheatstone, in 1857, introduced the idea of self-excitation, which some attribute to Werner von Siemens. This latter, however, was the first to build a self-excited dynamo in 1866. Similar discoveries in the field of self-excitation were made by H. Wilde, Warley and M. G. Farmer.

It is a known fact (although one not mentioned in some publications) that in 1860 Prof. Antonio Pacinotti, from Pisa, built his famous ring from which he created the first

[9]This corresponds, in 1990, to a drop from 18,400 lire to 4,600 lire per kg or from \$15.30 to \$3.83 per kg.

direct current induction motor that was also the core of the electric dynamo. He published a description of his discovery in the renowned Physics' magazine *Nuovo Cimento* on 13 May 1865 (some years after his discovery) and in the same year also discussed it with the head of *Usines Frémont* in Paris, the Belgian Zénobe Théophile Gramme. Gramme took out a patent for a dynamo using Pacinotti's ring in 1869 and began to produce it industrially in 1871. Pacinotti published his protest in the *Reports of the French Academy of Sciences* (Vol. LXXIII), which, however, did not achieve any other practical result, such as the cancellation of Gramme's patent. On this subject, a modern American encyclopedia [Microsoft Bookshelf 1994, on CD-ROM — The People's Chronology] reads: "*Energy, 1872 - Belgian electrician Zénobe Theophile Gramme, 46, perfects the world's first industrial dynamo, employing a ring winding of the same type invented independently by Italian physicist Antonio Pacinotti in 1860.*"

Lastly, it should be recalled that in 1879 the American Thomas Alva Edison, built a high voltage dynamo to power a group of direct current incandescent lamps and in 1882 he built the first direct current electric power station, using a dynamo, in Pearl Street, Manhattan.

Ancient gold- and silver-plating techniques

The art of covering an object with a coat of gold has been known and practiced since very ancient times. The ancient Egyptian alchemists well knew the effect produced by the immersion of a metal in a saline solution of another metal and interpreted it as a *transmutation* of one metal into another. The recipes for this were kept secret by priests in the Egyptian temples and later divulged in the second century AD by the Academy of Alexandria. Similar knowledge was possessed by the Chinese at around the same period as the Egyptian priests.

Historians narrate that the bronze statues of ancient Egypt were covered with thin sheets of precious metals. The roof of the temple of Jerusalem was also covered in gold at the peak of the Hebrew civilization. The Romans, in turn, used to cover furniture in the houses of wealthy citizens and the walls of their temples with thin sheets of gold obtained by hammering, known as *bracteae quaestoriae*. In order to make these *bracteae* adhere perfectly, the Romans used a mordant (adhesive) called *leucophoron*, and the whole was coated with egg white.

Silver-plating, on the other hand, was almost entirely unknown in ancient times, solid silver items being preferred, as the metal was extracted in huge quantities from the mines of Laurion and Asia Minor. Silver-plating was imported by the Moors when they invaded Spain and Sicily (eighth-ninth centuries) and from there spread throughout Europe.

During the middle ages (tenth-eleventh centuries) gilding with gold leaf was replaced by amalgam gilding which, although simple and economical, was a highly dangerous process because of the toxic elements employed. Mercury, which has the property of dissolving all noble metals, was used to produce the so-called amalgam; this was painted onto objects which were then fired. The mercury would volatilize and the gold remain attached to the metal. This system of amalgam gilding - which was employed until after the middle of the nineteenth century when it was replaced by galvanic gilding, i.e. electroplating - was extremely expensive. To give an example, in 1850 when the outside of the dome of the Church of *St. Isaac* in St. Petersburg, Russia, was gilded, the cost totaled 4,400,000 francs (equivalent to about 46 billion lire or 38 million dollars in 1990), without considering the cost of pensioning off about two hundred workmen, permanently injured by intoxication from the mercury vapors. It is understandable that the discovery of electroplating was immediately greeted with enthusiasm.

Origin and development of electrodeposition techniques

Electrodeposition techniques are based on the phenomenon of electrolytic decomposition (or *electrolysis*) of metal salts when an electric current passes through them. It was apparent from the very first trials, conducted by Count Volta himself, that an electric current was the most powerful method of chemical decomposition known. Volta was the first to remark in 1800 that the metal salt contained in the batteries decomposed into its constituent elements as the current passed through and, more especially, that the constituent metal deposited on the negative electrode. At almost the same time as Volta, W. Nicholson also attempted, but without success, to decompose certain metal salts by electrolysis in order to obtain a deposit of a thin layer of the component metal on certain objects.

As we shall see, as soon as this phenomenon was understood and controlled, the expensive gilding, silvering and other plating obtained by firing were completely replaced by electroplating, which produces coatings that are extremely thin, very even and hard-wearing and, moreover, less expensive. The other sector to benefit enormously from electrodeposition techniques was the printing industry. In the past, engraving had been a highly specialized and time consuming job; it was done on sheets of copper or steel or on wood and only a limited number of copies could be run because the original was subject to gradual and irreversible deterioration. With the more advanced electroplating techniques, on the other hand, it was possible to reproduce millions of copies of the original by preparing a plaster, wax or pure lead mold from which an *electrotype* or *plate* could be obtained rapidly and by less specialized workmen. It is worth, therefore, describing in some detail the origins and development of these two important branches of electrodeposition techniques.

Galvanic gold and silver plating

The first person to undertake thorough and serious research in this field was the physicist Luigi Valentino Brugnatelli (see a short biography below, under "Profiles"), a student of Count Volta (and later his friend and colleague as professor at Pavia University). In 1802, he described a method which he had successfully used to obtain a deposit of gold on the conductors of a voltaic battery, as reported in the *Annali Chimici di Pavia* of 1801-02. The description of his process was also published in Vol. I of the *Journal de Physique et de Chimie* of Mons (Belgium), in 1802, as follows (from: Savorgnan di Brazzà, op. cit.)[10]:

"*Take one part of saturated gold dissolved in turpentine, add six parts liquid ammonia; the solution will separate and precipitate gold oxide, that will instantly dissolve in part to form ammoniated gold. This mixture is collected in a glass container. The objects to be gilded are firmly attached to a steel or silver wire that is connected to the negative pole of a voltaic pile. The silver object to be gold-plated must be immersed in the liquid containing ammoniated gold. The galvanic current is closed with a large strip of dampened carbon which passes from the ammoniated gold to the positive pole of the pile. Within a few hours the silver is entirely coated with gold by galvanic action. The gilding can later be colored by ordinary means.*"

This passage is of considerable historical interest for it provides incontrovertible proof that Valentino Brugnatelli was the first to obtain gold-plating by means of electric current. The quality of the gold-plating, however, was not yet commercially acceptable: the gold was deposited in the form of a blackish-gray powder, with no shine. For this reason, Brugnatelli abandoned his experiments.

Many years later, his experiments were taken up again by the Swiss physicist Auguste Arthur De La Rive (see a short biography below, under "Profiles"). In 1825 he attempted to gild objects by decomposing gold chloride, but the results were not good. After Daniell pile was invented (1836) he noticed that the copper plate (cathode) of this battery was coated with a layer of copper, in a pure metal state, and that the coating was so perfect that after a while it could be detached its surface bearing an exact copy of all

[10]Some encyclopedias (*Scienziati e Tecnologi—Dalle origini al 1875*, see bibl.) quote the same Journal from *Brussels*, instead of *Mons* and the year 1803, instead of 1802.

the marks on the plate where it had been deposited. Also John Daniell had made the same observation on his battery. De La Rive continued his gilding experiments for several years but his results, in 1840, were only marginally satisfactory. The first layer of gold he obtained was very bright and adhered well but subsequent layers quickly turned powdery and uneven, just like Brugnatelli's. De La Rive's apparatus (see illustration) consisted of a cylindrical container of porous material which held the gold chloride; this container was placed in a larger vessel filled with acidulated water where a sheet of zinc was immersed, connected by a copper wire to the object immersed in the gold chloride.

De la Rive gold plating apparatus

This apparatus was composed of a two-liquid battery of the following type:

copper-object | gold chloride | acidulated water | zinc plate | copper,

closed in a short circuit by the copper wire.

Other scientists, such as Perret, Smée, Elsner and Beedger attempted to perfect De La Rive's method, but there was not much improvement on his results until they were joined by a German scientist, naturalized Russian, Moritz Hermann von Jacobi (see a short biography below, under "Profiles").

Jacobi, who at the time was professor of Physics at the University of Dorpat (now Tartu, in Estonia), began from the same observation made by Daniell and De La Rive concerning the deposit of copper on the copper negative pole - or cathode - of Daniell's pile. However, he also noted that although part of the deposit was composed of separate crystalline particles, beneath them were perfectly even coats of copper and it was these that matched the copper electrode exactly, reproducing even the smallest scratch or bump. After a series of experiments he concluded that the phenomenon was not due to the particular kind of the metal (copper) but was a general principle, applicable to all metals. He also managed to reproduce on the copper electrodes of the batteries, indented or in relief, any sort of pattern engraved on the electrode. More specifically, using weak but very constant batteries, he managed to obtain an imprint in relief of a plate engraved by burin.

This convinced him that he was on the verge of an important discovery and on 21 October 1838 (9 October in the Russian calendar) he reported the results of his experiments, supported by several sample objects made by him, to the Academy of Sciences of St. Petersburg. Jacobi's communication, which was read out by his secretary, Russ, was greeted with considerable enthusiasm and earned him the encouragement of Czar Nicholas I who later acquired the Russian patent for 25,000 rubles. The Duke of Leuchtenberg was commissioned by the Czar to set up a *State Institute of Galvanoplastics*, employing over 250 workers. A number of Russian churches still display work carried out in that factory, such as the twelve gilded bronze statues that decorate the inside of the dome of the Church of *Saint Iran* in St. Petersburg. The Russian government spent enormous sums of money on the Institute, of which it was justly proud. However, when the Duke of Leuchtenberg died, the Institute was sold to private industry.

After Jacobi obtained the financial support of the Czar, he continued his research and immediately sought to put his discovery into operation on an industrial scale. He thus introduced into the process one of the three fundamental innovations that earned him the title of *father of electrodeposition techniques*.

He had observed that the method used until then, which consisted in depositing the copper inside the actual cell, made it very difficult to perfect the process and, above all, did not allow large size objects to be copper plated. He found that decomposition improved when the battery was separated from the galvanic bath (of copper sulfate) and connected to the cathode and anode of the galvanic bath by two conductors. Unfortunately, in these conditions the bath was very quickly depleted. To overcome this problem he tried to increase considerably both the size of the bath and the amount of liquid, but this took up a lot of space and was very expensive.

It was in 1839 that he made his next major discovery, which made the process industrially viable: the *soluble anode*. He had observed that when an object is attached to the cathode of the galvanic bath and the anode consists of a sheet of the same metal as that contained in the salt dissolved in the bath, the sheet dissolves slowly in the bath and the amount of dissolved metal is practically equal to the amount progressively adhering to the object. The discovery of the *soluble anode* was of major significance; it not only allowed the electric battery to be separated from the apparatus where the deposit occurred, but it became possible to use any source of electricity whatever, since it no longer had to contain a salt of the metal to be deposited.

A last problem remained, but quickly solved by Jacobi. In his early experiments he had used only objects or molds in copper, which was very expensive. He discovered later that the molds could be made of any material, even an insulating material such as plaster or wax, provided it was coated with a thin layer of conductive material. More particularly, he found that because of its conductive properties, graphite was the most suitable material to use. His idea of using molds of other materials and of coating them with a conductive layer (conductive paints) was taken up and perfected by Berguillon in France and Murray in England. Incidentally, it should be pointed out that electrodeposition techniques would not have become so important had it always been necessary to rely on metal supports to obtain electroplating because of the technical problems involved in building them and their high cost. Thus, it can be said that Moritz Hermann von Jacobi well deserved the title of *father of electrodeposition techniques*.

Between 1839 and 1840, Spencer, as well as the brothers Henry and George Elkington (cutlers, inspired by earlier studies of John Wright), all English, and a Frenchman, Count Henri De Ruolz (see a short biography below, under "Profiles") discovered that galvanic gold- and silver-plating gave better results if, in place of a chloride, *alkaline* solutions of gold or silver cyanide in a solution of potassium cyanide were used. The deposits thus obtained adhered perfectly to the metal beneath and it was also possible to achieve exactly the desired thickness by leaving the object under the action of the electric current for a suitable time. Following these discoveries, industrial applications began, especially those of galvanic silver plating, which was the most widely demanded. Some regard the date of Elkington's patent, obtained on 29 September 1840, as the start of the galvanic gilding industry.

The two patents obtained by Count Henri De Ruolz were dated 8 December 1840 and 18 June 1841, respectively, the first one only shortly after that of the Elkington brothers. This close timing gave rise to lively disputes between the two parties, both acting in good faith, since their discoveries had seemingly been made without the one knowing about the other. On 9 August 1841, Count De Ruolz read a description of his invention to the Academy of Sciences in Paris and on 24 November the famous chemist Jean Baptiste André Dumas called the Academy's attention to the experimental results of De Ruolz's system, with particular emphasis on its industrial applications. Dumas' address, in which only a passing mention of the Elkington brothers was made, was met by a violent protest from the two English inventors and on 11 December their representative in Paris, one Truffart, wrote to the French Academy demanding that the Elkingtons' rights be safeguarded.

The dispute was an extremely difficult one to solve, for the Academy, which took the matter to heart, could not deny the true value of De Ruolz's research but had to recognize that the English inventors were indeed first. A compromise was found that would recognize the merits of both parties. On the proposal of the Commission appointed to assign the *Montyou Prize* of 19,000 francs to any person who had introduced *industrial improvements in unhealthy arts*[11], the Academy decreed on 6 June

[11]In fact, the electroplating techniques completely replaced the highly toxic system of mercury-based gilding.

1842 that the prize should be shared between Prof. Auguste Arthur De La Rive, Count Henri De Ruolz and the Elkington brothers, adducing the following motives (from Savorgnan di Brazzà, op. cit.):

"The Academy awards a prize of 3,000 francs to Mr. De La Rive, Professor of Physics at Geneva, as the first person to employ electricity in the gilding of metals, and especially of bronze, brass and copper.

A prize of 6,000 francs is awarded to Messrs. Elkington for the discovery of their method of damp gilding and for their discoveries of processes relating to galvanic gilding and the application of silver on to metals.

A prize of 6,000 francs is awarded to Mr. De Ruolz for the discovery and industrial application of several of his own methods for gilding metals, silver plating them and coating them with platinum and, lastly, for obtaining economic precipitation of metals onto one another by means of a battery."

De Ruolz's patents were purchased in 1841 by the French industrialist Charles Christofle (see a short biography below, under "Profiles"), who later set up the world's largest factory for electroplating.

Moreover, on 13 May 1842, Charles Christofle signed a contract with the Elkington brothers, under which the parties granted reciprocal use of their patents. In 1845, Christofle finally purchased all the patents, paying a sum of 150,000 francs to Henri De Ruolz (approximately one and a half billion lire or 1.25 million dollars at year 1990's values) and 500,000 francs to the Elkington brothers (just over 5 billion lire or over 4 million dollars in 1990). The patents expired and became public property in 1855, by which time Christofle had already won most of the market worldwide.

From what we have said above, it appears that the small electroplating industry set up by Antonio Meucci in Havana in 1844, quickly followed the progresses made in France and England, and antedates, according to Williams Haynes (see bibl.), the first electroplating industry in the United States, set up by Dr. Isaac Adams of Boston in 1869.

Electrotyping

It is difficult to separate the history of electrotyping from that of electroplating. The early observations, made in 1836 by De La Rive and Daniell and in 1837 by Jacobi, concerning the reproduction of scratches and bumps on copper deposits formed on the cathode of certain types of battery are at the origin of electrotyping.

At almost the same time as Jacobi, in 1837, an Englishman from Liverpool, Spencer[12], discovered that if he used a battery consisting of a sheet of zinc and one of copper, the first immersed in a copper sulfate solution, the second in a

[12] The author was unable to trace his first name.

sodium chloride solution (common salt), on top of the copper electrode a layer of copper was deposited with the same appearance and properties as copper obtained by fusion. Spencer then coated the copper electrode with paint and engraved letters on it with a metal point so as to reveal the underlying metal in the same way as for etchings. By passing the current through he ascertained that the metal was deposited in the hollows engraved in the paint, thus forming a design in relief.

Towards the end of 1838, Spencer decided to apply his discoveries to the reproduction of drawings and was thus the first to develop an electrotype. He used it to obtain large runs with the normal printing press in use at the time. It is believed that he conducted his experiments separately from Jacobi, whose results were probably unknown to Spencer. Some even attribute the discovery of galvanoplastics to him. This is not historically accurate, however, principally because Spencer published his invention several months after Jacobi's first communication, dated 21 October 1838; moreover, Jacobi's work embraced all aspects of electrodeposition techniques.

With the advent of electrotyping it became possible to obtain almost limitless runs while keeping the artist's original work intact. When the copy was printed directly using the engraved wood or zinc plate, these were rapidly worn down by the pressure of the printing press and roller. Therefore, the artist had to engrave several plates, wasting much time.

The electrotyping process most frequently used in the second half of last century was the following (from Savorgnan di Brazzà, op. cit.):

"*Take some gutta-percha or the mixture which practical experiments indicate should be made up according to the following formula: 2 parts pure wax, 10 parts granzuolo*[13]*, 2 parts stearin, 3 parts graphite; use it to form laminated plates and cut one to the required size, then heat it and press it onto the engraving or typographic form to be reproduced, thus obtaining a perfect template of the original. This template is coated with graphite and placed in the [galvanic] bath. When the copper film is taken out of the bath it must be reinforced by a coating of tin on the underside. This coating consists of an alloy of equal parts of tin and pure lead, made up as follows. To prepare the copper for tinning so as to ensure perfect adherence, first hydrochloric acid is decomposed with zinc and the resultant acid essence is used to wet the grainy surface of the copper plate over which a tin leaf or tin powder is then placed. The whole is then exposed to heat so that when the tin dissolves it will adhere to the copper; however, the heat must not*

[13]The author was not able to find a description of this substance, nor to give its translation in English.

be too high or the decomposed hydrogen will form stannous oxide on the copper plate, which will jeopardize the cohesion of the metal alloy to be poured on top afterwards. The copper sheet, which is unlikely to be more than 3/10 of a millimeter thick, could not withstand a long series of impressions. It must be reinforced and raised to the required consistency; to do so the electrotype is placed in a frame and a lead alloy containing 6% antimony and 6% tin is poured over it; the whole is put through the press to remove the excess alloy and ensure that the plate is perfectly flat since it may have been altered by the heat. A plate of this kind can be used to obtain runs of over 300,000 copies."

Galvanoplastics

Before explaining how the process of electroplating employed in the second half of last century works in practice, a brief description will be given of the methods used to prepare molds for galvanoplastics, that is the technique whereby an original object can be reproduced in any number of copies desired using a mold and a galvanic process. This method is very similar to electrotyping described above since in both cases there must be a support (mold) on which the galvanic deposit can form. In galvanoplastics, however, the mold is very often disposable, in the sense that each mold is used for one object. Metal was rarely used to make molds: almost always a plastic substance was preferred (hence the term *galvanoplastics*), such as plaster, sealing wax, gutta-percha or a mixture of waxes, which was transformed into a conductor by means of a layer of plumbago (graphite). Metal molds were used almost exclusively for very small objects, such as medals and coins, requiring the reproduction of fine details. The plastic materials employed for the molds had to be low-melting and highly plastic, as well as easily detachable. When bas-reliefs had to be reproduced, the best materials were plaster and clay. Below is a description of the process followed to obtain a mold of the kind mentioned (from Savorgnan di Brazzà, op. cit.):

"The original to be reproduced is coated with a thin layer of finest talcum powder and, in the case of a medal, placed in a circle of cardboard forming a border around it and giving the impression of being placed inside a box. After this, a plaster mixture of the right consistency is smeared on the original and carefully pushed into all the holes and corners. The plaster is then left to dry and thicken in a current of air or in a moderate oven. When the plaster is dry the two parts are separated and the mold is ready.

However, since plaster allows water through, the mold is waterproofed by immersing it in a bath of liquid stearin at a temperature of 100 °C; a large number of air bubbles are produced as the stearin fills the pores. After shaking thoroughly *to eliminate the excess stearin, the mold is left to cool.*

In all cases in which a mold can be obtained by pressure alone, gutta-percha is used. At normal temperatures this material is fairly hard and resistant but it becomes plastic after immersion for a while in warm water. In this state it will give a faithful indented reproduction of even the faintest marks. Preparing gutta-percha molds is a very delicate process because it is hard to avoid leaving tears in the original. Nowadays [ca. 1900, Editor's note], a compound of pure wax, granzuolo, stearin and paraffin, in varying proportions depending on the surrounding temperature, is preferred, especially in electrotyping.

When handling a particularly large object, simple manual pressure is insufficient to obtain the impression or cast and a press operated by a large screw or by hydraulic power must be used. A metal guide with square cross-section is installed on the platform of the press to keep the object perfectly horizontal; the object is lightly greased and placed in the frame of the guide so as to form a sort of box, the bottom of which is the object itself and the sides are the frame. A thick sheet of gutta-percha, wax or other plastic material is then cut to the exact size of the sides of the frame. This sheet is heated until it softens to the desired consistency, then applied to the surface of the object and lastly covered with a heavy cast iron plate, which can run inside the guide. The press is operated, taking care to slowly increase the pressure as the gutta-percha gradually covers the object. In this way an impression can be taken of even the smallest details."

Once the molds have been prepared in this way and coated with the layer of graphite to make the surface conductive, electrodeposition can begin using methods similar to electroplating.

Electroplating

In the majority of applications, the electrolytic bath was contained in a solid wooden tank, for instance seasoned larch, with a (double) lining of lead or stoneware tiles. The tank was filled up to just over 3/4 full so that once the objects are immersed the water surface rises to approximately 5 cm from the top of the tank. Two copper rods are placed at a certain distance (specified below) across the tank. The object (or graphitized mold) to be plated is hung by a metallic hook from one of these rods: this will be the *cathode* of the electrolytic bath and it will be connected to the negative pole of the external battery. From the other copper rod hangs the pure metal anode (*soluble anode*) from which particles will detach under the effect of the electrical current and replace, in the bath, the particles deposited on the object (or mold) to be plated (see illustration below). The soluble anode will be connected to the positive pole of the external battery[14]. The distance between the plate acting as *soluble anode* and the sides of the tank must be about 5 cm, while the distance from the object to be plated should be about 10 cm if the object is smooth or 20 cm if it is not. Lastly, the objects to be plated must remain immersed approximately 10 cm below the surface of the bath but placed about 10 cm above the bottom of the tank.

The electric generator is placed outside the electrolytic bath; this was a battery or, later, a dynamo or a rechargeable accumulator in tandem with the dynamo. To operate the bath a fairly low voltage is generally sufficient (usually 5-6 volts) and a strong current, which depends on a number of factors, notably the size of the object to be plated. For this reason it is not the current but the current density, in ampere per square decimeter (A/dm^2), that is usually given. If agitators are applied to the bath (either by mechanical means or by compressed air), higher voltage (and current) is required; this gives a greater yield in less time but generally at the expense of the quality of the deposit, which may tend to flake. Higher voltage is also needed for electroplating with strong metals, such as nickel, steel, cobalt, and so on.

The most usual form of electrodeposition is copper plating, which often precedes gold or silver plating. It is important to ensure that the copper deposit is of a considerable thickness - particularly on molds for galvanoplastics - if the final object is to be sufficiently solid. In the early years of electrodeposition it was possible to deposit about three quarters of a millimeter of copper every twenty four hours. Later on, deposits of one millimeter per hour could be obtained. To achieve this result, the concentration of the electrolytic bath had to be kept at 20° Bé[15], the temperature between 17 °C and 25 °C, the solution constantly saturated with copper sulfate (and stirred), and the electrical current very constant.

Preliminary operations

We will now describe the main stages of the process as followed in the mid-nineteenth century (see the block diagram on p. 404), most of which are still valid, in principle, today. Before a metal object could be plated it had to be thoroughly cleaned in order that an even deposit of the desired metal could be obtained on it. If impurities remained attached to the surface - and very often these were insulating particles such as grease - the coating

[14]The illustration (reproduced from Reuleaux, see bibl.) shows an incorrect connection, in that the positive pole (central electrode of the battery) appears to be connected to the cathode of the bath (the object being plated), instead of the soluble anode.

[15]°*Bé = degree of the Baumé scale*.— An ancient unit of measurement indicating the concentration of a substance in a water solution.

Copper plating of a cast-iron statuette

Procedure for galvanically gilding a metal or metal coated object

would be patchy. The cleaning operation proceeded as follows:

The first step was to very thoroughly eliminate from the objects any grease which may have been deposited during production or handling. To do so the object was immersed in a solution of potash, followed by a rinse (R) in lukewarm water and drying. This was followed by *chemical purging*, a two-stage operation involving, first, a fairly lengthy immersion of the objects in a weak acid solution and then a very brief immersion in baths of concentrated acids (*grazing*). The purpose of these two operations was to remove the layer of oxide that is always deposited, to varying degrees, on the surface of the objects to be treated. The concentrated acid solution was composed as follows:

Sulfuric acid at 66° Bé .... 20 parts
Nitric acid at 66° Bé .... 15 parts
Sodium chloride ....1 part

The objects were immersed in this bath for two seconds only because otherwise they would have been eaten and damaged by the acids. After removal they were thoroughly rinsed in plentiful running water. After drying, the pieces to be plated were given a final treatment to give them great brilliancy at the end of the process: they were immersed in a third acid bath composed of a 1 ‰ solution of mercury dioxide and sulfuric acid.

In the case of large objects, which could be mechanically cleaned, the *grazing* phase was replaced by energetic rubbing with powdered pumice stone by a wild-boar-hair brush. In industrial processes, the brush was fixed to a lathe operated by pedal or by a steam engine.

Copper plating

Objects were usually copper plated before being gold plated because gold will deposit in extremely thin but very resistant layers on top of a copper layer. An object that has been copper plated and then coated with a gold layer only one ten-thousandth of a millimeter thick will give excellent results as regards both color and wear. Moreover, copper can be very easily deposited by galvanic process on top of almost all metals.

In galvanic copper plating the bath most frequently used was the following:

Water ....1000 g
Copper sulfate ....25 g
Salic acid[16] ....50 g
Ammonia...............................50 g

The density of current required was between 2 and 4 A/dm^2. The deposit, at minimum current, was around 25 µm/h thick, that is about a quarter of a millimeter every ten hours.

[16]Probably, an acid obtained from silica and alumina.

This bath produced a good deposit of red copper. Incidentally, it should be recalled that in the last century, galvanic copper plating had a large number of very important applications. Savorgnan di Brazzà (op. cit.) refers that in the second half of the past century, in the United States, approximately 162 km of steel wire were copper plated each day for use in telegraph lines, employing around 2500 kilograms of copper.

Mention should be made of a major problem that arose in the copper plating of iron or cast-iron objects (such as statuettes). It often happened that as soon as the copper plating flaked, even in a very small area, the combination of the copper layer and the uncovered iron created a voltaic cell, which in turn oxidized the iron and caused it to gradually rust. Various ways of overcoming this problem were proposed. The Frenchman, Oudry, thought of coating iron objects with very hard-wearing and waterproof isolating paint, which he left to dry thoroughly before coating with red lead (acting as a conductive layer) and then depositing on this the layer of galvanic copper. Obviously, this process was much lengthier and more expensive and there were difficulties in obtaining an even deposit, particularly if a good part of the object was in relief. Nevertheless, Oudry's method was used to copper plate the chandeliers in the city of Paris, on which about a millimeter of copper was deposited, by a five-days immersion in the galvanic bath. The same method was also used to copper plate the large statues in *Place de la Concorde*, in Paris, which had to be left in the galvanic bath for two months.

The method employed to copper plate objects made of insulating material, such as wood, plaster, etc., involved first transforming them into conductors so that the copper could be deposited. They were therefore immersed in iodized collodion and subsequently in a bath of silver nitrate. After this, they were exposed to light for a given time and then immersed in a bath of iron protosulfate [ferrous sulfate, Editor's note]. The silver, which was thus transformed into metallic silver, made the surface of the object conductive and thus ready to receive the copper deposit.

Gold plating

Although nowadays galvanic gold plating has fewer practical uses than silver, nickel or copper plating, it occupies an important place in the history of electrodeposition techniques since it was the first to be extensively used.

Gold plating could be obtained by a hot or cold process. Hot gold plating produced a much quicker deposit and a much richer color. For this reason it almost entirely superseded the cold process, which was the only one used in early times. The best temperature for the hot process was 76 °C. The bath was usually composed of gold cyanide dissolved in an excess of potassium cyanide. Below is a description of the process, as given by Savorgnan di Brazzà (op. cit.):

"Fifty grams of pure gold are dissolved in aqua regia (consisting of two parts hydrochloric acid and one part nitric acid), placing the flask over a spirit lamp to speed up its dissolution. When this is completed, the liquid is poured into a china cupel and evaporated until a very dense deposit is obtained. Four liters of water and 1 kilogram of very pure potassium cyanide are then added to obtain a concentrated solution which is preserved in closed containers and is sufficient for 50 liters of bath. Rosseleur advises adding 500 grams of ammonia.

For rapid gold plating of steel objects, without prior copper plating, the following bath can be used:

Water	1000 g
Sodium phosphate	50 g
Sodium bisulfate	15 g
Potassium cyanide	2 g
Gold (transformed into chloride)	1 g

We now come to the actual gold plating. After the object has been subjected to a series of preliminary operations (degreasing, grazing, etc.), it is hung in the bath by copper hooks from a rod connected to the negative pole of the battery.

The baths that produce the galvanic deposits are rapidly depleted during the operations since they must provide the gold to be deposited. To continually replenish them, Jacobi's discovery of the soluble anode is exploited. To this end, a sheet of pure gold connected to the positive pole of the battery is placed in the bath. The cyanogen released by decomposition of the gold cyanide collects on this pole; the cyanogen attacks the gold, producing gold cyanide in equal amounts to that which has been decomposed. Practical trials have allowed to establish the best size for the soluble anode in each case.

As explained above, gold plating and silver plating can be done in either hot or cold baths, with or without bubbling current, as mentioned in Elkington's patent. It is only a matter of convenience whether hot or cold baths are used; to gold plate large objects, cold baths are preferred, while hot baths are advisable for other objects. In general, hot baths work faster and demand lower voltage; moreover, they require much less metallic gold content to produce an even, adherent and richly colored deposit.

When operating with a cold solution the current must be stronger. A cheap, cold bath that gives excellent results is that developed by Pfanhanger. The hot bath is prepared in exactly the same way as the cold bath; the simplest one is that shown in the second table.

Finishing

We quote from Savorgnan di Brazzà (op. cit.):

When the object is removed from the gold plating bath the process is not yet finished. What is deposited is pure gold, but as everyone knows, the color of pure gold, a slightly opaque yellow, is not the same as that of objects normally on sale. Coins and jewelry are made of an alloy of copper and 80 or 90 percent gold. Therefore, the pieces of voltaic gold-work must be given the same, well-known color as commercially available gold objects. Three further operations are needed to do this: buffing, coloring and burnishing.

The process that is carried out with the buffer is the touchstone of metallic deposits. In good conditions, metallic deposits can withstand rubbing with the buffer and acquire a beautiful glow; otherwise, if they do not adhere properly to the underlying metal they flake easily and come off in pieces. The buffer - called 'grattapugia' in Florence - consists of a bunch of brass wires attached to a wooden handle or a skein of brass wires folded in half and cut into the shape of a brush.

Buffing is always done inside a liquid substance, usually a decoc-

Pfanhanger cold bath

Water	1 liter
Sodium calcium carbonate	10 g
99% potassium cyanide	7 g
Pure gold in the form of gold fulminate	2 g
Voltage (at 15 cm distance between anode and object to be gilded)	2.85 volt
Voltage difference for each 5 cm of more or less distance, ca.	0.18 volt
Concentration	2.5° Bé
Resistance	4.4 ohm

Hot bath

Water	1 liter
Pure gold in the form of gold fulminate	1 g
99% Potassium cyanide	5 g
Voltage (at 15 cm distance between anode and object to be gilded)	1.3 volt
Voltage difference for each 5 cm of more or less distance, ca.	0.20 volt
Current required	0.1 A/dm^2
Concentration	2° Bé
Resistance	2.8 ohm

tion of licorice wood, a runny pulp, which softens the action of the buffer on the gilded surface. The liquid is placed in a tub with a plank placed right across the middle of the top. This plank does not touch the liquid and the workman rests on it to dip the buffer and the object in the liquid at frequent intervals.

This method is lengthy and laborious and is not used for smooth objects like cutlery or large goldsmith's objects. For these latter, a lathe buffer is used; this is a circular buffer with disc brushes that are turned at a speed of approximately 600 revolutions per minute by a foot pedal, in much the same way that the knife grinder turns his wheel. Smaller objects which are unsuited to polishing with the buffer are polished by 'bagging' or 'tubbing.'

In 'bagging' the objects are placed inside a long thin sack which is shaken so that the objects rub against each other evenly. In addition to the objects to be polished, the sack also holds a large quantity of box-wood or pine sawdust, in the case of very small trinkets, whereas for lightweight knickknacks it contains bran or fine sand. The sack is held at each end and spun round, first to the right and then to the left; occasionally, this operation is carried out by two people, each of which holds one end of the sack, shaking it rhythmically.

'Tubbing' is often used in place of bagging and is a process which jewelers have borrowed from confetti's producers. It involves drying the objects in a tub hung from the ceiling by ropes, containing a suitable quantity of sawdust, bran or sand. The worker takes hold of the tub with both hands and shakes it evenly so that the objects inside are rubbed energetically one against the other.[17]

The gilded objects are tinted with a pulp called 'ground gold,' made up of 30 parts alum, 30 parts potassium nitrate, 8 parts zinc sulfate, 1 part iron sulfate and 1 part sea salt. This powder is brushed onto the gilded object, which is then passed in a wood coal fire until the fused and dried paste acquires a burnished color. The oven employed for this operation is a vertical cylinder in which the coal burns between the walls and a concentric grate; the objects prepared with the above powder are placed in the center of this oven.

The object is then removed from the oven and immersed while still hot in water containing 3% hydrochloric acid. After this, the object is rinsed thoroughly in plenty of clear water in which it is suspended by means of a ladle or wire basket. The object is finally dried in sawdust. At the end of this process the object acquires the same color as gold objects available in the shops, having lost some of its gold under the corrosive action of the saline mixture."

[17] A similar effect is obtained nowadays with the sanding machines.

Silver plating

We quote from Savorgnan di Brazzà (op. cit.):

"Galvanic silver plating, which Elkington developed into an industrial process in 1840, was and still is used on an extremely wide scale. By endowing objects in daily use with a rich and beautiful appearance, it has provided industry with a line of production accessible to everyone, creating at the same time new sources of profit and new means of development for this industry.

Every day we see and use objects that have been subjected to galvanic silver plating. At one time, cutlery, for example, was made of tin; now it is made with a variety of less wearing and less expensive metals. The thin coating of silver makes it more attractive to the user and the consumer enjoys not only a more artistic effect and larger saving, but also a much greater guarantee of hygiene since the pieces are now rustproof.

In many respects, therefore, silver plate cutlery has become a major industry. However, we shall consider it from a purely technical point of view and describe only the underlying scientific process.

Basically, the processes involved in voltaic silver plating are similar to those used in voltaic gold plating.

Many different formulas are used, several of which present serious problems because the deposits obtained are uneven and non-adherent. Roselem's process is undoubtedly the best. The bath is composed of:

Water .... 1 liter
Potassium cyanide ....50 g
Silver cyanide 25g

The products must be absolutely pure, of course, and for this reason it is advisable to prepare the silver cyanide oneself. Dissolve 250 grams of silver in 500 grams of nitric acid in a china cupel; heat the whole gradually to boiling point and allow to boil until the liquid is completely evaporated. If the silver is pure, i. e. it contains none of the copper with which it is usually found, a white product will be found at the bottom of the cupel; this is the silver nitrate.

The silver nitrate obtained is dissolved in fifteen times its weight of distilled water to which a given amount of hydrocyanic acid has been added. A large quantity of white precipitate of silver cyanide will soon be formed in the colorless liquid, which is then filtered and thoroughly washed; once dry, the silver cyanide is ready for use. Potassium cyanide and water are added to it in the proportions quoted above. The potassium cyanide dissolves, when combined with the silver cyanide, giving a silver and potassium cyanide, , while the bath becomes absolutely clear. This bath now contains 25 grams of silver per liter which is the correct concentration; if it were greater, the deposit would occur faster but would be less even. The problem with this system is that in order to prepare the silver cyanide, *hydrocyanic or prussic acid is needed, which is extremely dangerous and toxic.*

Prof. Zinin has given us the formula for a bath that also gives satisfactory results and consists of an aqueous solution of silver cyanide and potassium iodide, the second in excess. This bath is more expensive than the previous one but it has the merit of producing a thicker coat of silver in a very short time.

The objects to be silver plated must first be degreased, grazed and cleaned as already described for galvanic gold plating. In this case, however, the operations are easier because the object to be treated is usually coated with a layer of copper to which silver adheres better.

For galvanic silver plating, wood vats lined with gutta-percha are employed. A copper rod runs around the mouth of the vat and from it hang the silver sheets, or anodes.

The objects to be silver plated are suspended from a second rod by means of hooks. The rod carrying the anodes is connected to the positive pole of the battery while the rod carrying the objects for plating is connected to the negative pole. The two rods must not touch, otherwise the current would pass from one to the other and not through the bath.

During the operation the objects must be moved from top to bottom since the parts of the liquid that are lowest in silver content tend to rise to the top. To overcome this problem, large factories employ a mechanical device to stir the bath continuously.

To have an idea of how important voltaic silver plating has become in our time, one needs only reflect upon the fact that an estimated 150,000 kilograms of silver are deposited electrically each year [in year 1900 Editor's note] *in the factories of Europe and America.*

The famous Christofle factory, which has given its name to a type of cutlery, produces every year 300,000 ordinary pieces of cutlery, 550,000 coffee spoons, 100,000 knife handles and 400,000 dessert settings.

After removal from the bath, the silver plated objects are buffed, in the same way as described earlier for gold plating. This process helps the silver to adhere while also revealing any objects in which the silver plating is defective. If that should happen, the operation must be repeated from the beginning, after removal of the silver deposited on the object. This is done by immersing the object in a bath of 10% pure nitric acid solution; the silver comes off and precipitates in the form of insoluble silver nitrate. This is the process followed for silver plating of objects, which were previously copper coated. The process is ineffective in removing the silver layer from iron, zinc and lead, in which case electricity must be used. This is done by inverting the action to which the objects were previously subjected, in other words by immersing them in a bath of *potassium cyanide and connecting them to the positive pole of the battery.”*

Profiles

Luigi Valentino Brugnatelli was born in Pavia on 14 February 1761 and died there on 24 October 1818. He was an equally talented physician, physicist and chemist and for many years was Professor of Chemistry at the University of Pavia. He wrote a number of books, including (translation from Italian): *Elements of Chemistry, with reference to the most recent discoveries* (Pavia, 1795-97, 2 vols.), *Human Lithology, i.e. Chemical and Medical Researches* (Pavia, 1819). He pioneered research on galvanic gold plating which was published in 1802 in the *Journal de Chimie et de Physique* of Belgium and in 1805 in the *Philosophical Magazine*. In the *Annali di Chimica* he also published an interesting note on the crystallization of benzoic acid and another on Phosphorus. Lastly, Valentino Brugnatelli was largely responsible for promoting periodical scientific literature in Italy. He founded the *Biblioteca Fisica d’Europa* (1788), the *Annali di Chimica*, the *Giornale fisico-medico* (1792) and lastly the *Giornale di Fisica, Chimica e Storia Naturale* (1808).

Robert Wilhelm von Bunsen

Robert Wilhelm von Bunsen, eminent physicist and chemist, was born on 31 March 1811 in Göttingen, Germany, where he began his studies, later continued at the Universities of Paris, Berlin and Vienna.

In 1836 he was appointed professor of Chemistry at the Polytechnic of Kassel, and, in 1852, at the Polytechnic of Heidelberg. He became principally famous for his studies on chemical decomposition produced by electricity. In one of his experiments he lost an eye, due to the explosion of a still. He perfected spectroscopic techniques, applying them to celestial bodies and began investigating photochemical reactions with studies on the effect of light on reagents. He made a major contribution to the design of scientific equipment for laboratories, the best known being the gas burner and the zinc-carbon electric battery which bear his name. He died in Heidelberg on 16 August 1889.

Charles Christofle, one of the greatest industrial entrepreneurs of the last century, as well as an excellent chemist, was born in Paris in 1805. He completed his early studies at the school of Sainte Barbe and then entered one of the most famous goldsmiths in Paris, first as an apprentice and then as a worker. He soon distinguished himself from the rest of his co-workers for his amazing technical and commercial skills and became a favorite with the owner, who entrusted him with the most delicate work and most important business, finally raising him to a partnership and placing him in charge of the workshop, in 1831.

The purchase of Count De Ruolz’s and the Elkington brothers’ patents for galvanic silver and gold plating enabled Charles Christofle to expand his factory into a giant. When he was first hired, the number of workers did not reach one hundred, whereas in 1845 they numbered more than 1500. The company, which was named after him *“Christofle & C.”* is still one of the most important in France at the present time and its products are known as *en christofles*. He was a man of outstanding brilliance, the author of several interesting monographs and books, the most important of which are: *Observations sur les lois qui régissent le commerce des marques de la bijouterie en France* (Paris, 1847), *Projet de loi sur fabrique* (Paris, 1847), *Histoire de la dorure et de l’argenture electrochimique* (Paris, 1851). He died, loaded with honors and vast wealth, at Brunoy in the Seine et Marne region on 13 December 1863.

Auguste Arthur De La Rive was born in Geneva on 9 October 1801. As a result of his great talent for scientific studies and exceptional brilliance, in 1823, at the age of only 22, he was appointed professor of Physics at the Academy of Geneva. In 1830 he was forced to leave his native city for political reasons and take refuge in Paris, where he had many friends and admirers. From there he moved to London, where he lived for two years. In 1836 he returned to Geneva, where he started teaching again and at the same time took over the management of the *Bibliothèque Universelle de Genève*, which he kept until 1841. Subsequently, he became director of the *Archives de l’Électricité* (1841-46) and, together with the renowned chemist, Prof. Jean-Charles Galissac de Marignac, director of the *Archives des sciences physiques et naturelles*, from 1846 to 1860.

Prof. De La Rive published a number of works and made several important scientific discoveries. He was the first, as we have said, to introduce, in 1828, the galvanic gold plating of copper and silver, using alkaline baths. He was also one of the first to demonstrate that the production of electricity in a battery was caused by a chemical phenomenon. He invented the sine compass and carried out extensive research on induction currents, on earth’s magnetism, on specific heat of gases and, finally, conceived a very elegant theory on the origin of aurora borealis.

He was a member of many scientific academies and societies, including the *Académie des Sciences* of Paris and the *Royal Society* of London. He died in Geneva on 27 November 1873.

Count **Henri De Ruolz-Moutchal** was born in Paris on 5 March 1808. His musical talent led him to study at the city’s Conservatory, where he was a pupil of the famous M° Anton Reicha. He wrote three operas: *Attendre et courir* (Paris, 1830), *Lara* (Naples, 1835), *Vengeance* (Paris, 1839).

Having exhausted all his wealth he was forced to look for a more

Moritz Hermann von Jacobi, pioneer of electrodeposition techniques

remunerative employment than that offered by the theater, which may certainly have given him glory but could not cover his living expenses. He decided to exploit the scientific knowledge he had acquired by attending, for mere pleasure, the laboratories of the University. He found employment with a dyer, one Chappée, where he undertook to find a system for galvanic gold and silver plating. After a lengthy series of experiments he finally succeeded and took out two patents, the first dated 8 December 1840 and the second 18 June 1841. Count De Ruolz was also the first to produce alloys by electrochemical process. In 1848 he was appointed inspector general of the railways for the Orléans network. He died at Neuilly-sur-Seine on 30 September 1887.

Moritz Hermann von Jacobi, brother of the famous mathematician Karl Jacobi, the man who discovered elliptical functions, was born in Potsdam, Germany, in 1801 and died in St. Petersburg, Russia, in 1874. In 1818 he went to Russia where he took Russian nationality and completed his studies, which he had begun in Germany in his native town. In 1832 he was commissioned to set up Russia's first telegraph line; he was the first man to attempt to eliminate one wire in the two-wire telegraph lines by using ground return. In 1837, while he was professor of physics at Dorpat (currently Tartu, Estonia) he made the three fundamental discoveries of electrodeposition.

He was covered with honors by Czar Nicholas I and commissioned to organize a regiment of electricians. At the same time he was made a member of St. Petersburg's Academy of Science.

He investigated all aspects of electricity, including a solution to the problem of applying electromagnetism to machines and studied the means of using electricity to explode mines from a distance. He published a number of important scientific works, summaries of which were published in the minutes of St. Petersburg's Academy of Science for the years 1834 to 1857.

Chronology

second century AD - The secret recipes of the Egyptian priests for the *transmutation* (deposition) of metals are revealed by the Academy of Alexandria. In previous centuries, Egyptians, Chinese, Hebrews and later Romans had coated common objects and even large buildings (roofs, columns, etc.) with thin sheets of gold (*gold leafing*)

eighth-ninth centuries - The Moors import silver leafing into Spain and Sicily

tenth-eleventh centuries - Gold leafing is replaced by amalgam gilding, which is employed until around 1840, when *galvanic gold plating* begins to take hold

1799 - Invention of the electric battery by Count Alessandro Volta

1800 - Discovery of electrolysis by A. Carlisle and W. Nicholson. Volta and Nicholson try (in vain) to decompose certain metal salts to obtain some electrodeposition of their constituent metal on small objects

1802 - Luigi Valentino Brugnatelli succeeds in completing the first galvanic gold plating, although his deposit is powdery and opaque. He reports his finding in 1803 in the *Journal de Chimie et de Physique* and in 1805 in the *Philosophical Magazine*

1809 - A physicist from Geneva, Delue, presents before the *Royal Society* a battery consisting of a column of 300 zinc discs and the same number of paper discs gilded on one side and acidulated on the other

1810-1812 - Giovanni Zamboni builds the first manganese dioxide dry cell, anticipating Leclanché's battery

1825 - Auguste Arthur De La Rive resumes research on Brugnatelli's galvanic gold plating using gold chloride but does not obtain satisfactory results

1829 - *A.C. Becquerel* explains the phenomenon of polarization of batteries

1831 - Michael Faraday demonstrates that it is possible to obtain electric power from a conductor moving across a magnetic field

1832 - Inspired by Faraday, H. Pixii builds a small machine to obtain direct current using natural magnets and a switch

1836 - John Daniell invents the first unpolarizable, two-liquid battery. He and De La Rive observe that a thin layer of copper is deposited on the cathode of this battery and reproduces every scratch or bump in the cathode

1838 - October 21 - The German Moritz Hermann Jacobi presents a number of galvanic deposits obtained by him to the Academy of Science of St. Petersburg and establishes that the phenomenon of electrodeposition is of a general nature and not confined to copper. Czar Nicholas I purchases his patent and creates the *State Institute of Galvanoplastics*, employing more than 250 workers. Jacobi demonstrates that deposition is much more successful when the battery is separate from the electrolytic bath. A few months later, an Englishman from Liverpool, Spencer, reports having obtained similar results in the field of electrotyping

1839 - Jacobi discovers the soluble anode and introduces non-metallic molds which are rendered conductive by a layer of graphite. Berguillon, in France, and Murray in England improve Jacobi's methods for preparing molds

1839 - The Englishman, William R. Grove, invents a zinc-platinum battery with an acid depolarizer (nitric acid)

1840 - 29 September - The cutlers Henry and George Elkington, in England, obtain a patent for galvanic gold and silver plating in an alkaline bath

1840 - De La Rive experiments an improved system of galvanic gold plating, obtaining a bright and adherent first layer, although subsequent layers soon become powdery and uneven. Other scientists, such as Perret, Smée, Elsner and Beedger obtain similar results

1840 - 8 December - Count Henri De Ruolz, in France, obtains a patent for galvanic gold and silver plating in an alkaline bath, similar to that of the Elkington brothers. A dispute breaks out over who succeeded first, which the French Academy of Science resolves by sharing the *Montyou Prize* among the two litigants and a third scientist, De La Rive. Count De Ruolz will obtain his second patent on 18 June 1841

1840 - The German chemist, Robert Wilhelm von Bunsen, modifies Grove's battery replacing the platinum with graphite to make it suitable for practical use. A number of versions of this battery were introduced in the years 1842, 1847, 1865 and others again towards the end of the century

1841 - 1842 (13 May) - 1845 - The French chemist and industrialist Charles Christofle purchases first the patents of De Ruolz, then signs an agreement with the Elkington brothers and later purchases their patents, thereby obtaining a monopoly (until 1855) of galvanic gold and silver plating

1844 - Antonio Meucci sets up in Havana the first electroplating workshop of America

1845 - Charles Wheatstone replaces natural magnets with electromagnets in H. Pixii's machine

1850 - The gilding of the dome of the Saint Isaac Church in St. Petersburg, is completed, using the amalgam method. Two hundred workmen are poisoned and permanently injured by the toxic mercury vapors

1850 - F. Nollet builds an electromagnetic machine which is used to power an electric lighthouse. C. Christofle also builds an electromagnetic machine to produce direct current in place of batteries

1855 - The Dane Søren Hjørth patents an electromagnetic direct current generator

1857 - Charles Wheatstone introduces self-excitation in electromagnetic machines

1859 - The Frenchman Gaston Planté invents the so-called *secondary battery* (or *reversible battery*), later termed *electric accumulator*. It becomes suitable for practical use many years later (1881) with the introduction of grated lead plates

1860 - Antonio Pacinotti creates his famous ring, which becomes a fundamental element of direct current induction motors and dynamos. He reports his findings in *Nuovo Cimento* on 13 May 1865
1863 - The Italian telegraph network adopts D'Amico's battery, based on Daniell's two-liquids battery
1866 - Werner von Siemens, followed by many others, such as Wilde, Warley and Farmer, builds a self-excited dynamo
1868 - The French chemist Georges Leclanché produces a battery with solid depolarizer (manganese dioxide), the fore-runner of the modern dry cell battery
1869 - The first large scale electroplating industry (nickel plating) in the United States is set up by Dr. Isaac Adams of Boston
1869 - The Belgian Zénobe Théophile Gramme patents a dynamo based on Pacinotti's ring, which was demonstrated to him some years previously, and begins industrial production in 1871
1879 - Thomas Alva Edison builds a high voltage dynamo capable of powering thirty incandescent lamps. In 1882 he builds, in Manhattan, the first direct current electric power station using dynamo
1957 - The mercury battery, developed during World War II by Ruben-Mallory Co., becomes commercially available
1968 - The English company Energy Conversion introduces the zinc-air battery, which is used extensively in telecommunications
1987 - The aluminum-air battery, developed by Alcan International, succeeds in powering an electric golf buggy for eight hours

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WHAT IS ELECTRICITY?

The explanation we have provided regarding the mechanism by which the Havana experiments were carried out is based, needless to say, on our current knowledge about electricity. Fortunately, neither in his deposition nor in his sworn affidavit, nor in any other circumstance as far as we know, did Meucci offer theoretical explanations on his experimental findings. He always limited himself to describing with simple and clear language how the events had occurred, loyal to the most orthodox experimental method. If he had not done so, he would have fallen into sonorous - and today risible - absurdities, like many scientists of his time.

It is nonetheless worth summarizing what the theoretical knowledge of electricity and magnetism was at the time. A brief review on the subject has been presented in our insert *'Electricity and Magnetism,'* on pp. 282 seqq. Glancing through it, today someone might be (wrongly) surprised by the fact that, for instance, the great Michael Faraday, discoverer in 1831 of electromagnetic induction, explained it with a phantom 'electrotonic state' of iron, capable of 'converting magnetism into electricity.' Nor should we be surprised by the fact that, even many years after 1833, when Faraday proved the contrary, many scientists were convinced that electricity produced by an electric battery was of a different nature than that produced by a frictional electrostatic machine or by a Leyden jar. As a consequence of such convictions, the word 'electricity' was reserved to static phenomena, while for all dynamic phenomena where an electrical current caused by a battery was present, the word 'galvanism' was used (Meucci in fact said: *"… I was one of the first to work with all assiduity in the art of electricity as well as galvanism …"*[18]). This use continued, as we have stated above, for many years still after the demonstration of the identity of *electric fluid* and *galvanic fluid* proved by Faraday.

This author also found interesting two conferences entitled *"What is Electricity?"* held thirty-five and, respectively, forty years after Meucci's famous experiment in Havana, by two renowned University professors, John Trowbridge of *Harvard College*, Cambridge, Massachusetts, Vice-President of the prestigious *American Association for the Advancement of Science*, and Amos E. Dolbear, Physics Professor at *Tufts College* (in Massachusetts). Both conferences presented a state-of-the-art report on the period's knowledge of electricity and magnetism and were reviewed and summarized in the *Telegraphic Journal and Electrical Review*, on 11 October 1884 and 17

[18]Letter of A. Meucci to I. Corbellini, published by *L'Eco d'Italia* of New York on 21 October 1865.

August 1888 respectively (see bibl.). Let us note from both of them several significant passages:

[Trowbridge, 1884] *"What is electricity?" We shall probably never know what electricity is, any more than we shall know what energy is … Fifty years ago scientific men attached a force to every phenomenon of nature … Out of all the theories of electricity, the two-fluid theories, the one fluid, or Franklin theory, and the various molecular theories, not one remains today under the guidance of which we are ready to march onward … What is the relation between electricity and magnetism and what we call chemical force of attraction? … It is evident that our knowledge of electricity will increase with our knowledge of molecular action …"*

[Dolbear, 1888] *"What is electricity?" Today we are better able to answer this question … There have been theories in the past that electricity is a fluid, or two fluids supposed to be imponderable, but nowadays no one thinks that it is a fluid in any sense. In a battery it is proportional to the chemical reactions, that is to molecular changes … It begins in the matter and ends in the matter and must be a property of matter … The phenomenon called electrification is due to the molecules being thrown into abnormal positions and the propagation from molecule to molecule by contact of this same abnormal position constitutes what is called a current of electricity …"*

To no avail, for the better understanding of what electricity is, was the publication in 1873 of a treatise containing the famous Maxwell's equations, with which all known phenomena of electricity and magnetism could be perfectly explained and precisely calculated. Moreover, new phenomena were predicted, such as electromagnetic waves, whose existence was to be experimentally demonstrated thirteen years later by Heinrich Rudolph Hertz, in his famous experiment performed on 13 November 1886 (in between the two conferences mentioned above). What left the scientific community unsatisfied with Maxwell's theory (which Prof. Trowbridge and Prof. Dolbear did not even quote) was that it appeared to be a marvelous product of intuition, demonstrated as correct a posteriori, but delivered as if it were a principle to be accepted without an ounce of demonstration or logical reasoning, almost like Moses' tables (and not to mention the appearance of a new character in the play, *ether*).

The answer to the question *What is electricity?* came, finally, from the same *Cavendish Laboratory* which had been directed by James Clerk Maxwell, thanks to a very young successor of his, Joseph John Thomson. The latter, in fact, in 1897 (thus at the very end of the century), discovered a carrier of negative electric charge, having a tiny mass - much smaller than the mass of the smallest known atom, hydrogen. This unknown particle, which was found to be present in all atoms of whatever nature, was named the *electron* and is, today, the key to understanding every electrical and magnetic phenomenon. The answer to the above question therefore came, as Prof. Trowbridge and Prof. Dolbear had predicted, from a better understanding - and consequently a new vision - of the structure of matter. Now, therefore, the electrical current in a conductor is none other than the flow of myriads of those tiny particles called *electrons*, while inside a battery, much heavier charge carriers, called *ions*, exchange electrons during chemical reactions occurring in the space between the two electrodes, as well as at the positive and negative poles of the battery itself. Finally, the mystery of *electric fluid* and *galvanic fluid* was unveiled. But this happened at the end of the century of which we speak, just as it was at the end of the century that the first University course on electrical disciplines was instituted in the United States.

One must therefore not forget that Meucci's experiment was performed at mid-century, so that one could not expect him to give a theoretical explanation of the phenomena he had observed, an explanation which no one could have correctly given, neither in his time, nor nearly half a century later. Further credit should go to Antonio Meucci for the fact that in Havana he had no way of exchanging technical ideas with anyone, and could only obtain scientific information from the books he had bought, just as many self-taught scientists who later became famous had done. This was one of the reasons, perhaps the most important one, that led Meucci to look for a better outcome of his experiments by moving to the United States of America.

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EXCERPTS FROM THE BELL/GLOBE TRIAL

Excerpts from Antonio Meucci's First Deposition (7 Dec. 1885 - 13 Jan. 1886)

Note. During the deposition of Antonio Meucci at the Bell/Globe trial, all direct questions to him were addressed by Globe Telephone Company's attorney, Mr. David Humphreys. The cross-examination was carried out by Mr. James J. Storrow, attorney for the American Bell Telephone Company. Therefore, the latter's questions are indicated as "Cross Question No. …" All questions were asked in English and promptly translated into Italian by an interpreter appointed by the Court. Meucci answered in Italian, and his answers were promptly translated into English by the same interpreter and recorded together with the original answers in Italian. In the trial records, the Italian translations of the questions are not reported. The text below includes the original questions in English and our own translation in English of Meucci's original answers in Italian[19]. Any observations and phrases we have added are shown in square brackets.

[Question No. 10] *If employed by anyone on electrical matters, state for whom?*

[Answer No. 10] *Now I must first state how I began with electricity.*

[Question No. 11] *Go on.*

[Answer No. 11] *About the year 1842 to 1844 I obtained several treatises on electricity, regarding galvanoplastics and galvanism of the authors Becquerel, Jacobi, Mesmer and others, and the idea came to me to dedicate myself to that branch of industry. Around the year 1844 a certain Gaetano Negretti was with me. He suggested that he could have all the necessary instruments for such an industry sent from England by his brother. Upon said Negretti's offer I gave him an order to have all that was necessary sent to me, and after a few weeks I received everything I had ordered, including many Bunsen batteries and other tools, and insulated-copper conductors, and all that was needed to undertake said industry.*

[Question No. 12] *Please state and specify who this Negretti was?*

[Answer No. 12] *He was an import merchant in New York whom I recommended to the theater impresario in order to buy and ship all the objects that were needed for the theater, so the above-said Negretti had relations with me by*

[19] In some cases, the Author did not consider the original translation of Meucci's answers from Italian into English wholly satisfactory. He then decided to have them retranslated by AIT in order for them to match Meucci's original words as faithfully as possible. Consequently, the reader may notice some differences between our translation and the version contained in the official records of the Bell/Globe trial.

way of the orders that I sent him, as received by said impresario.

[Question No. 13] *In your former answer you spoke of galvano-plastic; state if any use or experiment was made of same by you?*

[Answer No. 13] *Certainly. When I began to put in operation the said discoveries of the above-mentioned authors, I had occasion to obtain through the Captain General O'Donnell the job of galvanizing* [*electroplating,* Editor's note] *various supplies for the troops of the regiment, - such as swords, helmets and other things in metal, - it being very useful that said articles could be galvanized by me in Havana, instead of those coming from foreign countries; in that I served the government for some years. In addition, I manufactured for other persons in Havana several different objects in galvano-plastics, - medals, statuettes, etc., as well as gilding and silvering of chandeliers, etc., for private houses.*

[Question No. 14] *When and what, if any, experiments did you make in electricity?*

[Answer No. 14] … *Having studied Mesmer's treatise on animal magnetism, I had the idea to apply it and perform some experiments applying electricity to sick persons by order of some doctor friends who wanted to see if what Mesmer said was correct. And in the times when I didn't have much to do I would also give shocks to people employed by me - Negroes - and sometimes to my spouse. In the same period, I had laid an electrical conductor from my workshop to a third room and produced electricity by a series of Bunsen batteries that I kept in my workshop. One day an acquaintance came to me who was sick with head rheumatism. Then, I put him in the third room, and I put in his hands the two conductors connecting to the battery; and at the end of said conductors there was a cork implement, isolated from the conductor, of the shape I illustrate here* [at this point Meucci draws Fig. 1, reproduced on p. 306]. *Above said cork was a metallic tongue soldered to the insulated-copper wire conductor which passed inside said cork and communicated with the battery. In my workshop (Fig. 2* [see p. 307]*), where I had an instrument identical to the one he was holding in his hand, I ordered him to put the metallic tongue in his mouth, so that - he being in communication with me by the electric fluid - I wished to ascertain where was his disease. I put the same instrument to my ear. At the moment that the person put the little tongue to his lips, he received an electric shock, and yelled. At the same moment I obtained a sound in my ear. I interrupted the operation and, to prevent the person receiving an electric shock, I had an idea to remedy such accident. I took the two instruments, the one that was in the hands of the person and my own, and I covered them with a funnel of pasteboard in order to isolate the* *little tongue from contact with the flesh (Fig. 3* [see p. 307]*). I ordered the sick individual to repeat the operation performed earlier, to not be afraid of being hurt by electricity again, and to speak freely into the funnel. He did so immediately. He put his funnel to his mouth and I put mine to my ear. At the moment that said individual spoke I received the sound of the word - not distinct - a murmur - an inarticulate sound. I caused it to be repeated several times in the same day. I then tried again on different days and obtained the same result. From that moment this was my imagination and I recognized that I had obtained the transmission of the human word by means of a conducting wire connected with several batteries to produce electricity, and I gave it immediately the name of 'Speaking telegraph.' This was around the end of 1849 to 1850, when I released my experiments on this subject, reserving them for my arrival in New York, since I had to leave Havana around 1850 to 1851. I had an immense quantity of batteries, around 60.*

[Cross Question No. 161] *When and where did you first make the invention which you claim in this case?*

[Answer No. 161] *In Havana, in the year 1849.*

[Cross Question No. 162] *You have spoken of a workshop in Havana; was that at the theater or in your house where you lived, or where in Havana?*

[Answer No. 162] *In the theater, because I lived in the theater, and in the same place I had my workshop.*

[Cross Question No. 163] *What apparatus did you use in the experiment which you have said you made at Havana with the person who came to you sick with rheumatism, as you stated in your fourteenth answer? Describe the whole apparatus.*

[Answer No. 163] *Bunsen batteries. The apparatus was composed of a quantity of Bunsen batteries, as I said in my specification; it was in the first room of the workshop; the electric conductors went all the way to the third room, where was the person I intended to cure from rheumatisms. The person afflicted with rheumatisms was in the third room holding an instrument in his hands like the one I have shown in Fig. 1 of my deposition; I was holding one like his to be put up to my ear while the one the individual held, same as mine, served to be introduced into his mouth*

[Cross Question No. 164] *Did the person have one of those instruments or two of them?*

[Answer No. 164] *He had one.*

[Cross Question No. 165] *What part of the instrument did he take in his hand?*

[Answer No. 165] *He had the cork ball.*

[Cross Question No. 166] *Did he have anything in the other hand?*

[Answer No. 166] *I don't believe so.*

[Cross Question No. 167] *How did the current of electricity, coming from the battery, go, and where did it go?*

[Answer No. 167] *From the battery, it communicated from the positive pole to the instrument I held in my hand, and from that instrument to the one in the person's hand, and then went back to the negative pole of the battery.*

[Cross Question No. 168] *How did it return to the negative pole of the battery; by the metal wire, or how?*

[Answer No. 168] *By the same conductor.*

[Cross Question No. 169] *Do you mean that it went from the positive pole to the person in the other room, and then came back to the negative pole by the same wire?*

[Answer No. 169] *Certainly.*

[Cross Question No. 170] *And did the current in coming back pass through the instrument which you held in your hand?*

[Answer No. 170] *Certainly; it could not have been any other way, otherwise I would not have received the word from him.*

[Cross Question No. 171] *So there was one wire went from you to him, and the current went over that wire and came back over the same wire; is that what you mean?*

[Answer No. 171] *By another wire, of course. I could not have received it with the same wire with which I had sent it.*

[Cross Question No. 172] *Then do you mean that the current from the battery went through the instrument in your hand and by one wire to the person in the other room and then came back to the battery by another wire?*

[Answer No. 172] *Certainly; there are two wires connected to the battery; one for receiving and the other for transmitting. Many times one can receive and transmit with the same wire as is done currently with telegraphs.*

[Cross Question No. 173] *What I wish to know is whether in the experiments at Havana you always used two wires, and why you used two wires.*

[Answer No. 173] *Not always; sometimes I used only one and sometimes two, one for transmitting and one for receiving.*

[Cross Question No. 174] *When you used only one, how did you arrange it, and where did the current of electricity go?*

[Answer No. 174] *I said this before; it started from the positive pole and returned to the negative pole of the battery.*

[Cross Question No. 175] *When you were doing that did you have one wire which went from the positive pole to the person in the further room, and then the wire came back to the negative pole of the battery?*

[Answer No. 175] *When it was for transmitting.*

[Cross Question No. 176] *In that case did the current of electricity go from the positive pole of the battery by means of a wire to the person in the other room, and then come back from the person in the other room by means of a wire to the negative pole of the battery?*

[Answer No. 176] *Certainly; it formed a circuit.*

[Cross Question No. 177] *And is that what you mean by one wire?*

[Answer No. 177] *By one wire.*

[Cross Question No. 178] *Please look at Fig. 1, in your fourteenth answer and explain how the current of electricity ran in that utensil?*

[Answer No. 178] *It came from the positive pole, passed through the interior of the cork forming a double helix to which the metallic tongue was soldered, and returned back and went to the negative pole of the battery.*

[Cross Question No. 179] *Do you mean it went back to the negative pole of the battery by wire?*

[Answer No. 179] *Certainly, by wire.*

[Cross Question No. 180] *Why did you twist the wire into a double helix inside the cork handle?*

[Answer No. 180] *It was not necessary; but instead of just bending it I twisted it.*

[Cross Question No. 181] *You have described an arrangement of wires making a circuit; was that the way in which you usually had the wires arranged to give electricity to sick persons at Havana?*

[Answer No. 181] *Oh, no.*

[Cross Question No. 182] *How did you generally apply electricity to sick persons in Havana?*

[Answer No. 182] *Many times as in the explanation above; other times double conductors and double instruments were needed; that served one to receive and the other to send.*

[Cross Question No. 183] *(Repeated) How did you generally apply electricity to sick persons in Havana?*

[Answer No. 183] *I applied it coming out from the battery with the instrument they had in their hands, many times* [it was] *a metallic tube to be applied to the sick part of the body, and many times it was a sponge, as is currently used with rotary machines that doctors use in present system.*

[Question No. 531] *You have described how you broke the current when you gave your electrical shocks in Havana. Will you please state now how you placed the person that you desired to give an electrical shock to, and how you arranged the wires?*

[*Showing witness several small articles*]

[Answer No. 531] *This is a circuit-breaker which I used several times in Havana to give electric shocks; all the other pieces are missing, but I can make a drawing (Fig. 16) to show how it was constructed. Many times in Havana I didn't use it, and instead I adopted a method of interrupting the electrical current, in order to regulate the shocks according to the person, by taking the two conductors, No. 1 (Fig. 15), and separating them from the pressure screw No. 2 and touching and separating them alternately, I interrupted the current and*

Fig. 15 (above) and Fig. 16 (below), drawn by Antonio Meucci during his deposition in the Bell/Globe trial

gave the shocks as with the switch (Fig. 16) which I am going to draw.

No. 1, horizontal bobbin with a bundle of metallic wire in the center.

No. 2, wooden block serving as a base for the bobbin under which pass the conductors communicating with the battery.

No. 3, horseshoe fastened to the block by a screw; in the center of the horseshoe a vertical pivot topped by a horizontal cross, like No. 5, which turns when the electricity passes through it, and, since the arms of said cross come alternately into contact with the extremities of the horseshoe, it interrupts the current; the helix that surrounds the legs of the horseshoe carries the interrupted current to the person holding the ends of the wires. The current is produced by a battery made of a series of elements.

No. 4, conductors that receive the current from the battery and transmit it to the circuit breaker.

No. 5, the cross on the rotating pivot at the center of the horseshoe and set into motion by the current.

[*Defendants' Counsel offers in evidence the four pieces referred to in Question* 531, *and they are marked* 'Defendants' Exhibits 119, A, B, C and D, J. A. S.']

[Question No. 537] *Will you please describe the same?*

[Answer No. 537] *Electro-medical apparatus (Fig. 17)* [see p. 313]

No. 1, tubes of insulated wood to be kept in the hands, with a sponge above the tube connected to the conductor; the sponge is to be applied to the sick part.[20]

No. 2, breaker to break the current in giving the shock.

No. 3, series of Bunsen batteries; when I didn't want to use the breaker and give the shocks commonly, materially, I would take the conductor which had been held in the pressure screw and I touched the extremities as I said yesterday, obtaining the same effect as with the breaker.

[Question No. 538] *Now take the other side of the paper and explain it.*

[Answer No. 538] *This is similar to the preceding one, only it was used by me in Havana with instruments No. 1 that I mentioned in the first explanation of my invention (see Fig. 18)* [shown on p. 318].

No. 1, apparatus to transmit the human word.

No. 2, the same to receive.

No. 3, the same to transmit.

No. 4, the same to receive.

No. 5, large reel of conducting wire to have more resistance and more distance.

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[20]Captions of Fig. 17, translated from Italian are slightly different, i.e.: *"1. Insulated wooden tubes to be held in the hands, with a sponge on top communicating with the conductor, to be applied to the sick part of the body; 2. Apparatus to break the current in giving the electric shock; 3. Series of Bunsen batteries"*

Electrodes used by Meucci for electrotheapy

No. 6, series of Bunsen batteries, as in the preceding.

This apparatus I used in the first experiments of my invention in Havana and I repeated them with the same apparatus at Staten Island in 1851. The person speaking with me kept in his hands two instruments Nos. 2 and 3, one to transmit and the other to receive as for the same purpose I kept in my hand Nos. 1 and 4.

[Question No. 539] *You have been cross-examined extensively in regard to the experiments you made with Fig. 1. Please state whether you had more than one in the hands of each person experimenting with Fig. 1.*

[Answer No. 539] *Sometimes one, sometimes two, as I said be fore. When one instrument was used, instead of asking the person through the instrument, I told him with my voice to put the instrument to his mouth and speak, while I put mine to my ear; and this was the case in which the person received a shock to his tongue, and so I remedied it for the next experiment with the pasteboard funnel in order to avoid the contact of the tongue with the small tongue of the instrument. And it was then that I received the sound of the other persons voice, and then I gave my invention the name of "speaking telegraph." This was in 1849 in Havana; at my arrival in Staten Island, N. Y., I repeated the experiments with the same success.*

[Question No. 540] *When you used only one wire, how many cells of the battery did you use?*

[Answer No. 540] *In the first experiment I used many; I had 60 and I think I put them all together*[21]*; but then sometimes I took the conductor away from the negative pole of the last cell and put it in communication with only four or six cells, since by experimenting I found that I didn't need a current so strong as the one produced by many cells; and the current not being too strong, gave better results in the transmission of the sound.*

[Question No. 553] *Please look at your 537th answer and say if it is correct.*

[Answer No. 553] *What I meant to say is that when I didn't want to use the breaker and give the shocks in the usual way I took the two conducting wires away from the pressure screw and alternately joined and separated them, obtaining the same effect as with the breaker, and a spark at every contact.*

[Question No. 574] *Please to look at Fig. 16 referred to in your answer 531. If I understand the figure and your description of it, the current went from the battery to the person in the other room to whom you were giving electricity, interrupted only from time to time by the circuit breaker as that rotated; am I correct about that?*

[Answer No. 574] *The current passed from the battery through the breaker, and from this, by traveling*

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[21]The elements of the battery were arranged in series, as Meucci clearly indicated in fig. 18 of his deposition (see p. 318).

through the conductors, it went to the person who was to receive electrical shocks.

Comments on Antonio Meucci's First Deposition

Electrodes used by Meucci

First of all, let us look more closely at how those *two conductors* used by Meucci were made, as in his sentence: *"I put in his hands the* ***two*** *conductors connecting to the battery …"*

The figure shown below seems to us clearer to non-experts than the schematic Fig. 1 of Meucci's deposition. The object described is an instrument with an insulated handle and a copper tongue, to which a double wire of insulated copper was soldered, which passed through the handle and was connected to the circuit. The handle could be made of cork or wood and was meant to insulate the patient's or therapist's hands from the electrical current; the copper tongue was applied on the sick area. In the place of the two straight copper wires as in our drawing, Meucci indicates, in his Figs. 1 and 3, *twisted* wires. Mr. Storrow, the opposing party's attorney, asked him why: "*Why did you twist the wire into a double helix inside the cork handle?"* And Meucci replied [Answer No. 180]: *"It was not necessary; but instead of bending it back, I twisted it."* Therefore, as we will see on another occasion, Meucci simply did not want to cut the conductor, because *it was not necessary*.

Apparatus to break the current

First of all, we note that a description of the device concerned was given in order to answer a question posed by Mr. Humphreys (Question No. 531), in which Meucci was asked to explain what were 'those four small pieces' which the defense displayed as 'Exhibits No. 119 A, B, C, D.' In his answer, Meucci stated that 'all the other pieces' were missing. Indeed, according to Fig. 16 which illustrates this device (shown on p. 422), it seems that there were 'nine pieces:' inductance *1* (wound around a bundle of wires); wood base *2* with clamps for conductors *4* connecting the battery on one side and the patient on the other (as confirmed by Fig. 17, shown on p. 313); electromagnet *3* with a screw to fix it to the wood base; rotating iron cross *5*; the vertical pivot around which the latter rotates; the yoke containing the eyelet to house the tip of the pivot; the two rods supporting the yoke; and, perhaps, also a return spring for the rotating cross (although the latter is not visible in the picture).

According to Meucci's deposition (see, in particular, his answers Nos. 531, 537, 574 as well as his Figs. 15, 16 and 17), he felt the need to send the electric shocks to the patient through a special device which he called *apparatus to break the current* (that is how it is labeled in the previously-mentioned Fig. 17). Apparently, he wasn't happy

Layout of an electric bell

with delivering the shock simply by bringing one end of the wire close to (and then, away from) the clamp of the battery manually, or (as is illustrated in Fig. 15 of his deposition, shown on p. 422) by cutting in two the wire coming from the battery and then joining and separating the two crop ends alternately, making them slide inside a special sleeve, through the eyelets of the respective clamps (or *pressure screws*, as he called them). Indeed, it is clear that, with either of the foregoing methods, it was difficult for him to control the duration of the electric shock to be delivered to the patient, a duration which could accidentally result longer than needed.

Meucci's precise aim was (Answer No. 537) to *"break the current in giving the shock,"* namely, as we would say today, to *interrupt the circuit immediately after having established it*. Indeed, this way he could send to the patient an impulse of current that was always short and of the same duration, that is to say independent of the time required for manually connecting the two wire ends together (or one end of the wire to the battery). Then, he could repeat the operation as many times as necessary, giving the patient any desired number of calibrated shocks.

From an analysis of the previously-mentioned Fig. 16 of his deposition - in which all the electric components of the device are shown, but not their interconnection - it seems reasonable to suppose that in order to achieve his aim, Meucci had thought of resorting to a device similar in principle to an electric bell. In fact, the electric bell, whose basic electric diagram is shown here, was already applied, around 1831 (shortly after its invention by the German physicist Neef) by Charles Wheatstone and William Cooke for call signaling in telegraphy. Therefore, it was well known in 1844-1846, when Antonio Meucci began his electrotherapy experiments.

As is shown in the picture above, the electric bell consists of a switch, in series with an electromagnet, which is kept in its *on* position by means of a spring but that is turned *off* automatically whenever the electromagnet is excited. To achieve automatic switching off, the armature of the electromagnet is rigidly connected to an end of the mobile arm (*spring*) of the switch, as shown in the picture, so that, when the armature is attracted, the circuit is interrupted. Thus, in the electric bell, *the circuit is interrupted immediately after having been established*, as was Meucci's aim, thereby causing the battery to give off a flash or impulse of current, which, in the case of an electric bell, is accompanied by a stroke of the hammer on the drum. Naturally, the longer the *primary switch* (the one set immediately after the battery) which operates the bell is kept in its *on* position, the more alternations of connections and subsequent interruptions (and the more strokes of the hammer on the bell, or the more impulses of current sent to the patient) there will be. The frequency of the electric impulses is determined by the frequency of the oscillating system comprised of the spring and the armature with its hammer (not only joined together but also fixed at one end to the base of the device).

Thus, it is likely that Meucci thought of solving his problem by simply inserting the patient, in series, in a circuit similar to that of an electric bell, according to the diagram shown below. However, in addition to the electromagnet, this layout also features a second inductor, with iron core, inserted in series with the battery, which corresponds to the *'horizontal bobbin with a bundle of metallic wire in the center,'* indicated as No. 1 in Fig. 16 and in Answer No. 531 of Meucci's deposition. It is very likely that this second inductor served to delay the action of the electromagnet in order to extend the duration of each current pulse[22].

«horizontal cross… which turns when the electricity passes through it»

Hypothetical layout of Meucci's current breaker

The scheme that we have hypothesized is supported by a passage from Meucci's deposition (Answer No. 531), in which he says: "*The helix that surrounds the legs of the horseshoe carries the interrupted current to the person holding the ends of the wire.*" Furthermore, as regards the *relay switch* (*on* at rest), Meucci thought of making it with an iron cross (No. 5 in his Fig. 16) which rotates horizontally around a vertical pivot. Meucci says about it (Answer No. 531): "*In the center of the horseshoe a vertical pivot topped by a horizontal cross, like No. 5, which turns when the electricity passes through it; and, since the arms of said cross come alternately into contact with the extremities of the horseshoe, it interrupts the current.*"; and, further on: "*No. 5, the cross on the rotating pivot at the center of the horseshoe and set into motion by the current* [i. e. controlled by the electromagnet]."

Following Meucci's indications, we have drawn the figure below which shows how electricity could travel through the cross when it was in the *on* position a) (left of the figure) and how - once the magnet becomes excited in this condition - it is made to rotate (either clockwise or counter-clockwise) so as to reach its position b) (right of the figure), that is to say with its two opposite branches facing the polar ends of the electromagnet. The figure clearly shows that, in the latter position, the circuit will be interrupted and the electromagnet will then be disconnected. If the cross (or the pivot to which it was rigidly attached) had been provided with a return spring whereby to hold the cross, at rest, in its *on* position a), it would have occurred that, when the cross reached its position b) and the magnet was no longer excited, it would automatically return to position a) and the cycle would have

[22]Indeed, the rise time of the resultant current pulse is proportional to L/R where L and R are the total inductance and resistance of the circuit, respectively.

be repeated for as long as the primary switch of the device was kept on. During this time interval, the cross would oscillate between positions a) and b), very much like the *spiral balance wheel* of a clock[23].

Lastly, it is worth observing that the solution envisaging the horizontal oscillation of the cross, as compared to the more conventional vibration of a rod with a hammer, as in the electric bell, is much more elegant and original and, furthermore, that the duration of the impulse was probably the same (ten-fifteen milliseconds) as that used in modern electro-stimulators, such a duration being typical of an electromechanical device like the one created by Antonio Meucci.

Excerpts from Antonio Meucci's Affidavit (9 October 1885)

[passages regarding his Havana's experiments]

"(…) While I was in Havana, I had very considerable leisure, and spent a considerable time in the study of electrical matters. I provided myself with the best books then extant treating of matters connected with electricity. Among my authors were Daniell, Thenard, Jacobi.

My first experiment in electricity was in consequence of reading that disease could be told and cured by electricity.

I had familiarized myself with galvano plastic electricity, and Captain General O'Donnell, then governor of the Island of Cuba, was anxious to save expense in galvanizing buttons, sword-hilts and such other things used in the army. I told the general that I could do it at less price than he was then paying, if I could procure the proper batteries for that purpose. These could not be procured at that time in Havana, but in the year 1844, Gaetano Negretti brought to Havana some galvanic batteries and other electrical supplies that I needed for galvano plastic purposes. I purchased the batteries and other articles needed of Mr. Negretti. I then made a verbal contract with the Governor General to galvanize the articles required by the soldiers. I found that I was able to galvanize satisfactorily with the articles I purchased of Mr. Negretti. I opened a factory for this purpose, and employed several men — as near as I can remember, about 12 or 15. I did not have sufficient batteries for my work, and Mr. Negretti, in a year or two after, sent me further supplies from New York, which I purchased of him. For about four years I continued supplying the army as by previous agreement.

During the time that I ran this factory, I had constructed an electrical machine for the purpose of

[23] We wish to remind that the use of the spiral balance wheel in clocks was introduced by Christiaan Huygens in 1675, and was thus known in the period under consideration (1844-1846). However, had Meucci's solution been applied to clocks, it would have introduced the use of electricity as a *motor* in clocks more than one hundred years earlier (see the appendix "The clock" on pp. 188 seqq.).

using it on persons who were sick, or for the mere amusement of giving shocks. This factory was connected with my residence. I frequently gave electricity to colored people, employees of the theatre and others. I did this sometimes when they were sick. I put up wires through the rooms in which we resided, which were four in number, and I gave currents of electricity to my wife. I once gave it at an unfortunate period, which affected her quite seriously [further on Meucci says she was affected by *chronic rheumatism,* Editor's note].

The instrument I used to convey the currents of electricity to persons is represented in Figure 1 [shown on p. 310]*. The upper part is a copper plate, which I placed in the person's mouth or other parts of the body when I used to shock them. The wire was covered by a piece of cork, which the party receiving the shock held in his or her hands. A man in my employment at one time, somewhere about 1849, complained of being sick, and I thought to try electricity on him. He was placed in one room, and the end of the wire being in circuit two rooms beyond his, I went there wishing to know how strong a current I was using, and I had a duplicate of his instrument with me. I called to him to put the copper part of his instrument in his mouth. I did this because I had read that disease could be told by electricity. The man, while he had the copper in his mouth, cried out from the effects of the shock. I thought I heard this sound more distinctly than natural. I then put this copper of my instrument to my ear, and heard the sound of his voice through the wire. This was my first impression, and the origin of my idea of the transmission of the human voice by electricity. I then covered the implement I had, and the one the employee had at that time, with a paper cone, as represented in the instrument and drawing. I directed him to speak through his. I being at the end of the third room, I placed mine, covered like his, to my ear. I then heard, while holding this to my ear, quite distinctly, the sound of his voice,— so much so that I believed it came over the wire. I made him repeat what had said several times, which convinced me that I heard his voice over the wire electrically (…)*

My business prevented me from making further experiments, as I was the superintendent of the mechanism of the theatre; was closing up the contract that I have mentioned; also, at this time, I was contemplating coming to New York as soon as I could make my arrangements; and knowing that I would have better opportunities there to experiment, than in Havana, was another reason why I deferred any further experiment (…)

I know the date of 1849, when I first conceived the idea of a speaking telegraph, is correct. (…)

[referring to the two figures reported on page 310:]

No. 1 is my first instrument made in Havana in 1849.

***A** is a tongue of copper soldered to the metallic conductor which conducts the electrical current to the said metallic tongue.*

***B** is a cork ball for means of isolating the current from the hands.*

***C** is a double copper wire conductor that brings the electricity to the said metallic tongue, and sends back to the battery of the negative pole.*

No. 2. The same instrument as No. 1, but with the improvement of a pasteboard tube to prevent the electricity touching the lips, having seen, with the first instrument, that the person which was holding it received a strong electric shock, so I calculated in this way to keep it isolated by using the said pasteboard tube which I call C. (…)"

Excerpts from other Depositions and Affidavits

*Domenico Mariani's Deposition (31 Dec. 1885- **16 Jan.** 1886)*

Note. In the following, as we have done with Antonio Meucci's deposition, whereas the questions addressed to Domenico Mariani are reported in their original English version, Mariani's answers (given in Italian), were newly translated by us into English, to faithfully match Mariani's original answers.

[Answer No. 4] *When I gained greater familiarity with Mr. Meucci, I heard from many Spaniards that he was a great inventor. He had invented water filters, and in addition he had a contract with the government to galvanize belts and gilt buttons for the military, by means of electricity. I told him he had a great head, having invented so many nice things; and then he showed me the buttons, the belts and the electrical apparatus, then he told me that on the following Sunday he would demonstrate the curing of a Negro. He gave in his hands two things, that I don't know whether they were of wood or of metal. When the Negroes took those things in their hands they began to jump and make grimaces, and I laughed.*

[Question No. 5] *Please describe the rooms and the wires with which Meucci used electricity.*

[Answer No. 5] *The rooms were three or four: the theater tailoress's workshop, then came the parlor, the kitchen and the bedroom. In the* [theater's] *workshop he had these wires with the two handles attached. Sometimes he gave the shocks on the doorsteps of the house, sometimes behind the stage. Once I saw that Meucci had put these wires from the workshop to the last room, but as he didn't tell me what they were for. I didn't ask him because it wasn't my business. With that, I am done with Havana, where I remained for five years, working in Havana in winter and coming north in summer. In all these winters I always amused myself watching these experiments repeated with old and young, black and white people, and always different. This is all that I saw in Havana.*

Incidentally, the sometimes playful aspect of those electric shock treatments was confirmed by Meucci himself in his affidavit: *"… I had constructed an electrical machine for the purpose of using it on persons who were sick, or for the mere amusement of giving shocks …"*

Luigi Tartarini's Affidavit (2 **April** 1880)

I, Luigi Tartarini of the City of New York, State of New York, do hereby make oath, to the best of my knowledge and belief

That previously to the year 1852 I lived for about twenty years in the City of Havana, Island of Cuba, where I have been almost always engaged by Mr. Fes Marto Torres, proprietor of Tacón Theatre and manager of the Italian Opera, as a painter during the day in works for the theatre, and as a chorister in the performance.

That in the said theatre Mr. Antonio Meucci, now of Clifton, Staten Island, was employed as director of the mechanism; and I recollect that during the year 1849 I have seen him sometimes occupied in making experiments for the transmission of human voice by electric wires, and several times I was requested by him to help him in his work, by extending or holding electric wires in the long corridor or in the yard of said theatre …

*Esther Meucci's Affidavit (2 **April** 1880)*

I, Esterre Meucci, of the town of Clifton, Richmond County, Staten Island, State of New York, wife of Antonio Meucci, do hereby make oath, to the best of my knowledge and belief that during the year 1849, we were living in the City of Havana, Island of Cuba, where my husband was engaged as Director of the Mechanism and I as Superintendent of the costume department in the Tacon Opera House, and sometimes my said husband devoted his attention in the business of manufacturing various articles in Galbano Plastic [*galvanoplastics*, Editor's note], *and making experiments endeavoring to speak to another person at some short distance through the use of a wire attached to his electric batteries connected with or used by his said business.*

The person with whom he made experiments, as well as myself heard words through the wire, but not satisfactorily plain to my husband, who said it was because he had not the proper material, and that for a time he would cease his experiments, because sometimes they were witnessed by other people.

I further depose and say that we moved from Havana, and came to live in Clifton, Staten Island and that in 1852, at the request of Signor Padner [*Pader*, Editor's Note], *a gentleman who had seen my husband experiment while we were in Havana, and upon his promise to pay for the necessary material, my husband resumed his study of speaking at a distance through an electric wire, resulting for his greater facilities in a marked im-*

provement in his power to talk through electric wire….

We learn from Esther Meucci's affidavit that a certain Carlos Pader, a Spaniard, also declared to having witnessed Antonio Meucci's experiments on his speaking telegraph. As we will see in Vol. 2, Mr. Pader, meeting Meucci in New York, directed him to Charles Chester's shop, where he could buy high-quality electric materials in order to improve his experiments.

Gaetano Negretti's Affidavit ***(5 July** 1880**)***

I, Gaetano Negretti, of the city of Como, Kingdom of Italy, temporarily residing in the City of Lucca, district of Tuscany, do hereby solemnly declare, that in the year 1844 I went to Havana, Cuba, and I brought there some galvanic batteries which I had purchased from my late brother Henry Negretti, of the firm of Negretti & Zambra, Scientific Instrument Makers, of London, to Mr. Antonio Meucci, who was then working in making experiments in electricity, and that when I went to New York in the year 1846, I sent to him in Havana, some other implements for the same purpose, which implements I had bought from Mr. Benj'n Pike, Jr., Optician, Broadway, New York, and from other manufacturers.

I do further solemnly declare, that on and after Meucci's arrival in New York, in the year 1851, he being unable to speak the English language at that time, and often afterwards, I have bought for him some other implements for the same object, as he was continuing his electrical experiments.

L. Meriance's Affidavit ***(date unknown)***

We could not trace the affidavit of a certain L. Meriance, who declared having met Meucci in Havana in 1847, and that the latter was conducting experiments to transmit the human voice across an electric wire. Said affidavit was quoted, in the Globe Telephone Company's circular letter (see bibl.), whose relative passage is reported below.

"… L. Meriance states in his affidavit that he first became acquainted with Mr. Meucci in Havana, in 1847. Mr. Meucci was then making experiments with the instruments to transmit the human voice by electric wire …"

It must be pointed out that Mr. Meriance stated that he first met Antonio Meucci in Havana in 1847 and that the latter was *then* making experiments with his speaking telegraph, without specifying the exact year of these experiments. He might have possibly watched, in 1847, Meucci's electrotherapy experiments.

Charles R. Cross's Affidavit ***(**22 **April** 1886**)***

[Excerpts from parts regarding the Havana experiment]

… I have carefully examined a certified copy of the caveat of Antonio Meucci …

I have caused to be constructed instruments in accordance with this caveat, containing every element or *feature described in the caveat, connecting them by a wire fifty to hundred feet long, passed through several intervening rooms by going through the transom holes of the door being supported by screw eyes or staples and fastened to the ceiling or door frames, the wire not being pulled very tight. With these instruments so constructed and arranged I have transmitted words after the manner of a lover's telegraph or string telephone, and without the employment of electricity whatever. Insulating the wire and the operators—either or both— and connecting the wire with a battery would not change the effect at all. I used a copper bell wire, and found a large wire better than a small one.*

I have also read the deposition of Antonio Meucci, lately given in New York before Mr. Shields, Commissioner and have particularly examined his drawings and the description he gives with them. I have constructed a pair of instruments like his Figure 3, and find that they make quite good string telephones. I placed the instruments about eighty feet apart, one operator in one room and another operator in another, with two rooms intervening, two of the intervening walls being heavy, brick walls. I connected them by a copper wire such as bellhangers use, and found it possible to transmit words and easy sentences from one person to the other. In some cases we got long and difficult sentences. One sentence I remember which we got through was this: 'I see the pictures of Stokes and Faraday on the wall.' In the course of these experiments I also tried the effect of having the listener hold the wire in his teeth, and found it possible to understand words by holding the wire in the teeth quite as well, and in some instances better than when the instrument was held at the ear. Indeed, in some cases I found that one person could listen at the instrument and understand the words, while another person by taking with his teeth the wire several feet away from the receiving instrument, could also hear and understand what was said.

I have read in that deposition the letter written by Meucci, and published in the Commercio of Genoa, Dec. 1, 1865, referred to in Mr. Meucci's answer to Int. 516. From that description it is not difficult to construct an apparatus by means of which, either listening at the receiver or holding the wire near the receiving end in the teeth, words spoken into the instrument at the other end can be understood by mechanical transmission, upon the principle of the string telephone or lover's telegraph; but it is not possible by following that description to construct an electric speaking telephone, for the letter contains no reference to, much less any description of the parts which are absolutely necessary to make up any form of an electric speaking telephone …

Comments on Prof. Cross's Affidavit

As we have seen, the affidavit sworn by Prof. Charles R. Cross of the Massachusetts Institute of Technology (MIT) in favor of the American Bell Telephone Company aimed to demonstrate that, in Meucci's experiments it was true that the word was transmitted, but the transmission occurred according to the already-known principle of the mechanical *string telephone* or *lover's telegraph.* We want to demonstrate here that Prof. Cross - a good friend of Alexander Graham Bell, as is evident from the excerpts below - was either grossly negligent or in bad faith.

First of all, we note that, in the first drawing of Meucci's affidavit (shown on p. 309), in the second room there appears an object labeled "***spiral** to demonstrate distance."* The same is also indicated graphically (without labeling) in Fig. 2 of Meucci's deposition (shown on p. 307), and was further described by him in his Answer No. 576 when commenting on his Fig. 18 (shown on p. 318):

[Answer No. 576] *From the positive pole it* [the current] *goes to instrument No. 1, surrounds* ***reel*** [24] *No. 5, goes to instrument No. 2 where the person receives the voice; afterwards it passes to instrument No. 3, where the person speaks, transmitting the word to instrument No. 4, where I receive it, and then it goes back to the negative pole, completing the circuit.*

Moreover, in the same Fig. 18, Meucci's handwritten words (translated from Italian), read: "***bundle** of the same conductor to have a long distance*," the same object that he calls a *reel*, in the above answer, as well as in the following one:

[Answer No. 538] *"… No. 5,* ***large reel*** *of conducting wire to have more resistance and more distance."* We therefore find this *reel* or *bundle* or *spiral* indicated in at least five different places of Meucci's deposition, as a recurring element in his Havana experiments. On the other hand, in addition to the important requirement of having more resistance through the use of a reel of wire (to limit the maximum current from the battery) it seems obvious that Antonio Meucci found it more convenient to simulate distance by a reel, instead of going out in the streets to make his experiments[25].

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[24]The Italian word for *'reel'* or *'reel of wire'* used by Meucci in his original answer was *'rocchetto,'* which, however, was translated by the official interpreter as *'bobbin.'* The same interpreter used the word *'bobbin'* also to mean *'coil'* or *'inductance.'* According to the *Merriam-Webster* dictionary, the meaning of the word *'bobbin'* is that of *'small round devices,'* hence it is more appropriate to indicate *coil* or *inductance*, than *reel of wire,* which latter we have correctly used here, thus avoiding to mislead the reader.

[25]The author did exactly the same thing, when he experimented with fiber optic systems in a laboratory, using a 5-10 km *reel* of optical fiber.

This notwithstanding, in Prof. Cross's affidavit, although he stated that he had faithfully reproduced in his Physics laboratory at MIT Meucci's experiments in Havana, succeeding in transmitting the voice *mechanically*, there is no mention of the reel of wire, repeatedly mentioned in Meucci's deposition. As for the rest, Prof. Cross went on to explain minutely, in his affidavit, how he had placed the two communicating persons at a distance of 80 feet apart, (more or less equivalent to the length of the three rooms plus the width of Meucci's workshop in Havana), that there were brick walls between the rooms, and closed doors with transoms across which the wires were pulled (but not too tightly, Cross emphasized), and so on. Cross added that he had used copper wire of the type currently used by bellhangers, but that a large wire was better (alluding to the corresponding phrase inserted into Meucci's caveat, of which we will speak in Vol. 3). It therefore appears evident that Cross's scrupulousness was applied to all distinctive elements characterizing Meucci's experiment, except those that would have unequivocally demonstrated that there was an *electrical* transmission of sound.

In fact, had Prof. Cross inserted a (large) reel of copper wire into the circuit - as in all of Meucci's experiments in Havana - he would *not* have been able to transmit sound mechanically, since the words would not have been able to pass *mechanically*, neither across the reel of wire nor, in the opposite direction, across the sixty Bunsen cells. Had he, instead, considered the presence of the reel, his thesis - which was nonetheless accepted by judge William J. Wallace in his sentence adverse to Meucci - would have fallen apart. In fact, it was well known, long before the time of the Bell/Globe trial, that a fundamental requirement for mechanical transmission of sound (and especially of speech), is that the transmitting medium either be rigid (such as wooden or metal rods, juxtaposed head to head) or that it be made with a string, even a thin one, of any material, as long as it is *tightly* stretched between the two membranes, the transmitting one and the receiving one, so that the vibration of the first can be transmitted to the string and from there to the second (receiving) membrane.

Besides, the thesis upheld by Prof. Cross was rather puerile, in addition to being offensive to Antonio Meucci, considering that even children had known how to make a good string telephone for at least a couple of centuries. Cross's thesis worked well only because of judge Wallace's connivance (or ignorance), and also because of the negligence on the part of Globe's lawyers, not having summoned an expert to witness for their party. There were, indeed, many professors in New York who would have been able (and happy) to counter Cross's affidavit, among them Professors Amos E. Dolbear and C. A. Young, who so admirably described (two years before the Bell/Globe trial) the *static telephone*, upon the principle of which Meucci's experiments in Havana were based.

As for Prof. Cross's comments and experiment based on Antonio Meucci's letter published by the *Commercio di Genova* on 1 December 1865, we have already remarked (see p. 319) that this letter was gratuitously interpreted by Prof. Cross to mean that also the person at the receiving end may hold the conductor between his teeth. We reproduce, at the end of this paragraph the whole passage of said letter, so that the reader could verify that Meucci correctly quoted his first experiment in Havana, saying that with "… *an instrument held to the ear … one could transmit the exact word by holding the conductor in the mouth and pressing it between the teeth …"*

Finally, it is hard to believe that Prof. Cross was not aware, at the time he swore his above affidavit (April 1886), of the theory and experiments on the *static telephone* (see also our appendix on p. 437), that would much better explain Meucci's second experiment in Havana. Analogously, Prof. Cross could easily imagine a *variable resistance* mechanism to explain the transmission of the word in Meucci's first experiment in Havana. Had he done so, however, he would have admitted that in both experiments the word was transmitted *electrically*, not *mechanically*. His unfair behavior can only be explained with his friendship with Alexander Graham Bell (we give in the following some quotations on this subject) and his consequent loyalty to the party, American Bell Telephone Company, in favor of which he testified.

*Letter from Antonio Meucci to Ignazio Corbellini **(13 October** 1865**)***
[published by *L'Eco d'Italia* of New York under "*Nuove Scoperte Italiane"* on 21 October 1865 and by *"Il Commercio di Genova"* as editorial news, on 1 December 1865][26]

Clifton, Staten Island,
13 October 1865.

To Mr. Ignazio Corbellini,
Arenzano (Genoa)

In the Eco d'Italia published last 19 August, I read of a new discovery that regards one of my efforts; I

[26]This letter, as published by *Il Commercio di Genova*, was exhibited by the lawyers of *American Bell Telephone Co.* at the Bell/Globe trial as *Complainant's Exhibit F*, together with their own translation into English, as *Complainant's Exhibit G*, and also, as published by *L'Eco d'Italia*, as *Complainant's Exhibit F* (including their translation into English). However, the author decided to have the translation newly made by AIT, to match as faithfully as possible Meucci's original letter. As a consequence of that, the reader may find some differences between our translation and those exhibited at the Bell/Globe trial.

enclose it here so that you may examine it.

I was one of the first to work with all assiduity in the art of electricity as well as galvanism since the time of their first discovery; at the time I lived in Havana. Having abandoned this branch of research because of the huge expenses, I devoted myself when I came to the United States to other branches, but I did not abandon it. On the contrary, every now and then I made some tests on this beautiful discovery, and by means of some little experiments I came to discover that [with] *an instrument held to the ear and with the aid of electricity and a metallic wire, one could transmit the exact word by holding the conductor in the mouth and pressing it between the teeth, and at any distance two persons could put themselves in direct communication, without the necessity of communicating their secrets to others. But because of my too many occupations I abandoned it with the idea of communicating it to some intelligent compatriot so that the first experiments could be made in our beautiful Italy.*

In the year 1860, starting my friend Mr. Bendelari for Italy and offering me his services, I communicated to him my discovery, which I have always believed very useful, reserving myself to give him further clarifications when he should come to see me again, which he was not able to do because of his many occupations and, not seeing him anymore, all remained in oblivion.

As I have told you supra, I found the article, enclosed here, in the Eco d'Italia and I wanted and still want to justify that I had made this discovery, and since it is identical with that of Mr. Manzetti I thought that Mr. Bendelari had disclosed to someone what I had verbally communicated to him. I then wrote to Mr. Bendelari on the subject and he responded, copy of which letters I remit to you.

I do not pretend to deny Mr. Manzetti his invention, but I only want to let it be remarked that two thoughts can be found to contain the same discovery, and that by uniting the two ideas one could more easily arrive at the certainty about a thing so important.

If ever you should find yourself together with said Mr. Manzetti or with any friend of his, I pray you to communicate to him what I have told you, and I send you my thanks in advance for doing so (…)

Antonio Meucci

Cross and Bell

[from: Robert V. Bruce, see bibl.]

[p. 93] … *in October 1872 Bell began attending free public lectures on zoology, geology, and experimental mechanics… at the Massachusetts Institute of Technology. The lectures on experimental mechanics were given by Charles A. Cross, assistant to MIT's Professor Edward Pickering, an acoustical physicist. Cross had just helped improve a device Pickering had contrived two years earlier for "the electrical transmission of sound"…*[27]

[p. 110] *In March* [1874] *he* [Bell] *went to see Charles Cross demonstrate Helmholtz experiments in a lecture at MIT and afterwards talked with Cross about tuning forks and sympathetic vibrations. After Bell's own lecture at MIT in April on speech training for deaf-mutes, it was Cross who came up to offer him the use of the Institute's apparatus and laboratories …*

[p. 112] … *Bell's ingenious ideas won him an invitation to describe them at Cross's own Society of Arts lecture on the phonautograph and manometric flame… But Cross welcomed Bell as a full partner in "our acoustic experiments." In late April* [1874], *writing about an idea for making a liquid-column gauge more sensitive to sound waves, Cross added, "If you are at leisure and care to try a few more experiments I should be glad to see you."* …

[p. 125] [September 1874, Editor's note] *Professor Cross invited him to talk over the summer's work "and perhaps plan for a little more."*…

[p. 131] [mid November 1874, Editor's note] … *Bell even "ventured cautiously" to try his telephone theory on Farmer… "He advised me to publish the idea in the Philosophical Magazine after I had protected my* [*multiple*, Editor's note] *telegraphic scheme." Professor Cross agreed with Farmer but like Bell, Farmer and Cross thought the currents generated by the voice would be too feeble for practical use…. Two days later* [end November 1874, Editor's note] *he made what seemed "a most extraordinary discovery."… Elated, Bell invited Professor Cross and others to a demonstration. But Cross had to disabuse his young friend… as Joseph Henry had anticipated him. … More than that, Cross told Bell of Philipp Reis's use of the effect in his "telephone" of 1861.* …

George F. Durant's Deposition ***(19 April** 1886)*

[passages regarding the Havana experiment]

[27]Both Prof. Edward E. Pickering and Prof. Charles R. Cross opposed Alexander Graham Bell in the question of precedence of inventing the telephone, and in particular in the trial of United States vs. American Bell Telephone Co. et al., in the State of Massachusetts.

Note. Mr. George F. Durant testified in favor of the American Bell Telephone Company. He was examined by Mr. James J. Storrow attorney for the American Bell, and cross-examined by Mr. David Humphreys, attorney for the Globe Telephone Company.

[Question No. 1] *State your age, residence and occupation.*

[Answer No. 1] *Age 44. Vice-president and general manager of the Bell Telephone of Missouri; I reside at St. Louis.*

[Question No. 3] *Were you ever connected with the American District Telegraph Company of New York?*

[Answer No. 3] *Yes sir.*

[Question No. 4] *When and in what capacity?*

[Answer No. 4] *From about 1871 to October, 1874, as superintendent of the New York Division.*

[Question No. 12] *Do you remember while you were at the 62 Broadway and New Street office* [of the American District Telegraph Company], *some Italians coming to the office about some alleged electrical invention; if so, state generally what your recollection is about it?*

[Answer No. 12] *I remember one day two foreigners coming into the office and one of them having a conversation with Mr Grant perhaps for half an hour or so. After they had conversed with Mr Grant for some time, Mr Grant introduced them to me; and I think Mr Grant handed me some papers; and one of them, who spoke English quite well, told me the story which the papers contained, or were said to contain. I don't remember it in detail now. Mr Grant told them that I would give the matter attention, and the gentlemen left. I took the papers and put them in the drawer of my desk. It was in manuscript; I think it was perhaps ten or a dozen pages of legal cap; my best recollection is that it was written on both sides.*

[Question No. 13] *Did you afterwards read it?*

[Answer No. 13] *Yes sir I think I read it that same evening.*

[Question No. 14] *Did these Italians, or either of them, ever come again and talk with you?*

[Answer No. 14] *Yes sir, they called repeatedly, at intervals, perhaps of two weeks or a month. And I had told Mr Grant that I didn't see anything in the papers at all; that I thought the man was a crank, although when they came I treated them very politely and told them I had been pressed for time and had not given the matter any attention. After they called several times Mr. Grant suggested that I had better hand the papers to him, which I did, and was very glad to get rid of them.*

[Question No. 15] *Do you know where the papers are now?*

[Answer No. 15] *I do not.*

[Question No. 16] *Did these two men ever explain to you anything about any experiment they had made, or what did they tell you on that subject?*

[Answer No. 16] *At the time the papers were handed to me this gentleman who spoke English described to me the contents of the papers which related to some experiment they had had, and the gentleman who was with him listened very attentively to the explanation; and it seems to me that it was in relating this story that they referred to some apparatus which was stuck in the mouth. I remember distinctly when the gentleman described about the device being placed in the mouth, and the other man having it in the mouth that some sensations were produced; and this gentleman who was with him seemed to confirm what he said by gestures, by pointing to his mouth particularly. Apparently he understood everything that was said, although he didn't say a word himself*

[Question No. 17] *Did they tell you where they had made any of these experiments; did they mention the place?*

[Answer No. 17] *I think it was in Cuba. My recollection is that this man was a dentist, and an experiment was made with his assistant. It is so long ago that I have forgotten that part of it. That is my best recollection about it.*

[Cross Question No. 62] *Why didn't you ask them to bring their instruments to the office?*

[Answer No. 62] *I don't think there were any instruments involved in those papers at all; it was a piece of metal stuck in the mouth. My best recollection is this: that the papers described a story of an experiment made by one of these gentlemen in Cuba, where one party lived. They were in separate rooms and a wire or two wires between them, and on that wire they had a galvanic battery of several cells; and by sticking one end of the circuit or loop of wire, represented by a piece of metal, in the mouth, they transmitted some signals, or sensations, rather, which were received by another person in another room, who had also a piece of metal in his mouth.*

(…)

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THE STATIC TELEPHONE

We report a few quotations of the time, that may help the reader to better understand this unusual type of telephone.

Prof. Dolbear's lecture

We reproduce below the paper *The Static Telephone*, referring to a lecture by Prof. Amos E. Dolbear (Physics professor at Tufts College, Medford, MA) held before the *American Association for the Advancement of Science* (AAAS) on 31 August 1883. His lecture was followed by a discussion with the participation of Prof. H. A. Rowland, AAAS President, Prof. C. A. Young, inventor Elisha Gray, F. E. Nipher, AAAS Secretary, and others. We have pointed out in bold characters the passages that evoke Antonio Meucci's experiments in Havana.

«*The Static Telephone*
By Prof. A. E. Dolbear, of College Hill, Mass.

In the static telephone, a ring of hard rubber is used, within which are ***two*** *parallel* ***metal plates*** *separated by a body of air (a non-conductor) one plate connected with the line carrying the current. The electrifying of one plate then causes attraction or repulsion of the free plate, and thus a sound in the receiver.* ***This does away with magnetism****. This system therefore requires a very large electromotive force, and uses an induction coil of 2,000 ohms. A ground or return circuit is not present here. The equivalent is the body itself. There is no passage of electricity from plate to plate: the action is purely inductive through space. The insulation is accomplished by the intervening air space, and by a coating of varnish—an excellent di-electric. There is a device to discharge the induction plate in connection with this instrument, which keeps it constantly up to its full possibilities. When this instrument is fully charged, and the electrical conditions are perfect, the receiver may be entirely disconnected from the transmitter, and the sounds and conversation can still be heard, even across a room.*

He also called attention to the fact, that instruments that have been in use work much better than new ones, as each plate acts as a condenser.

In the discussion which followed, Dr. Dolbear was asked if the state of the atmosphere in any way, affects the operation of the instrument. ***I have used these instruments****, said he,* ***on an actual line between Boston and New York****, on a night when it rained over the whole length of the line, and the whole line was as badly insulated as it well could be. I have also used it on the same line under the most favourable conditions for insulation, and could not really perceive much difference. It seemed to be as loud at one time as at another.*

President H. A. Rowland: *Of course this is on an entirely different principle from our telephone. What interested me considerably was the* *fact, that* ***one could hear better when the plates were charged****. The explanation theoretically is very simple; and* ***it is the same as*** *that the* ***Thomson electrometer*** *is more sensitive when the jar is charged than when it is not charged; the reason being, that the attraction is proportionate to the square of the difference of the potentials, rather than the simple difference of the potentials. Therefore a small difference in the quantity, when it is large, produces a greater effect than when it is small. So the explanation is exactly the same as that the Thomson electrometer is more sensitive when you have the jar charged than when you do not. So, the higher the charge one would get, the more sensitive the instrument would be. I was especially interested in it, because it was on such* ***an entirely different principle from the Bell instrument****. I don't wish to say anything about patent laws or decisions on this subject, for they have nothing to do with this; but, scientifically, this is an entirely different instrument from the Bell instrument, and I am especially interested on that account.*

Prof. T. C. Mendenhall: *I profess not to have quite understood the statement made by Prof. Dolbear. I should like to hear your own (the president's) opinion with regard to that charge which remains in spite of the fact that the two poles of the condenser are connected by conductors. I may have misunderstood the statement; but if that is correct, I should like to know whether that can be explained or not.*

President Rowland: *Well, I suppose we all know how retentive an electroscope is of a charge. I suppose the idea is very similar in this case. I do not suppose the plates have a difference of potential. If you should leave them for a moment, I should suppose they would soon have a little return charge. If the two plates of the condenser were together, they would have the same potential. I understood it as merely a return charge. I do not know how Professor Dolbear understands it.*

Prof. Dolbear: *The instrument itself is a most delicate electrometer when tested in this way; and when it is charged and really in good working order, the gentlest tap upon the instrument serves to show that it is in good working order, for one can apply the instrument to his ear and hear himself talk. This is the case, even when the two plates of the condenser are connected with each other through the induction coil and so, although they may have been there for hours, or even for days—the difference between an instrument that has not been used and one that has been charged is very appreciable.*

President Rowland: *I suppose in that case it would be simply from the charge of the varnished surface?*

Prof. Dolbear: *Yes; I think they retain their charge for a much longer time if the surface is varnished. I do think there is a differ-*

ence between the behaviour of this and the charged cable. If a cable be charged for half an hour by battery, it will require half an hour to run out again, but it will be at that time quite discharged. But that is not the case with this instrument.

President Rowland: *I should suppose it was the charge in the varnished surface.*

Prof. W. A. Anthony: *Professor Dolbear did not say anything about one advantage that this telephone has over the other, that struck me when I read the descriptions of it earlier—that, in consequence of using this electricity at such a high potential, the ordinary telegraph lines or other instruments would have very little effect upon it: therefore the telephone is very free from induction.*

Prof. Dolbear: *My experience has been in accordance with that theory. Electromotive force from induction from telegraph-lines is ordinarily tolerably small, although there may be at times considerable strength of current. But, the electromotive force being so strong in my circuit, it follows that the action of such induced currents is very slight, and does not interfere with work.*

Prof. C. A. Young: *I would like to inquire whether you have tried any experiments in putting the end of the wire to the ear to illustrate the sensitiveness of the ear?*

Prof. Dolbear: *Yes;* ***I have heard simply by putting the end of an insulated wire to my ear****,* ***and listening. I consider the instrument as simply the enlarged terminal of a wire****, and that you are actually listening at the end of a wire.*

Mr. E. Gray: *I have made a good many experiments in another line, which I may state briefly, which may throw some light upon this, and yet I think it is very well understood. You remember, some of you, reading of such experiments made in 1874, relating to the reproducing of music on a plate by simply rapping with the finger or with some animal tissue. Now, I made this experiment, which seems to prove to my mind that the operation is as Prof. Dolbear has explained it. I set my revolving disc, which was a simple disc of zinc, revolving at a steady rate, giving it a pressure with the fingers. Then* ***I had fifty cells of battery set up****, as much as I could bear, passing through them, and had some one close the circuit with a Morse key. At the same time the key was closed, my finger would be jerked forward in the direction of the rotation of the disc: and it would remain in that forward condition, showing an increase of friction, until the key would be opened, and then it would drop back; showing that from some cause there was an increase of friction, either due to molecular disturbance, or, what is probably the case, to attraction between the finger and the plate. It is necessary, to produce this experiment, that the cuticle be perfectly dry. You must rub it a long time, and have it perfectly polished; and then the cuticle becomes a* *dielectric, and the body is charged with one kind of electricity, and the wire or the plate with another. Later I got some fairly good results in articulation by using a small diaphragm with all the conditions as nearly right as possible; and, having a current of sufficient electromotive force, l could actually understand words produced on the end of my finger.*

President Rowland: *What is the difference between that and Edison's motorphone?*

Mr. Gray: *In Edison's motorphone, when the current was thrown on, there was a decrease of friction; there was chemical action taking place on the surface. In this case there is none, and there is an increase of friction when the current is on: perhaps "current" is a bad word to use.*

President Rowland: *The principle is the same.*

Mr. Gray: *One is a chemical action, which causes the friction to be less at the moment of charge. In this case, however, this is purely static contact, and increases the friction in the same manner that the plates are thrown together when they are charged in this telephone. And the motion, of course, or sound, is produced by a letting-go of the finger from the plate, and not by actual vibration, in the same sense that it takes place between the two plates in this receiver of Prof. Dolbear.*

President Rowland: *You attribute it to attraction?*

Mr. Gray: *Yes; my experiments seem to prove that; I presume, because there was adhesion, there was an increase of friction during the time of the charge and the letting-go, when the circuit was open. There was really no circuit except when the charge was taken off.*

Sec. F. E. Nipher: *In regard to the case of which Prof. Dolbear spoke, when it might be supposed that electricity does actually pass from the line into the ground, it seems to me that that fact, so far as it did exist, would be prejudicial to the action of the instruments; that* ***what we want to bring about is not a current but as great a difference of potential as possible between the plates****.»*

We have already commented on Prof. Dolbear's statements in the main text. All the same, we wish to emphasize how this type of telephone did not require magnets and was experimented successfully on the New York - Boston line in the worst atmospheric conditions, with excellent results. Elisha Gray, besides fully confirming Prof. Dolbear's affirmations, added that he had himself experimented with a static telephone over another stretch and that he had there used fifty cells, just like Meucci who, in Havana, had used up to sixty.

Especially interesting is also Prof. Rowland's observation about the analogy between the static telephone and the Thomson electrometer, whose static polarization greatly influences its sensitivity. Finally, quite striking is Prof. Dolbear's answer to Prof. Young's question, affirming that the receiver held to the ear could be reduced to a simple enlarged conductor terminal, which reminds us Meucci's copper tongue.

As referred by F. V. Hunt (see bibl.), the principle of the static telephone was not only used in the various types of *condenser microphones*, but also in the *static loudspeaker*, which made its first appearance in the decade between 1925 and 1935 (when many patent applications on static loudspeakers were filed) and which was taken up again, with better materials and performance, in the 1950s.

'Telephone — The First Hundred Years,' by John Brooks

«… Maintaining that the Bell patents covered only the magneto transmitter and receiver, Dolbear, in October 1880, applied for a patent on his own carbon transmitter and condenser receiver … in April 1881, the patent was granted, whereupon Dolbear proceeded to incorporate the Dolbear Electric Telephone Company …»

'Telephone' (Encyclopaedia Britannica), by Bernard Finn

«… another method of transmitting sound electrically was developed in 1878 when A. E. Dolbear, a professor of physics, devised a transmitter in which the diaphragm was one plate of a small battery. When it vibrated, so did the voltage of the battery and the current in the circuit. In a separate arrangement Dolbear designed a receiver with metal plates in the form of a capacitor. The fluctuating current caused one plate to vibrate, producing sound. Dolbear's devices were not competitive as telephone instruments, though the capacitor principle proved valuable in some microphone designs in the 20th century …»

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INNOCENZO MANZETTI

Innocenzo Manzetti

Innocenzo Vincenzo Bartolomeo Luigi Carlo Manzetti was born in the town of Aosta on 17 March 1826. After primary school, he went to the Saint Bénin boarding school run by the Jesuits, and then to Turin, where he obtained a diploma as a land surveyor, thereafter returning to Aosta. For a time he worked in the Civil Engineering Corps. He became interested in acoustics, mechanics, hydraulics, electricity and astronomy. It is said that he only slept an average of two hours per day, working and experimenting all the rest of the time.

His first work, which brought him much fame, was a flute-playing automaton, built in 1849. It was in the stylized shape of a man, life-size, seated on a chair with a flute in hand. Hidden inside the chair were levers, connecting beams and compressed-air tubes, which made the automaton's fingers move on the flute keys, as well as its lips, according to a program mechanically recorded on a cylinder, similar to those used in player pianos. The automaton was wound like a clock, and could perform twelve different arias. At the beginning of its performance, the automaton would rise from the chair, bow its head and roll its eyes.

In his workshop, Innocenzo Manzetti constructed geodetic instruments that he needed for his work as a land surveyor and also musical and scientific instruments for third parties. He also built a bicycle and a piano. He amused himself by inlaying precious miniatures in ivory or bone, often using a special pantograph conceived by him for the reproduction of bas-reliefs on marble, ivory or wood, scaled at pleasure. Subsequently, Manzetti succeeded in making his *joueur de flûte*[29] play any piece executed by a musician on an organ, by making the latter's keys mute and connecting them to the automaton's finger controls. He also built, as a toy for his daughter, a wooden *flying parrot* (*perroquet en bois volant*) also mechanically wound, which began by beating its wings, then slowly rose into the air and hovered for two or three minutes, then went to settle on a shelf.

In 1855 Manzetti invented an ingenious hydraulic machine to empty water from the wells of the Ollomont mines, which were otherwise unserviceable. His construction is minutely described by his clergyman friend Edouard Bérard in *La feuille d'Aoste* in 1862. In 1864, just after marrying Miss Rosa Sofia Anzola, he built a steam-powered car, 27 years ahead of the one realized in Paris by Serpollet, and an earth telescope with three converging lenses that allowed to observe a lizard's movements at a distance of 7 km. He also built a

[29] *Flute player*. It must be recalled that in the whole Aosta valley - though being a region of Italy - the language currently spoken is mainly French, whereas all official deeds and labels are bilingual, Italian and French.

The "Flute player" automaton

pendulum watch which could be wound to work for one year.

Tancredi Tibaldi, a personal friend of Innocenzo Manzetti, recounted, in 1896, that the telephone idea came to Manzetti out of the desire to make his automaton talk just as he made him play. That is, analogously to the execution of a piece played by another person, he wanted the automaton to pronounce words spoken from a distance by another person. Innocenzo's brother, Anania, recounted that the inspiration came from the memory of their childhood games with the *chapeau à gibus* (a sprung top hat that could be flattened for carrying under one's arm) that they used as a loudspeaker to scare their peers by speaking from another room into another hat, connected to the first with the usual system of the taut string.

Manzetti called his first telephone model, made in 1864, *télégraphe parlant* (speaking telegraph). It was never patented nor presented at conferences or described in the newspapers by Manzetti himself, because he was timid and retiring and, moreover, did not care about money. All the same it was spoken of, though in generic terms and with a nearly identical text, in the following papers, probably informed by Manzetti's friends or after reading the first news in the Aosta's paper *L'Indépendant* of 29 June 1865: *Il Diritto* of Turin[30] on 10 July 1865; *La Feuille d'Aoste* on 25 July 1865; *L'Italia* of Florence on 10 August 1865; *L'Eco d'Italia* of New York on 19 August 1865; *Il Commercio di Genova* of Genoa on 1 December 1865; the *Petit Journal* of Paris on 22 November 1865; *La Verità* of Novara on 4 January 1866; and again *Il Commercio di Genova* on 6 January 1866.

Here is the English translation of the text published by the *Petit Journal* of Paris, written by the lawyer Émile Quétand of the Paris' Imperial Court:

CURIOSITIES OF SCIENCE

Discovery of the transmission of sound and speech by telegraph

«A new discovery immensely fruitful in its possible applications both in the fine arts as well as the industries is going to augment the marvels of this century; and this is the transmission of the sounds and of the spoken words by telegraph.

The author of this discovery is Mr. Manzetti of Aosta, inventor of a famous automaton … … Manzetti transmits directly the word by means of the ordinary telegraphic wire, with an apparatus simpler than the one which is now used for dispatches.

Now, two merchants will be able to discuss their business instantly from London to Calcutta, announce each other speculations, propose them, conclude them. Many

[30]There were two different magazines titled *Il Diritto*; one from Turin and the other from Florence-Rome.

experiments have been made already. They were successful enough to establish the practical possibility of this discovery. Music can already be perfectly transmitted; as for the words, the sonorous ones are heard distinctly …»

At this point in the text, *L'Eco d'Italia* of 19 August 1865, which had lifted it, adds: *" those* [the words] *with a closed pronunciation are heard confusedly; that comes from the material Manzetti has been able to use for his apparatus, which he is now perfecting …"*

In its second announcement, published on 22 August 1865, *La Feuille d'Aoste* reported the following news: "… *It is rumored that English technicians to whom Mr. Manzetti illustrated his method for transmitting spoken words on the telegraph wire intend to apply said invention in England on several private telegraph lines."*

It is also known that Antonio Meucci, having read said news in *L'Eco d'Italia*, published in New York, sent a letter to *Il Commercio di Genova*, as well as to *L'Eco d'Italia*, claiming his priority and quoting his experiments, made in 1849 in Havana.

Il Diritto on 21 December 1865, confuted Meucci's argument, writing in defense of Manzetti, and especially exalting the properties of a (vaguely described) mechanical mouth used by Manzetti, *"certainly more practical than Meucci's system which, requiring one to hold the conductor between one's teeth, impeded the speaker's proper elocution." Il Diritto* also made a point of underlining how Meucci's suspicion that his friend Enrico Bendelari, going to Italy in 1860, might have unveiled the news of Meucci's discovery - which might then have been picked up by Manzetti - was denied in a letter sent by Bendelari to Meucci on 15 September 1865. Besides, Meucci's expressions toward Manzetti were very cordial, admitting that *"two thoughts can be found to contain the same discovery,"* as we have reported in the foregoing.

The only technical description of Manzetti's invention came from the pen of Dr. Pierre Dupont, a friend of the inventor's, who was a medical doctor and a Major in the Sardinian army. His description, however, was only found after his death, among his papers, without date on it, although Caniggia and Poggianti (see bibl.) maintain that it was written in 1861. J. Brocherel (see bibl.) maintained that the same description appeared in *"an Aosta newspaper of the period,"* not better specified. We include Dupont's description here, translated from French:

"The speaking telegraph consisted of a funnel-shaped cornet in which was placed, transversally, an iron lamina, in the shape of a very thin plate. This plate easily vibrated under the impulsion of the sound waves coming from the bottom of the funnel. In the cornet, there was also a magnetized steel needle,

running inside a bobbin, vertically placed with respect to the vibrating lamina and very close to the same.

From the bobbin or spindle started a silk-coated copper wire, the other end of which was connected to a bobbin placed in an apparatus identical to that described above. From this second apparatus started another electric wire, which was connected to join the former. Now, if in the vicinity of the lamina of one of the cornets a sound was emitted, this sound was immediately reproduced by the lamina in the other cornet.

The communication between the laminae of the two cornets took place thanks to the principle that the vibrations of an iron plate in front of a pole of a piece of magnetized iron produce electric currents, the duration [i.e. *frequency*, Editor's note] *of which is the same as that of the motion of the vibrating lamina.*

In a word, the acoustic waves produced by speech, voice, sound into a cornet were transformed in the apparatus into electric waves, and then transformed back into acoustic waves in the other cornet."

Drawing of Manzetti's telephone, according to Caniggia and Poggianti

The drawing reproduced here—supposed to be consistent with the above notes by Dr. Dupont—is taken from a recent book, authored by Caniggia and Poggianti (see bibl.).

Both the drawing and the description above seem to refer to a "make-and-break" telephone transmitter and to a magnetostriction receiver, quite similar to those developed by the German Johann Philipp Reis in 1861 (probably, without Manzetti being aware of). In fact, in both cases we have a needle, as a magnetic core, against which an iron plate vibrates. And, due to the known limitations of the make-and-break systems, the instrument showed defects in the transmission of articulated words, that Manzetti was not yet able to eliminate, as was written in *L'Eco d'Italia*. Another confirmation of this hypothesis, comes from the clergyman Bérard who declared that words containing the letters *c*, *f*, *g*, *j*, *l*, *u*, *v*, *x*, and *z* could not be transmitted and that, consequently, it was impossible to hold a complete conversation.

Another posthumous description of Manzetti's telephone came from a short notice in *Il Progresso Italo-Americano* of New York on 12 January 1937, by a certain *Italia T. Gronbony*. She affirmed that a model of Manzetti's telephone was on display in the cabinet of Physical Sciences of the "Accademia C. D. Andreis," and that *"it is composed of a permanent steel magnet shaped in a narrow V, about 15 centimeters long, enclosed in a wooden sheath."* From this notice, we can only learn that one of the models contained, as a core, *a permanent steel magnet shaped in a narrow V about 15 centimeters long*, instead of a *magnetized steel needle* (perhaps also 15 centimeters long), not a big difference.

Count *Théodose Du Moncel* (see bibl.), who studied Manzetti's discovery fairly thoroughly, concluded, along our own hypothesis, Innocenzo Manzetti's house and the commemorative plaque, placed there in 1886

that Manzetti's telephone was similar to Reis's. Finally, the Royal Commission instituted in Italy in 1910 with the task, among others, of verifying priority on the invention of the telephone, thus expressed itself regarding Manzetti (see bibl.): *"Innocenzo Manzetti of Aosta had invented something similar* [to a telephone] *except that no trace of the principle on which it was based has remained."*

After 1865, the press no longer wrote of Manzetti's *télégraph parlant*, nor of a practical application for it, which leaves us to suppose that it was abandoned. Only on 30 January 1878, the *Fanfulla* of Rome reminded its readers - a year after the death of the Aostan inventor - that not all credit was owed to the most acclaimed Alexander Graham Bell.

Manzetti died poor and unrecognized in Aosta on 17 March 1877 on the exact day of his fifty-first birthday, one year after the death of his second and last daughter, Marina Fortunata, who strikingly resembled him and whose loss had caused him enormous pain. The first daughter, Maria Sofia, had died in 1867, at the age of two. The obituary that appeared in the *Echo du Val d'Aoste* on 19 March 1877, thus described Manzetti's character: "… *His excellent qualities of heart and character, his kindness, his incomparable affability made him be loved by all …"* Tibaldi (see bibl.) describes him as "… *of medium height. He had a blond beard and hair the latter worn long and flowing on his nape, like a Nazarene, a pale complexion, light blue eyes, a nose rather large at the base, slightly angular lineaments …"*

On the façade of the little house on Via Xavier de Maistre in Aosta, which Manzetti inhabited in the last three years of his life, the Association of Mechanical Industry and Related Arts of Turin placed a plaque in 1886, with the following inscription:

TO
INNOCENZO MANZETTI
Executor in 1864
of the first telephone apparatus

Nearly three years after Manzetti's death, precisely on 7 February 1880, two Americans from New York, Prof. Max Meyer, an American citizen residing in Paris and Sir Horace H. Eldred, a New York Telegraph inspector, accompanied by the already cited clergyman of the Aosta Cathedral, Édouard Bérard, went to visit Manzetti's widow, Mrs. Rose Anzola, and Manzetti's brother, Louis, with the aim of purchasing the rights, as well as the documents and models of Manzetti's *télégraph parlant*. On the same day a deed was signed, at the offices of the notary public César Grognon, by which the two Americans committed to pay ten thousand Italian lire of the time (slightly over 40 million lire, or 30,000 dollars, in 1990) to the widow, *"as soon as it* *was established that Innocenzo Manzetti was the first inventor of the telephone."* An analogous document was signed with the brother, Louis Manzetti, for the sum of five thousand lire. After signing the deed, the two Americans obtained drawings and models from the widow and the brother, for the sum of thirty French francs of the time (around 1 million lire, or $830, of 1990).

The clergyman Bérard was accused by Prof. M. P. Fornari of the University of Milan of having made a deal with the two Americans, supposed to be emissaries of the American Bell Telephone Company, in disfavor of Manzetti's widow. His accuses appeared in two articles on *L'Educatore Italiano* of Milan on 13 and 20 December 1883, which were later translated into French and published in three parts (18 and 25 January and l February 1884) by the Aosta Valley's paper *Le Patriote*. Bérard defended himself with long arguments - published in three more issues of *Le Patriote* (15 and 18 January and 14 March 1884) - essentially taking Graham Bell's side and diminishing the importance of Manzetti's *télégraph parlant*. Moreover, he had Manzetti's widow release a statement in which she affirmed, among other things (translation from French): "*… The matter of the telephone of my husband, I. Manzetti, consisted of a sort of sleeve, slightly tapered, with two ends made of pasteboard and a parchment kept at one extremity by means of a little ring, fairly solid. This parchment was perforated and contained inside some thing of which I have no clear recollection …"* Thus, Manzetti's widow did not mention any iron plate, nor the *magnetized needle with bobbin*, though the shape of the instrument seems to comply fairly well with that of the drawing shown above.

In another letter written by Baron B. C. Bich of Aosta to the clergyman Bérard, dated 28 December 1883, it was specified that the few remains of Manzetti's telephone, consisting of "*a little pasteboard cornet with a little iron plate"* had not been entrusted to the Americans but to the Rev. Father Denza, Physics professor at the Moncalieri boarding school, who intended to pay honor to Innocenzo Manzetti. The clergyman Bérard had the above letter published and further declared that the two Americans were by no means emissaries of the Bell Company and that, on the contrary, they intended to use the evidence gathered in Europe to have the Bell patents annulled. Nevertheless, subsequent searches for the two Americans, made by order of Manzetti's brother, Louis, both in New York and in Paris (where Prof. Meyer had said he resided), yielded no results; the two seemed to have vanished, thus leaving a shadow of doubt on the assertions of clergyman Bérard.

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MAPS SHOWING LOCATIONS QUOTED IN THE TEXT

Locations in intramural Havana, quoted in the text

A *Pescadería;* **B** *Plaza de la Catedral;* **C** *Plaza de Armas;* **D** *Puertas de Monserrate;* **E** *Gran Teatro de Tacón;* **F** *Estación de Villanueva;* **G** *Plaza y Mercado del Santo Cristo;* **H** *Plaza Vieja;* **I** *Teatro Principal;* **L** *Alameda de Paula;* **M** *Iglesia de San Francisco de Paula;* **N** *Iglesia de San Francisco de Asís y Fuente de los Leones.*

Locations in extramural Havana, quoted in the text

A *Fuente del Neptuno (current location);* **B** *Malecón;* **C** *Torreón de San Lázaro* **D** *Calle San Lázaro;* **E** *Castillo del Príncipe;* **F** *La Zanja;* **G** *Paseo de Tacón;* **H** *Estación provisoria de Ferrocarriles;* **I** *Calzada de San Luis Gonzaga;* **L** *Paseo Extramural;* **M** *Gran Teatro de Tacón;* **N** *Estación de Villanueva;* **O** *Plaza del Vapor;* **P** *Campo de Marte;* **Q** *Calzada del Monte;* **R** *Castillo de Atarés;* **S** *Luyanó stream*