Shaping 'good neighbor' practices in science: Mobility of physics instruments between the United States and Mexico, 1932-1951

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Introduction

In this chapter I address the mobility of physics instruments between the United States and Mexico. In particular, I explore how it contributed to create links between scientific communities in both countries that are better understood in the context of good neighbor practices. I focus on three different historical moments, which were intertwined with changes in the understanding of scientific cooperation. First, I analyze scientific expeditions leaded by Arthur Compton in the 1930s for measuring cosmic rays and their role in the establishment of international collaborations and research programs in physics in Mexican institutions. Second, I review the intervention of foundations such as the Rockefeller and the Guggenheim in the encouragement and diversification of experimental research activities until the mid-1940s at the first physics institute in Mexico. Finally, I discuss the acquisition and arrival in Mexico in 1951 of a particle accelerator manufactured by a US company. In all these cases, scientific instruments were central actors moving between the US and Mexico and playing a relevant role in the making of the physics community in Mexico, its professionalization and institutionalization, as well as the consolidation of physics research in the first half of the twentieth century.

Cosmic ray instruments and the establishment of physics research in Mexico

The international research front on cosmic rays stopped by Mexico in 1932 when US physicist Arthur Compton coordinated a survey for measuring the intensity of cosmic radiation at different geographical latitudes. Compton's expedition in Mexican land was the beginning of collaborative connections between US physicists and a community of Mexican engineers who became deeply interested in cosmic ray research. Their rising interest in that field of research was such that it became a discursive and material ally for the creation of the first physics research institute in Mexico in 1938. Cosmic rays not only provided them with a specific research topic in physics, but it also allowed them to access scientific instruments for their research, as well as professional and scientific training for Mexican students. Particularly, the construction of a counter for detecting cosmic rays at azimuthal angles through a cooperation agreement signed in 1937 by the University of Chicago, the Massachusetts Institute of Technology (MIT) and the *Universidad Nacional Autónoma de México* (UNAM) allowed the Mexican scientific community to initiate research in the area of cosmic rays.[1]

In the early 1930s, the composition and origin of cosmic rays were subject to discussion among nuclear physicists. Early on, cosmic ray measurements had been mainly performed at different altitudes in the Northern Hemisphere (US and Europe). Hence, it was considered relevant to develop expeditions in the Southern Hemisphere.[2] In 1932, Compton organized eight groups of experimentalists to carry out the Cosmic Ray Survey, funded by the Carnegie Institution of Washington (CIW).[3] Each expedition would travel to different sites around the world: Switzerland and Norway (Spitzbergen) in Northern Europe; Canada, United States (Alaska, Hawaii, California, Colorado, Michigan, Illinois, and Boston), Mexico, Panama, and Peru in the American continent; and Australia, India, Ceylon, Malaya, Java, New Zealand, Ladakh and South Africa, then European colonies in the Southern Hemisphere.[4] Compton was in charge of taking measurements in Hawaii, New Zealand, Australia, Panama, Peru, Mexico, northern Canada, Michigan and Illinois. Using a cosmic ray meter designed, tested and standardized by Compton's group,[5] each experimentalist-traveller collected measurements of cosmic ray intensity. It was a coordinated and centralized survey whose main purpose was to detect an association between the intensity of cosmic rays and terrestrial latitude. This was called the latitude effect and it had consequences for understanding the origin and composition of cosmic rays.

In May 1932, Compton announced preliminary results that confirmed the existence of the latitude effect in a letter to the editor of the *Physical Review*. He wrote: 'This letter is the first report of an extensive program involving similar measurements by many physicists in widely distributed parts of the world'.[6] In the following months Compton would complete the planned measurements in Peru, Panama, and Mexico.

In a way that reminds us of the patterns of eighteenth-century scientific expeditions,[7] Compton contacted a native from Mexico to arrange his trip there. In fact, Manuel Sandoval Vallarta was not simply a local contact, but an active mediator with exceptional qualities.[8] Sandoval Vallarta came from an elite Mexican family. He had grown up and studied in Mexico before his family sent to him to Boston, where he started his preparation as electrical engineer at MIT. By the time of the cosmic ray survey, Sandoval Vallarta worked as a professor at MIT, where he had developed a prestigious career as a theoretical physics.[9] Compton and Sandoval Vallarta were both part of the American physics community and thus were connected. When Compton asked for advice, Sandoval Vallarta recommended places in Mexico to take cosmic ray measurements and he personally made local arrangements for the expedition.[10] Moreover, he travelled with Compton and his wife and assistant, Betty,[11] and he was the link between Compton, the Mexican authorities and the local community of engineers interested in Compton's research. While at MIT, Sandoval Vallarta had maintained contact with Mexican intellectual and scientific community, particularly professors at UNAM. He was especially close to Ricardo Monges López and Sotero Prieto, both civil engineers by profession but respectively a geophysicist and a mathematician by practice, who promoted the creation of institutional spaces for training and research in mathematics and physics at the Mexican University.[12]

Fig. 1 - Arthur Compton and Manuel Sandoval Vallarta.[13]

Moreover, after their encounter in Mexico Compton and Sandoval Vallarta began a work collaboration. While Compton continued his travel, Sandoval Vallarta returned to MIT and started working on the explanation of the interaction between charged particles and the magnetic terrestrial field - a study that would eventually be used as a theoretical demonstration of the results of Compton's cosmic ray survey.[14] At MIT, Sandoval Vallarta and his colleague George Lemaître worked together on the so-called Lemaître-Vallarta theory.[15] For Sandoval Vallarta, this work was a turn in his research and stood out as his major contribution in the field of physics. For Lemaître, this theoretical explanation fruitfully incorporated his cosmological hypothesis of the primitive atom. For Compton, a theoretical proof of the latitude effect strengthened his results and research program in cosmic rays.[16] Thus, this was a profitable collaboration for the main actors involved.

Additional expeditions for measuring cosmic ray intensity were organized after 1932. This time the purpose was to find out if there was an East-West asymmetry in the intensity of cosmic radiation (azimuthal effect), as predicted by Lemaître-Vallarta's theory. If cosmic rays came mostly from the West, then it would be possible to sustain that they were constituted principally by positively charged particles. In 1933, Luis Alvarez and Thomas Johnson went to Mexico city to take new measurements.[17] Johnson returned in 1934 to prove the accuracy of his instruments.[18] Once again, Sandoval Vallarta and Ricardo Monges López were involved in the logistic arrangements[19] and sometimes attended the experiments with other Mexican engineers. Since the task of measuring the East-West effect required different instruments, Johnson proposed new designs of experimental and instrumental settings. He built a cosmic ray coincidence counter that consisted mainly of Geiger-Müller counters. This kind of design allowed adjusting the counter at different directions, as required for the detection of the azimuthal effect. In order to register the azimuthal direction when an event was detected, a camera was used to take pictures of the experimental arrangement. This was a different use of images from the case of the cosmic ray meter, where images themselves constituted evidence of the events. According to Peter Galison, the cosmic ray meter belongs to the image tradition, whereas the cosmic ray coincidence counter is inscribed in the logic one.[20]

In all cases, when the expeditions arrived in Mexico either Sandoval Vallarta or local engineers were involved not only in their travel and stay arrangements but also as technical assistants.[21] It is important to note there were no professional physicists at the time in Mexico, but physics was practiced by an important community of engineers. Basically, the community of civil engineers encouraged the creation of schools and research institutes in mathematics and physics at UNAM. Ricardo Monges López, an important civil engineer who was close to Sandoval Vallarta, participated in the internal transformation of the University in the 1930s and he championed the creation of its institute of physics and mathematics, as well as the faculty of sciences.[22]

Simultaneously, Sandoval Vallarta was trying to create a group in cosmic ray research involving Mexican engineers. For this purpose, he encouraged and intervened in the award of fellowships offered by the Guggenheim Foundation to Mexican engineers.[23] Alfredo Baños (1935) and Carlos Graef (1937) were the first Mexican engineers who received Guggenheim fellowships to conduct their PhDs in theoretical physics at MIT. Under the supervision of Sandoval Vallarta they became physicists specialized in theoretical research on cosmic rays. The plan was that Baños and Graef would lead physics research when they would return to Mexico. Ricardo Monges López justified his request for the creation of an institute of physics and mathematics at UNAM by arguing that Alfredo Baños was finishing his PhD in physics and he could be in charge of this scientific institution once he returned to Mexico.[24]

In addition to these training programs for Mexican specialists in cosmic ray research, there were plans to acquire instruments for measuring cosmic rays and install them permanently in Mexico. In 1937, a cooperation agreement was signed between MIT, the University of Chicago and UNAM's National School of Physical Sciences and Mathematics.[25] This agreement was promoted by Compton, Sandoval Vallarta and Monges López. MIT and Chicago were in charge of supplying the instruments, while UNAM would provide a building and people for taking measurements. Instruments included Geiger Müller counters, which would serve to build a cosmic ray counter similar to the one designed by Johnson. This cosmic ray counter was eventually designed and assembled by a Mexican engineer, Manuel Perrusquía Camacho, with the assistance of Fernando Alba Andrade, then a physics student at UNAM. It was installed at the premises of the National School of Physics and Mathematics, created in 1936, at the Palacio de Minería, where the UNAM's National School of Engineering was located. It would be subsequently used for measuring the azimuthal effect of cosmic rays.[26]

Also in 1937 a cosmic ray meter was installed permanently in Mexico and local scientists and technicians were in charge of its operation. Compton had planned to establish a cosmic ray station in Mexico since 1934, when he consulted with Sandoval Vallarta on where it could be located.[27] The appropriate instrument for such station was the cosmic ray meter, as it would enable latitude effect measurements to continue. In 1937, the cosmic ray station at Teoloyucan was launched. Compton brought its instruments to Mexico and supervised their installation.[28] At that time, Compton was also promoting the installation of a cosmic ray meter at the Magnetic Observatory in Huancayo, Peru, as an attempt to develop a network of cosmic ray stations in Latin America.[29]

In early 1938, the UNAM Physics Institute was inaugurated and Alfredo Baños became its first director.[30] Its main department was the Cosmic Ray one, which included theoretical and experimental research, both in relation to the work of Sandoval Vallarta. Baños continued the theoretical work initiated at MIT and he encouraged the construction of the cosmic ray coincidence counter started by the 1937 MIT-Chicago-UNAM cooperation agreement, which was installed at the Palacio de Minería.[31]

Through the study of cosmic rays, people, instruments, and practices circulated in a round trip journey between North and South. The program was definitely relevant for the understanding of cosmic rays in the US and close to Arthur Compton's ambitions. Likewise, the cosmic ray research encountered a fertile terrain in the Mexican civil engineering community since it became a vehicle to materialize its effort to create academic institutions specialized in physics and mathematics. Mexican engineers became increasingly involved in cosmic ray research. Some attended the observations made by Compton, Johnson and Alvarez and became familiar with the experiments and instruments. The cosmic ray experiments developed by Compton's team were based on two different types of instruments: the cosmic ray meter and the cosmic ray coincidence counter. The Physics Institute was developed around the latter and theoretical studies on cosmic rays. This association was possible partly due to the theoretical training of Mexican engineers and partly to experience acquired during the cosmic ray expeditions to Mexico. The use of cosmic ray instruments and the theoretical work on cosmic rays became justifications for creating the first Mexican research institute of physics. Hence, at the beginning of the 1940s there were two different experimental locations for measuring cosmic rays in Mexico, one at the Palacio de Minería in Mexico City and the other in Teoloyucan in the State of Mexico. They were different because of their instruments and experimental practices. Whereas Teoloyucan had a cosmic ray meter for measuring cosmic ray intensity, the Station at the Palacio de Minería had a cosmic ray coincidence counter for measuring variations for azimuthal angles.

Lab equipment, US foundations and Good Neighbor Policy

As mentioned earlier, Mexican engineers were awarded fellowships by the Guggenheim Foundation for studying physics in US universities. Alfredo Baños and Carlos Graef were the first to receive these fellowships and used them to pursue PhDs in theoretical physics at MIT, where Manuel Sandoval Vallarta could host, train, and supervise them. After their return, Baños and Graef became key figures in the development of physics research at UNAM. Baños was the first director of the Physics Institute between 1938 and 1943; subsequently Graef occupied the same position for a long period, 1945 to 1957.

To a certain extent, their training in the US contributed to increase their local prestige and allowed them to get positions of power for the establishment of physics in Mexico.

During the period in which Baños directed the Physics Institute, cosmic ray research remained at the centre of the Institute plans. At the same time, Baños tried to improve the material resources of the Institute through funding provided by the Rockefeller Foundation.[32] In 1940, the Foundation had added to its financial programs funds for acquiring laboratory equipment in order to strengthen scientific institutions abroad. The Foundation offered to buy scientific equipment in the US and send it to selected foreign institutions.[33] This new program was announced by Harry Miller Jr., assistant director of the Division of Natural Sciences at a meeting with all the directors of research institutes at UNAM.[34] Baños took the opportunity and in 1941 he applied for funds to equip a laboratory of precision electrical measurements, conceived as a central standards bureau for the service of the scientific research institutes at the University and the entire country.[35] His request was approved by the Rockefeller Foundation Associate Director, Frank Blair Hanson.[36] In 1942, the instruments arrived in Mexico, one year after the agreement was signed.[37]

The same year, the arrival in Mexico of the Spanish physicist Blas Cabrera as a result of the fascist dictatorship in Spain, promised new possibilities for physics research in Mexico. In 1932, Cabrera had secured funding from the Rockefeller Foundation to create the National Institute of Physics and Chemistry in Spain, so he knew how to handle this type of plans and funding applications. He achieved an agreement with the Foundation in May 1942 for the purchase of instruments for mechanics and glass blowing workshops.[38] However, this time the Foundation offered the grant with the condition that Cabrera would be hired as head of research, that he would have two technical assistants and a site for installing workshops.[39]

A serious problem that limited the growth of the Physics Institute was the lack of an independent and appropriate building for physics research. Although Baños had received the Rockefeller's donations to equip laboratories and workshops, he did not succeed in finding adequate premises for their installation. The University authorities had too many problems to solve, apparently of higher priority than the needs of the Physics Institute. Baños then considered an alliance with the Secretariat of National Defense of Mexico. He presented a building project to the Secretariat, which could encompass the entire Physics Institute and a military firearm school belonging to the Mexican army. Apparently, he managed to pass this proposal and started to organize the transfer of the instruments sent by the Rockefeller Foundation. He announced his plan to the Rockefeller authorities, asking also for a donation of books for the new library; he proposed to name it 'Rockefeller Library' as recognition of all the donations received.[40]

However, Baños' plan did not materialize. Moreover, during that period he suffered political attacks from the Mexican science community that further complicated his work. He was accused of plagiarism in relation to a book that he used in a course on atomic physics.[41] Although he denied this charge and was supported by the American author and publisher of the book in question, the situation led to a climate of suspicion.[42] The plagiarism accusation may have been prompted by opposition within the Physics Institute to the potential agreement with the Mexican Secretariat of Defense. In any case, the result was that Baños resigned from his University positions in 1943.[43] The instruments donated by the Rockefeller remained in their boxes, and the Institute remained in the same inadequate premises. No data exist on the subsequent fate of the instruments, although it seems that a proper space for their installation was not found. Furthermore, no staff was available to operate them. Blas Cabrera initially replaced Baños in the direction of the laboratory of precision electrical measurements, but he died unexpectedly in 1945. Hence, with the resignation of Baños, the Physics Institute entered a phase of stagnation due to the lack of both appropriate buildings and staff.

The Rockefeller Foundation had a profound influence in twentieth-century Mexican science. It deployed a network of support programs in different areas; especially important were the programs for the training of physicians, disease eradication and agriculture technical assistance.[44] These programs stand out as powerful and controlled initiatives in terms of their scope and objectives, the social and political structures they involved, and their impact on local practices. Specialists in the study of the influence of the Rockefeller Foundation in Latin America agree that the philanthropic interest of the Foundation went hand in hand with both US expansionist interests and the commercial interests of the Rockefeller family.[45] Together with large-scale programs in agriculture and medicine, the Foundation supported other projects more limited in scope, but no less important. This support favoured the constitution of an inter-American network of institutions and researchers, which was a seed for subsequent co-construction of US scientific hegemony.[46]

By 1941, the Good Neighbor Policy promoted by the US government towards Latin American countries materialized as a state structure with the creation of the Office of the Coordinator of Inter-American Affairs. Headed by Nelson Rockefeller, it brought the experience of the Foundation Rockefeller in the establishment of intellectual and cultural networks abroad. In addition, science began to have a special priority in inter-American policy. In this respect, Clark A. Miller argues that the US experience in Latin America shaped an understanding of the potentialities of associating science and technology as a way to achieve progress and social welfare, which became the central argument in post-war scientific internationalism.[47]

A group of US scientists was specially implicated in the establishment of scientific institutions in Latin America. Arthur Compton, Harlow Shapley, and George David Birkhoff were particularly visible. As seen earlier, Compton built and brought together a network of cosmic ray stations in Latin America, as well as promoting research on that topic.[48] Shapley did something similar in the case of astronomical observatories.[49] In 1942, Birkhoff went on a tour around Latin American countries where he presented his theory of gravitation and other topics of his specialty.[50] In a way, these scientists contributed to, and profited from, an inter-American framework of good neighbor practices aimed to extend collaborative scientific networks in Latin America.

Sandoval Vallarta was also involved in these initiatives. Not only was he often consulted regarding the selection of Latin American Guggenheim fellowships, but he also participated actively in organizations for the promotion of Latin American scientific networks. In 1941 and 1942, he directed the recently created Committee on Inter-American Scientific Publications, an organization that was funded by the Coordinator of Inter-American Affairs. This Committee would collect scientific publications produced by scientists in Latin American countries and translate them into English in order to place them in US scientific journals.[51] This was one among several activities "in the interests of promoting both the international spirit of science and inter-American cooperation".[52] This particular initiative appears as a remarkable mechanism to drive fluxes of knowledge from South to North.

In 1942, as president of the Committee on Inter-American Scientific Publications, Sandoval Vallarta initiated in Mexico a tour through Latin America, similar to Birkhoff's, with a grant from the Office of the Coordinator of Inter-American Affairs. He intended to organize the Inter-American Academy of Science.[53] However, support for this project was suspended in mid-1942 and he was unable to get additional funds. Sandoval Vallarta pointed out the importance of his Latin-American tour for the promotion of US strategic alliances.[54] This episode is representative of a turn in priorities for US institutions because of the mobilizations induced by the declaration of war. New urgencies emerged for the US government, scientific institutions, and scientists. In this context, MIT urged Sandoval Vallarta to return and resume his teaching duties.[55] Instead, Sandoval Vallarta resigned from MIT after the Mexican government offered him the direction of an especially tailored national institution for the encouragement of science, the Commission for the Promotion and Coordination of Scientific Research.[56] At this crossroad, his career was confronted to a national and professional choice which not only determined on what side of the US-Mexico border he would henceforth work, but also the type of scientist he would be remembered for. Since then, Sandoval Vallarta was permanently established in Mexico and began to occupy national positions in the coordination and promotion of scientific research.

After Baños' resignation, Sandoval Vallarta directed for two years the Physics Institute, but his leadership did not manage to change the state of affairs in relation to its research development. In 1945, Carlos Graef was appointed as the new director of the Institute and from that time, in addition to cosmic ray research, he prompted theoretical studies on Birkhoff's gravitation, in which the Institute staff worked until the end of the forties.

A Van de Graaff accelerator on the move: US-Mexican scientific relations, post-war scientific internationalism, and Mexican nuclearization

1950 was a crucial year for physics research in Mexico. This was the year of the launch of construction UNAM's new campus. Located in the Southern part of Mexico City, the University City was an ambitious governmental project whose alleged purpose was the encouragement of the entire higher education structure in Mexico; all faculties and institutes would benefit from it. The project was especially important for the Faculty of Sciences and the Institute of Physics. In addition to benefitting from appropriate premises, the plan included the acquisition of a particle accelerator. How and why did substantial differences appear in relation to the previous situation for physics research and scientific education?

Physics research was in the public eye since the detonation of atomic bombs by the US five years earlier.[57] As a result, Mexican physicists consolidated their relations with the government, as it occurred almost in every country. They were called to represent the country in recently founded international agencies and organizations, especially when the topic under discussion was science or nuclear energy. The Mexican government realized that if the country wanted to compete for better social and economical conditions, it was its duty to invest in scientific education and research; an idea promoted by industrialized countries in international forums. The project of the new campus for UNAM and the acquisition of a Van de Graaff accelerator were seen as initiatives closely connected to that imperative.

The positioning of Mexican scientists in strategic institutions and governmental departments, combined with their connections with US science, were central factors in the choice of a Van de Graaff accelerator. Manuel Sandoval Vallarta and Nabor Carrillo were involved in diplomatic tasks since 1946 regarding the atomic test in the Atoll of Bikini, the United Nations Commission for Atomic Energy and the first meeting of UNESCO.[58] At that time, Carrillo was Coordinator of Scientific Research at UNAM and Sandoval Vallarta was president and representative of physics research at the Commission for the Promotion and Coordination of Scientific Research, founded in 1942. Their experience and opinions on development and management of scientific research were considered trustworthy by Mexican authorities.

Carrillo belonged to the group of Mexican civil engineers awarded with Guggenheim fellowships, along with Baños and Graef. He had worked with Arthur Casagrande at Harvard University, where he specialized in soil mechanics and got a PhD in Science. Remarkably, soil mechanics was part of physics research in Mexico, even if this might not be usual in other national contexts. Furthermore, Casagrande had donated to UNAM a complete laboratory for research in soil mechanics, which was associated to the Physics Institute from 1939 to 1943. As seen before, civil engineers and the small community of physicists were closely related in Mexico during the first half of the twentieth century. Carrillo maintained collaboration with Casagrande after his return to Mexico and their relationship played a relevant role in the acquisition of the particle accelerator.[59]

According to mainstream Mexican historiography,[60] Mexican scientists became interested in the Van de Graaff accelerator after Carrillo visited the High Voltage Engineering Corporation (HVEC) when he was lecturing on soil mechanics at Harvard on Casagrande's invitation. The HVEC was a company founded by Robert Van de Graaff, John D. Trump, and Dennis Robinson in 1946; it commercialized Van de Graaff accelerators.[61] Denis Robinson, director of the company and brother-in-law of Casagrande, showed Carrillo the accelerators that were being built and commercialized. In addition, at MIT, William Buechner explained him the possibilities of research opened by this type of accelerator.[62] Buechner was head of the MIT High Voltage Laboratory and one of the closest collaborators of Robert Van de Graaff.

Sandoval Vallarta was also familiar with Van de Graaff accelerators. When he worked at MIT he visited the Round Hill locations to observe the developments that Robert Van de Graaff was performing on his famous and huge accelerator.[63] Van de Graaff and Sandoval Vallarta were both professors at MIT's Department of Physics. Furthermore, William Buechner was married to Sandoval Vallarta's secretary when the latter was the president of the Committee on Inter-American Scientific Publications.

Carrillo, Sandoval Vallarta, Carlos Graef, then director of the Institute of Physics, and Alberto Barajas, director of the Faculty of Sciences, led the application for the purchase of a Van de Graaff accelerator. Carlos Lazo, chief manager of the project of the University City, backed them and conducted the negotiation to get funds. They got the support from the president of Mexico, Miguel Alemán, and the Van de Graaff accelerator thus acquired a dimension of national politics.[64]

Carlos Lazo became an active promoter of nuclear energy as a potential resource for solving social problems and for the production and distribution of electrical energy. He incorporated these ideas in his discourses about the University City Project. In connection to the acquisition of the Van de Graaff accelerator he said: “our wish was to establish a symbol of modernity in this new university; we wanted this idea of nuclear power handled by the Mexican student not for political or military goals but for human purposes, that is with the aim of developing all our natural resources, also to shape the thought of our philosophers, economists, and technicians”.[65] Certainly, the Van de Graaff accelerator gave another image and meaning to the University City. In the context of national political discourse, both the University City and the Van de Graaff accelerator were material evidence of the progress and modernization of Mexico.[66] First, modernization as avant-garde: the architectural design, the use of certain building materials, and the incorporation of artwork. Modernization also because the campus would concentrate colleges and institutes with a novel spatial conception that would allegedly impact on the production of knowledge. Finally, modernization because right at this centre would emerge a nuclear research program for the service of the country.

Hence, the press announced that “Mexico is now definitively incorporated into the atomic age by integrating an active research program in nuclear physics at the laboratories of the new University City”. Carlos Graef, then director of the Physics Institute, repeatedly said that the instrument would benefit research into agricultural production because it could be possible to irradiate seeds and achieve better crops.[68] Furthermore, he argued, it could be possible to obtain new materials that would benefit the national industry and the implementation of therapies against cancer.[69] Likewise, the potential benefits for the entire country were linked to the discourse of peaceful uses of nuclear energy: “the University of Mexico will launch in our country the exciting atomic age, promise of a more comfortable, hygienic and affluent future when, as Mexico is going to do, the energy of atoms is exploited for peaceful purposes”.[70]

All the propaganda obviously exaggerated the real functions and research possibilities of the Van de Graaff accelerator. Nonetheless, it highlights the construction of a public image around this instrument based on its association with nuclear energy. In a sense, nuclear energy represented a promising future for developing countries. Scientists, governments, and the general public learned to desire nuclear energy as a tool for reaching better social conditions.[71] Mexico was becoming a nuclear country with the acquisition of the Van de Graaff. Using a term proposed by Gabrielle Hecht,[72] the Van de Graaff represented a form of nuclearization of Mexico.

Fig. 2 - The Van De Graaff accelerator.[73]

At the new University City, José Chávez Morado, a prominent Mexican painter, represented the Van de Graaff accelerator in a mural entitled 'Science and work/Builders'. Chávez Morado was in charge of the murals that would decorate the walls of the Faculty of Sciences. In the University City project artists and architects tried to put in practice principles of the so-called movement of Plastic Integration. This movement aimed at producing artworks with architectural features. Nowadays, no visitor of Mexico City can miss a visit to the murals of the University City. Famous Mexican muralists participated in the project, such as Juan O'Gorman, Francisco Eppens, Diego Rivera, and David Alfaro Siqueiros. The aforementioned mural by Chávez Morado includes a sequence of images depicting stages and social roles involved in the construction of the University City. At the left end, there are farmers leaving their land to allow for the construction of the new campus. Immediately, there are workers digging and carrying a wheelbarrow. Next, there are a group of engineers and architects studying building maps. Right after, the directors of the project are supervising the state of the construction. Finally, there is a group of Mexican scientists (Carlos Graef, Alberto Barajas, Nabor Carrillo and Alberto Sandoval, director of the Chemistry Institute) in front of the Van de Graaff accelerator, as if they were manipulating it. This mural remains a testimony of this close and powerful association between the Van de Graaff accelerator and the University City Project.

The University City also preserves the building that was constructed in the early 1950s following special requirements to install the Van de Graaff accelerator. Architectural plans for designing an appropriate building for the instrument began immediately after the purchase contract was signed in August 1950. Although the design was commissioned to a group of Mexican architects and engineers, the final proposal had to be sent to the High Voltage Engineering Corporation for approval.[75] The Van de Graaff Laboratory, as the building would be called, was constructed quickly in comparison to the rest of the University City, as it had to be finished by the time the instrument arrived in mid-1951.[76]

Fig. 3 - In front, the Van De Graaff Laboratory.[77]

Now the University had a particle accelerator and its dedicated building. A next crucial step was to conceive a research plan and also a group of nuclear physics experimentalists. The physical characteristics of the Van de Graaff accelerator and the technical requirements for its installation and operation partly favoured its acquisition and use in Mexico, over other possible choices in the nuclear physics instrumental arsenal. In 1952, there were 87 HVEC accelerators distributed around the world.[78] One of them was the Mexican. Its design was very different from that of the accelerator built in Round Hill by Robert Van de Graaff in 1933. It was relatively small - thus transportable - and had a high-pressured tank containing the accelerator system (a rubber band followed by a device for concentrating electrical charges, a terminal ion source and the accelerator tube surrounded by equipotential rings to stabilize the voltage). It was able to attain 2 MeV in the acceleration of positive particles. The installation and operation of the Van de Graaff accelerator in Mexico was also supported by William Buechner's offer to host and advice a group of Mexican specialists at MIT.[79] Thus, training and technical knowledge developed by the MIT group on this kind of instrument was available to Mexican physicists. Two members of the Mexican team, Fernando Alba Andrade and Eduardo Díaz Lozada, were commissioned to train at MIT. Both had a major in engineering and Alba Andrade was also a physicist. They travelled to MIT with grants from the Mexican National Institute for Scientific Research (directed by Sandoval Vallarta). Buechner hosted them at MIT's High Voltage Laboratory, where they were trained for three months in order to be able to supervise the installation of the Van de Graaff in Mexico.[80]

Fig. 4 - The Van De Graaff accelerator located in the first floor of the Laboratory, 1952[81]

The full installation and calibration of the Van de Graaff took at least two years, although modifications were constant until it was finally substantially transformed into a different type of instrument in 1963, an electron accelerator. The process involved the adaptation of the instrument to local conditions, in addition to the design and construction of complementary instruments. Thus, the installation of the Van de Graaff spurred the production of additional scientific instruments in Mexico. To this purpose, the development of technical workshops was essential, and Mexican practitioners developed a genuine experience and tradition in this field.

In 1951, the Mexican Scientific Congress met to celebrate the 400-year anniversary of the foundation of UNAM. It was a huge scientific meeting, bringing together, among others, US scientists who in different ways had been involved in the shaping of good neighbor practices in science between the US and Mexico: Harlow Shapley, George Garret Birkhoff, and Arthur Casagrande, as well as their Mexican counterparts: Manuel Sandoval Vallarta (by then established in Mexico), Alfredo Baños (then in the US), Carlos Graef, and Nabor Carrillo.[82] The scenario could not be better, as the Congress was held at the new University City, where the recently arrived Van de Graaff accelerator was located.

Concluding remarks

The acquisition of the Van de Graaff accelerator in 1950 is a major episode in the contemporary history of science in Mexico, helping our understanding of the complexities of the process of institutionalization and professionalization of the physical sciences in national and international perspective. It is a crossroad where several elements converge: the international relations between Mexican and US scientists, the national project of the University City, the involvement of Mexico as a nuclear state and the emergence of a specialized research group in experimental nuclear physics in Mexico.

Analysis presented in this chapter shows the diversity of actors (including scientific instruments, persons, and institutions) and processes, involved in the circulation of scientific knowledge and practices. This phenomenon implied a tremendous mobilization of material, social, and political resources. I have demonstrated the interest of focusing on scientific instruments in the study of the practice of science and how their analysis can bring new insights and broader implications, ranging from international politics to local public opinion, national identity and the configuration of professional communities.

Resorting to the idea of 'good neighbor' practices in science is a way to put inter-American scientific relations both as part and as a consequence of the implementation of political plans whose ultimate aim was to strengthen regional and international alliances. In this process, actors from North and South were actively involved, even when their particular objectives and rewards were different and asymmetrical. Nonetheless, the mobilization of people, practices, and instruments was deployed in one direction and the other.

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All translations from Spanish into English were made by the author.

Notes

[1] For a detailed analysis of Compton's Cosmic Ray Survey and its implication for professionalizing and institutionalizing physics in Mexico, see G. Mateos and A. Minor García, 'La red internacional de rayos cósmicos, Manuel Sandoval Vallarta y la física en México', *Revista Mexicana de Física E* (2013), 59, 148-155.

[2] For a discussion about cosmic rays in the 1930s, see D. C. Cassidy, 'Cosmic Ray Showers, High Energy Physics, and Quantum Field Theories: Programmatic Interactions in the 1930s', *Historical Studies in the Physical Sciences* (1981), 12, 1-39; M. De Maria and A. Russo, 'Cosmic Ray Romancing: The Discovery of the Latitude Effect and the Compton-Millikan Controversy', *Historical Studies in the Physical and Biological Sciences* (1989), 19, 211-266; M. De Maria, M. G. Ianniello and A. Russo, 'The Discovery of Cosmic Rays: Rivalries and Controversies between Europe and United States', *Historical Studies in the Physical and Biological Sciences* (1991), 22, 165-192.

[3] The Cosmic Ray Survey was similar to another CIW's research program deployed in the early twentieth century for mapping terrestrial magnetism. See Mateos and Minor, *op. cit.* (2013), 59, 148-155; G. A. Good. 'Geophysical travelers: the magneticians of the Carnegie Institution of Washington', *Geological Society, London, Special Publications* (2007), 287, 395-408.

[4] A. H. Compton, 'A Geographical Study of Cosmic Rays', *The Physical Review* (1933), 42, 387-403.

[5] A. H. Compton and J. J. Hopfield, 'An Improved Cosmic Ray Meter', *Review of Scientific Instruments* (1933), 4, 491-195.

[6] A. H. Compton, 'Variation of the Cosmic Rays with Latitude', *Letters to the Editor Physical Review* (1932), 41, 111-113.

[7] Cultural encounters driven by expeditions resulting in new hybrid knowledge and where local actors took part as active mediators or 'go-betweens' are analyzed, for example, in S. Schaffer, L. Roberts, K. Raj, and J. Delbourgo (eds), *The Brokered World: Go-betweens and Global Intelligence 1770-1820*, Sagamore Beach, Science History Publications USA, 2009; M. Nieto, *Remedios para el Imperio, Historia Natural y la Apropiación del Nuevo Mundo*, Instituto Colombiano de Antropología e Historia, Bogotá, 2000; J. Pimentel, *Viajeros Científicos. Tres Grandes Expediciones al Nuevo Mundo: Jorge Juan, Mutis, Malaspina*, Nivola, Madrid, 2001; N. Safier, *Measuring the New World: Enlightenment Science and South America*, University of Chicago Press, 2008.

[8] Sandoval Vallarta was able to mediate between different cultural worlds. In addition to Spanish (his mother tongue), he was fluent in English, French, and German. He also moved between several academic disciplines and traditions. At MIT, first he got a major in electrical engineering and later a PhD in theoretical physics. In addition, his doctoral thesis was an attempt to link classical mechanics with quantum theory.

[9] Sandoval Vallarta belonged to a generation of physicists who were involved in the encouragement of physics research in US institutions. See S. S. Schweber, 'The empiricist temper regnant: Theoretical Physics in the United States 1920-1950', *Historical Studies in the Physical and Biological Sciences* (1986), 17, 55-98.

[10] Telegram from Manuel Sandoval Vallarta to Arthur Compton, 15 March 1932, Archivo Histórico Científico Manuel Sandoval Vallarta (AHCMSV), Sección Personal, Subsección Correspondencia, Serie: Científica, Box 30, File 9.
[11] Interview with Betty Compton by Charles Weiner, http://www.aip.org/history/ohilist/4560_2.html#11, accessed: January 15, 2013.
[12] M. de la P. R. Lara, 'De la física de carácter ingenieril a la creación de la primera profesión de física en México', *Revista Mexicana de Física E* (2005), 51, 137-164, and 'Los ingenieros promotores de la física académica en México (1910-1935), *Revista Mexicana de Investigación Educativa* (2007), 12, 1241-1265; R. Domínguez Martínez, *Historia de la ingeniería civil en México 1900-1940*, PhD thesis, Universidad Nacional Autónoma de México, 2010.
[13] AHC-MSV, Sección Fototeca, Subsección Congresos y Conferencias, Serie Internacionales, Subserie Fotografías, Álbum 1, Expediente 1, Unidad 3.
[14] Letter from Manuel Sandoval Vallarta to Nathan Rosen, 17 November 1932, AHC-MSV, Sección Personal, Subsección Correspondencia, Serie Científica, Box 23, File 3.
[15] George Lemaître was a Belgian scientist and Catholic priest, affiliated to the University of Louvain. He obtained a PhD in Physics at the MIT in 1927; Sandoval Vallarta was part of the committee of referees that evaluated his dissertation. Their article on latitude effect was their first collaborative work: G. Lemaître and M. Sandoval Vallarta, 'On Compton's Latitude Effect of Cosmic Radiation', *The Physical Review* (1933), 43, 87-91.
[16] Lemaître and Vallarta stated that their theory constituted an explanation of the results obtained by Compton's team's expeditions. Also, the article by Compton in which he announced results of the Cosmic Ray Survey explained the agreement between his experimental data and calculations and Lemaître and Vallarta's theory.
[17] A. H. Compton, 'The Significance of Recent Measurements of Cosmic Rays', *Science* (1933), 77, 480-482. Luis Álvarez worked with Compton at the University of Chicago, where he developed improvements to the design of cosmic ray counters. Johnson took measurements of cosmic radiation intensity with cosmic rays counters of his own design; some were important for measurements in balloons.
[18] T. H. Johnson, 'Progress of the Directional Survey of Cosmic-Ray Intensities and Its Application to the Analysis of the Primary Cosmic Radiation', *The Physical Review* (1933), 48, 287-299.
[19] Letter from Manuel Sandoval Vallarta to the Mexican director of the customs service, 24 August 1934, AHC-MSV, Sección Personal, Subsección Correspondencia, Serie Científica, Box 21, File 15.
[20] P. Galison, *Image and Logic. A Material Culture of Microphysics*, University of Chicago Press, 1997.
[21] Mexican collaborators were acknowledged in the papers presenting the expedition results. See e.g. T. H. Johnson, 'Coincidence counter studies of the corpuscular component of the cosmic radiation', The Physical Review (1934), 45, 569-585. Information about activities undertaken by Mexican engineers concerning the cosmic rays expeditions are mentioned in the 'Official report of activities of the UNAM School of Physical Sciences and Mathematics', 2 July 1937, Archivo Histórico de la Universidad Nacional Autónoma de México (AH-UNAM), Fondo Universidad Nacional, Ramo Rectoría, Box 39, File 455.
[22] Letter from Agustin Aragon Leiva to Manuel Sandoval Vallarta, May 1934, AH-UNAM, Fondo Memoria Universitaria, Sección Consejo Universitario; Informe del Consejo Universitario, 16 December 1933, AHC-MSV, Sección Personal, Subsección

Correspondencia, Serie Científica, Box 23, File 3; Letter from Alfredo Baños to Manuel Sandoval Vallarta, 22 March 1938, AHCMSV, Sección Personal, Subsección Correspondencia, Serie Científica, Box 26, File 24.
[23] Letter from Manuel Sandoval Vallarta to Ricardo Moges López, 25 February 1941, AHC-MSV, Sección Personal, Subsección Correspondencia, Box 15, File 12.
[24] Formal request to the Rector of UNAM, 1 December 1937, AH-UNAM, Fondo Universidad Nacional, Ramo Rectoría, Box 39, File 458.
[25] Letter from Ricardo Monges López to Luis Chico Goerne, 2 July 1937, AH-UNAM, Fondo Universidad Nacional, Ramo Rectoría, Box 39, File 455. The National School of Physical Sciences and Mathematics was officially created in 1936; in 1938, it was transformed in the Faculty of Sciences.
[26] Letter from Alfredo Baños to Manuel Sandoval Vallarta, 22 March 1938, AHC-MSV, Sección Personal, Subsección Correspondencia, Serie Científica, Box 26, File 24.
[27] Rough draft of a letter from Sandoval Vallarta to Arthur Compton, 30 October 1935, AHC-MSV, Sección Personal, Subseccción Correspondencia, Serie Científica, Box 21, File 6.
[28] Letter from Ricardo Monges López to Luis Chico Goerne, 2 July 1937, AH-UNAM, Fondo Universidad Nacional, Ramo Rectoría, Box 39, File 455.
[29] A. Giesecke and M. Casaverde, 'Historia del observatorio magnético de Huancayo', *Revista Geofísica* (1998), 49, 7-45; J. Ishitsuka and H. Trigoso, 'Cosmic Rays in Peru', unpublished paper given at the Third School on Cosmic Rays and Astrophysics, Arequipa, Perú, 25 August to 5 September, 2008.
[30] 'Informe que rinde el rector de la UNAM al H. Consejo Universitario sobre las actividades desarrolladas por la Universidad hasta el 1o. de febrero de 1939', 1939, AH-UNAM, Fondo Memoria Universitaria, sección Rectoría.
[31] 'Programa de labores del Instituto de Física para el año 1939', 23 January 1939, AH-UNAM, Fondo Universidad Nacional, sección Rectoría, serie 1/073 proyectos, Box 43, File 413.
[32] The Rockefeller Foundation was very active in Latin America, see for instance Almeida's chapter in this volume.
[33] Formal letter to the sub-secretary of the Mexican Secretariat of Finance, Sr. Lic. Ramón Beteta, 30 August 1941, AH-UNAM, Fondo Universidad Nacional, Sección Rectoría, Serie 1/100 Asuntos Generales, Subserie 1/100-61 Facultad de Ciencias, Box 67, File 673.
[34] 'Informe de la Rectoría', 1942, AH-UNAM, Fondo Memoria Universitaria, sección Rectoría.
[35] Letter from Alfredo Baños to Rodulfo Brito Foucher, 3 August 1942, AH-UNAM, Fondo Universidad Nacional, Sección Rectoría, Serie 1/100 Asuntos Generales, subserie 1/100-93 Instituto de Física, Box 76, File 863.
[36] Letter from Dr. Fran Blair Hanson to Mario de la Cueva, 12 September 1941, AH-UNAM, Fondo Universidad Nacional, Sección Rectoría, Serie 1/100 Asuntos Generales, Subserie 1/100-61 Facultad de Ciencias, Box 67, File 673.
[37] Letter from Alfredo Baños to Rodulfo Brito Foucher, 24 August 1942, AH-UNAM, Fondo Universidad Nacional, Sección Rectoría, Serie 1/100 Asuntos Generales, Subserie 1/100-61 Facultad de Ciencias, Box 67, File 673.
[38] Letter from Alfredo Baños, director of the Physics Institute, to Mario de la Cueva, rector of the UNAM, 9 May 1942, AH-UNAM, Fondo Universidad Nacional, Sección Rectoría, Serie 1/100 Asuntos Generales, Subserie 1/100-93 Instituto de Física, Box 76, File 863.
[39] Letter from Alfredo Baños, director of the Physics Institute, to Mario de la Cueva,

rector of the UNAM, 11 May 1942, AH-UNAM, Fondo Universidad Nacional, Sección Rectoría, Serie 1/100 Asuntos Generales, Subserie 1/100-93 Instituto de Física, Box 76, File 863.
[40] Letter from Alfredo Baños to Harry Miller, Assistant Director of the Division of Natural Sciences of the Rockefeller Foundation, 3 December 1942, AH-UNAM, FUN, sección Rectoría, serie 1/100 Asuntos Generales, Subserie 1/100-93 Instituto de Física, Box 76, File 863.
[41] Letter from Eduardo Vázquez Zarco, member of the Mexican Society of Physical Sciences, to Alfonso Noriega, vice-rector of the UNAM, 13 March 1943, AH-UNAM, Fondo Universidad Nacional, Sección Rectoría, Serie 1/100 Asuntos generales, Subserie 1/100-93 Instituto de Física, Box 76, File 863.
[42] Letter from Rodald P. Hobbs, editor of Henry Semat, to Rodulfo Brito Foucher, rector of the UNAM, 30 March 1943, AH-UNAM, Fondo Universidad Nacional, Sección Rectoría, Serie 1/100 Asuntos generales, Subserie 1/100-93 Instituto de Física, Box 76, File 863.
[43] Letter from Alfredo Baños to Alfonso Noriega, vice-rector of the UNAM, 11 March 1943, AH-UNAM, Fondo Universidad Nacional, Sección Rectoría, Serie 01/01/24, Box 19, File 230.
[44] A. Szymanski, 'Las Fundaciones Internacionales y América Latina', *Revista Mexicana de Sociología* (1973), 35, 801-817; D. Fitzgerald, 'Exporting American Agriculture: The Rockefeller Foundation in México: 1943- 53', *Social Studies of Science* (1986), 16, 457-483; A. Solórzano, 'Sawing the Seeds of New-Imperialism: The Rockefeller Foundation's yellow Fever Campaign in México', *The International Journal of Health Services* (1992), 22, 529-554; A. Solórzano, 'La Influencia de la Fundación Rockefeller en la conformación de la profesión médica mexicana, 1921-1949', *Revista Mexicana de Sociología* (1996), 58, 173-203; M. Cueto, *Cold war, deadly fevers. Malaria erradication in Mexico 1955-1975*, Johns Hopkins University Press, Baltimore, 2007.
[45] See previous note and M. Cueto (ed.), *Missionaries of Science: The Rockefeller Foundation and Latin America*, Indiana University Press, Bloomington, 1994.
[46] This association is explored in a recent book, although not exclusively for the case of Latin America: J. Krige and Helke Rausch (eds.), *American Foundations and the Coproduction of World Order in the Twentieth Century*, Vandehoeck & Ruprecht GmbH & Co, Göttingen, 2012.
[47] C. A. Miller, 'An Effective Instrument of Peace': Scientific Cooperation as an Instrument of U. S. Foreign Policy, 1938-1950' in *Global Power Knowledge. Science and Technology in International Affairs* (eds. John Krige and Kai-Henrik Barth), Osiris (2006), 21, 133-160.
[48] I. Silva and O. Freire, 'Arthur Compton's Journey to South America: Diplomacy and Cosmic Ray Scientific Research on the Eve of the II World War', *Eos Transactions American Geophysical Society, Meet. Am. Supp.* (2010), 91, Abstract U21B-01
[49] Jorge Bartolucci has studied the involvement of Shapley in the creation of the Astronomical Observatory of Tonantzintla, Mexico. See J. E. Bartolucci Incico, *La modernización de la ciencia en México. El caso de los astrónomos*, CESU, Plaza y Valdés, Mexico City, 2000.
[50] E. L. Ortiz, 'La Política Interamericana de Roosevelt: George D. Birkhoff y la Inclusión de América Latina en las Redes Matemáticas Internacionales', *Saber y Tiempo* (2003), 15, 53-112.
[51] Letter from Christine Buechner, secretary of the Committee on Inter-American Scientific Puclications, to Manuel Sandoval Vallarta, 12 March 1942, AHC-MSV,

Sección Personal, Subsección Correspondencia, Serie Científica, Box 24, File 2.
[52] H. Shapley, 'The Committee on Inter-American Scientific Publication', *Science* (1949), 109, 603-605.
[53] Letter from Manuel Sandoval Vallarta to Dr. Henry Allen Moe, 25 April 1942, AHC-MSV, Sección Personal, Subsección Correspondencia, Serie Científica, Box 24, File 2.
[54] Letter from Dr. Henry Allen Moe to Manuel Sandoval Vallarta, 28 April 1942, *Idem*.
[55] Letter from John C. Slater to Manuel Sandoval Vallarta, 20 November 1942, *Idem*.
[56] Telegram from Manuel Sandoval Vallarta to John C. Slater, Chief of the MIT Department of Physics, 22 December 1942, AHC-MSV, Sección Personal, Subsección Correspondencia, Serie Científica, Box 24, File 2.
[57] R. Cabral, 'The Mexican Reactions to the Hiroshima and Nagasaki Tragedies of 1945', *Quipu* (1987), 4, 81-118.
[58] Official letter from the Mexican government to Nabor Carrillo, 27 May 1946, AH-UNAM, Fondo Nabor Carrillo, Sección Formación Académica, Subsección Nombramientos y Títulos, Box 1, File 5; R. Heliodoro Valle, 'Diálogo con Manuel Sandoval Vallarta', *Revista de la Universidad de México* (1950), IV (43), 8.
[59] Biographical account of Nabor Carrillo, AH-UNAM, Fondo Universidad Nacional, Sección Rectoría, Serie 1/102 Datos Biográficos, Box 5, File 87.
[60] M. de la P. R. Lara, 'Particle Accelerators in Mexico', *Historical Studies in the Physical and Biological Sciences* (2006), 36, 297-309; R. Domínguez Martínez, 'Los Orígenes de la Física Nuclear en México', *Revista Iberoamericana de Ciencia Tecnología y Sociedad* (2012), 7, 95-112.
[61] For a general revision of the development of Van de Graaff accelerators see P. Brenni, "The Van de Graaff Generator. An Electrostatic Machine for the 20th Century", *Bulletin of the Scientific Instrument Society* (1999), 63, 6-13.
[62] This account was widespread among Mexican scientists who were involved in the acquisition of the accelerator. Moreover, it was disseminated in the Mexican press through articles and interviews. See e.g. C. Graef Fernández, 'En el campo de la investigación: campeones de la ciencia', *Revista de la Semana*, (15 September, 1951), 86.
[63] Personal letter, 13 November 1933, AHC-MSV, Sección personal, Subsección Correspondencia, Box 21, File 5.
[64] In 1952, Miguel Alemán included the acquisition of the Van de Graaff in his annual report to the Mexican House of Representatives. See *Los presidentes de México ante la Nación: Informes, Manifiestos y Documentos de 1821 a 1966*, Vol. 4, Cámara de Diputados, México, 1966.
[65] 'La Ciudad Universitaria de México', October 1950, AH-UNAM, Fondo Memoria Universitaria, Sección Publicaciones Periódicas, Subsección Revista de la Universidad de México, Rollo 8, Volumen IV, Número 46, p. 16.
[66] G. Mateos, A. Minor and V. Sánchez Michel, 'Una Modernidad Anunciada: Historia del Van de Graaff de Ciudad Universitaria", *Historia Mexicana* (2012), 245, 415-442.
[67] 'Experiencias Atómicas'. *Mañana*, (21 June 1952), 13.
[68] J. Avendaño Iniestrillas, 'Idea Universitaria Semillas Atómicas desde la Ciudad U', El Universal, (8 July 1952), 10.
[69] 'Experiencias Atómicas', Mañana, (21 June 1952), 13.
[70] J. Avendaño Iniestrillas, 'México y la Fuerza Atómica', *El Universal*, (17 July 1952), 4.
[71] J. Krige, 'Techno-Utopian Dreams, Techno-Political Realities: The Education of Desire for the Peaceful Atom', in *Utopia/Dystopia: Conditions of Historical Possibility*,

(ed. M. Gordin, H. Tilley and G. Prakash), Princeton University Press, 2010, 151-175.
[72] G. Hecht, 'Nuclear Ontologies', *Constellations* (2006), 13, 320-331; G. Hecht, 'The Power of Nuclear Things', *Technology and Culture* (2010), 51, 1-30.
[73] Photo CU-3496, AH-UNAM, Colección Universidad, Sección Construcción de Ciudad Universitaria.
[74] M. K. Coffey, *How a Revolutionary Art Became Official Culture; Murals, Museums and the Mexican State*, Duke University Press, 2012; E. X. de Anda, *Historia de la Arquitectura Mexicana*, Gustavo Gili, México, 1995.
[75] Letter from D. A. Ross, Installation Engineer of the High Voltage Engineering Corporation, to Carlos Lazo, 25 October 1950, Archivo General de la Nación (AGN), Archivo Carlos Lazo, Box 79, File Energía Nuclear 12/146.
[76] “We are worried about the deadline of the export-permit of the American Government, and we are trying very hard to have the housing ready as soon as possible”, 2 April 1951, *Idem*.
[77] Photo CU-3492, AH-UNAM, Colección Universidad, Sección Construcción de Ciudad Universitaria.
[78] 'Van de Graaff Accelerators HVEC', 12 August 1951, AGN, Archivo Carlos Lazo, Box 79, File Energía Nuclear 12/146.
[79] *Idem*, *ibidem*, 23 August 1950.
[80] C. Graef, 'Notas', *Boletín de la Sociedad Mexicana de Física* (1951), I, 36-37.
[81] Photo CU-3497, AH-UNAM, Colección Universidad, Sección Construcción de Ciudad Universitaria.
[82] 'Asistentes al IV Centenario de la Universidad de México', *Revista de la Universidad de México*, (1951), V (58), 9-10.