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Gago Coutinho and the Aircraft Navigation

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Gago Coutinho was one of the two Portuguese navigators that crossed by air the South Atlantic in the beginning of the 20th century. He developed a new model of sextant that could be used to measure the altitude of a star when flying without the need of the sea horizon. This new instrument was called "precision sextant" and used an artificial horizon line which was defined with the help of a water bubble. Due to his knowledge of Navigation, Astronomy, Geography and Mathematics he received from the Portuguese King D. Carlos I several assignments in Africa and Asia. Gago Coutinho received several important official medals and prizes, including the PhD *Honoris Causa* from the Universities of Lisbon and Oporto, and authored several scientific publications. He received the distinct position of Admiral of the Portuguese Navy in 1958, and died in the following year.

I. Introduction

GAGO Coutinho was one of the two Portuguese navigators that crossed by air the South Atlantic for the very first time in the beginning of the 20th century. They developed and used for the first time scientific methods of astronomic navigation when flying out of sight of land.

Fig. 1 Gago Coutinho on bord of the Lusitania seaplane.

Navigation is the art and science of maneuvering a ship efficiently and safely. The ancient navigators often found their way through the observation of physical landmarks, such as large rocks or trees along rivers and coastlines. When out of sight of land, they derived clues about their location by measuring water depth, monitoring wind pattern and wave shape, and observing the position of the Sun as it moved across the sky. At night they steered by the stars. Later navigators developed tools to measure the ships position and progress more precisely. They used a magnetic compass to determine direction and measured the height of the Sun or stars on the horizon to fix their position. Their progress and routes were recorded on nautical maps called charts. During the fifteen's century, Portuguese explorers were traveling south along the coast of Africa searching for the route to the orient. As a seafarer nears the equator heading south, Polaris disappears below the horizon. So, in southern seas, mariners had to have a different way of finding their latitude. Under orders from the Portuguese Prince Henry by 1480, Portuguese astronomers had figured out how to determine latitude using the position of the Sun as it moved north and south of the equator with the seasons, what we now call its "declination". In simple terms, the navigator could determine his 'altura' (latitude) by using his quadrant to take the altitude of the sun as it came to its greatest altitude at local apparent noon, and then making a simple correction for the position of the sun north or south of the equator according to the date. Such as ship navigation, human beings have been obsessed by the idea of flight since the dawn of recorded history. Men have always imagined themselves cavorting among the clouds, wheeling and soaring like birds. The first controlled flight in an aircraft was made on December 17th 1903 by the Wright Brothers. On October 23rd 1906, the Brazilian Santos Dumont made a public flight in Paris in his famous 14-Bis airplane. The world's first freight-carrying flight occurs only in November 7th 1910, when Philip Palmalee pilots a Wright Model B biplane, from Dayton to Columbus in Ohio, USA, flying 63 miles in one hour and two minutes, reaching a new speed record of 61 miles/h. The French pilot Louis Blériot flew the first maritime extension from Calais in France to Dover, England, on July 25th 1909, nearly 27 miles. Four years

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later, on September 23rd 1913, Roland Garros flew the 475 miles that separate France from Algeria, across the Mediterranean in 7h 53m. During the World War I (1914-1918) considerable development of aeronautics occurred, although most of the results of the planning had not time to come to daylight before the Armistice. An important example is the NC- 4 flying boat, designed by Glenn Curtiss, to become an alternative to the Allied shipping that was being threatened by submarine warfare. To fulfill the US Navy requirements, this aircraft was designed to fly between the United States and Europe on its own power, however with the external orientation help. Several ships were positioned along the route to provide radio assistance to the crew. Until then, all of the existing self-navigational tools where from maritime application, and they could not be applied to aviation due to the difficulty of the definition of the sky-line at a normal flight altitude.

Gago Coutinho developed a new model of sextant that could be used to measure the altitude of a star without the need of the sea horizon. This new instrument was called "precision sextant" (see Fig. 2) and used an artificial horizon line which was defined with the help of a water bubble[1-6]. It also used an illumination system to allow its use during weak light conditions, including the night. An advanced version of this instrument happened to be manufactured in Germany by C. Plath under the name of "System Admiral Gago Coutinho". Another instrument called "path corrector" was also developed by Gago Coutinho to calculate graphically the angle between the longitudinal axis of an airplane and the direction of flight, taking into account the intensity and the direction of the winds. The navigation methods and instruments were tested during short flights, and then applied with quite success to the flight between Lisbon (Portugal) and Recife (Brazil) in 1922. For the first time in the history of the aviation the crossing of the South Atlantic had been achieved and using an instrument that enabled an airplane's position to be determined by astronomic navigation when flying out of sight of land.

Fig. 2 Precision sextant used by Gago Coutinho in Crossing of the South Atlantic.

II. Gago Coutinho and the Aircraft Navigation

Gago Coutinho was born in Belém, Lisbon, on February 17th 1869. His work can be divided in four areas, which follows chronologically as areas for priority action: Navy, especially from 1893 to 1898, geographical works, between 1898 and 1920, air navigation, from 1919 to 1927, and history of navigation and discovery, from 1925 to 1958.

In 1885 he graduates from high school and registered himself at the Polytechnic School to prepare its entry into the Naval Academy a year later. Its record of promotions in the *Marinha de Guerra Portuguesa* (Portuguese Navy) demonstrates a clear rise: On October 30th 1886 - Aspiring 1st class; on January 21th 1890 – Midshipman; on March 07th 1891 - Second Lieutenant; on October 26th 1895 - First Lieutenant; on February 07th 1907 - Lieutenant Commander; on December 09th 1918 - Sea and War Captain; on March 30th 1922 - Rear Admiral (with distinction); on August 17th 1932 -Vice Admiral and on April 22nd 1958 - Admiral (by resolution of the National Assembly)[3]. In mid-December 1887 he made its first sea voyage to London as a cadet. In December 7th 1888 he embarked on the

Fig. 3 Portraits of Gago Coutinho at different stages of his life: on the left, in 1892 as Second Lieutenant; in the middle, in 1895 as First Lieutenant; on the right, as Rear Admiral in 1922.

"*Afonso de Albuquerque*" corvette in which he traveled to Mozambique and joined the Marine Division of East Africa, participating in the military occupation of the area of Tungue, Mozambique, to counteract the territorial ambitions of the Sultan of Zanzibar. He remains in this ship till January 16th 1891. Then follows a long list of ships which he navigated: Corvettes: "*Mindelo*", "*Duque da Terceira*", "*Rainha de Portugal*" and "*Vasco da Gama*"; Gunboats: "*Zaire*", "*Zambeze*", "*Douro*", "*Limpopo*" and "*Liberal*"; Transport ship: "*Pero de Alenquer*" (School-Ship): He was garrison officer of the gunboats "*Limpopo*" (in Angola) and "*Liberal*"(in Portuguese coastline). From his many travels two were famous: In the corvette "*Mindelo*", under the command of Admiral Augusto de Castilho, made its first Luanda-Rio de Janeiro cross Atlantic voyage, sailing most part of the trip; In transport ship "*Pero de Alenquer*" (1896) he made the cross Lisbon-Lourenço Marques, only by sailing, following as far as possible the historic route of *Vasco da Gama*, on his journey to India, nearly 400 years before. This crossing as came to provide great teachings for his studies of "*Náutica dos Descobrimentos"*. In March of 1898, he left the corvette "*Vasco da Gama*", to fulfill the first of several committees as a geographer overseas within the Portuguese Cartographic Commission, established in 1883. In addition to extensive and lengthy travels made in ships moved exclusively by engine, in ships with engine and sail, or in ships only sailing, Gago Coutinho crossed the sea serving the Portuguese Navy, covering the South Atlantic coast to coast and the western Indian Ocean. He would get this geographer job in the following decades, although in 1911 and 1912 he did made two more ships command: the gunboat "*Sado*", on mission in Portuguese India, and the gunboat "*Patria*", in East Timor campaign, between April and June 1912. During a native attack, he designed a pioneering system to increase the range of the ship's artillery. It is estimated that throughout his life Gago Coutinho had sailed 30,837 miles[3, 6]. His task assignments, on board of all the ships in which he served, were almost exclusively of "officer in charge of navigation" from which resulted the knowledge of the classic sextant. Already with 75 years old, on board the Portuguese ship "*Foz do Douro*", he did a new crossing, sailing from Santos (Brazil) to Leixões (Portugal) during which sailed 105 days using the historical astrolabe, like the ancient Portuguese sailors thereby confirming their views on the routes followed by them.

In 1885, the Berlin Conference on International Law devotes the recognition of effective occupation of overseas territories and calls for a more effective territorial division of its borders. In 1886 Portugal signs with France and with Germany the limits of Guinea and Angola, and in 1891 signs treaties with England relating to Mozambique borders with South Africa. This work requires knowledge of Navigation, Astronomy, Geography and Mathematics. By the decision of Carlos I, King of Portugal in 1898, Gago Coutinho receives order to develop this work. Between July 27th 1898 and April 19th 1899 he work on the East Timor demarcation border, where he carries out the reconnaissance of the coastline and the survey of an area of nearly 1,200 miles[2]. From September 5th 1900 to January 28th 1901 his work consisted on the delimitation of the border of Niassa, North Mozambique in an extension of nearly 190 miles. Later in the same year he worked in the delimitation border of Mozambique with British Central Africa territories. Then he went to Angola, where he devoted himself to the demarcation of the Noqui (North of Angola) border, by the end of 1901. Then he worked in the delimitation borders of Tete, Mozambique, from February 27th 1904 to December 18th 1905. From 1907 to 1910 he worked in geodesic triangulation of Mozambique from the southern border to the Barotze. Barotze was part of the policy of occupation of central Africa, which is symbolized in the called "*Mapa Cor de Rosa"* (see Fig. 4). In 1913 and 1914 he was accompanied by several officers, among them Sacadura Cabral, and demarcated the border between Angola and Rhodesia. During this mission some longitudinal determinations were made by two different and innovative forms: by Moon measures, and by underwater cable. These works are considered unprecedented in the "*Academia de Ciências de Portugal"* (Portuguese Academy of Sciences). In 1918 he completed his work as a geographer with the triangulation of the S. Tomé and Príncipe archipelago. In this mission he determined the point over which crosses the geodetic equator - the small island "*Ilha das Rolas*" (Pingeon Island) that has also received his name – "*Ilhéu Gago Coutinho*" (see Fig. 5). During the period (1898-1920), that Coutinho worked in Portugal geographical interests on almost all Portuguese overseas

Fig. 4 Detail of the map called "Mapa Cor de Rosa" oposing Portuguese and British interests in Africa.

Fig. 5 Monument over which crosses the geodetic equator, over S. Tome and Prince territory.

provinces, he has defined more than 1250 miles of borders and performed work of triangulation in areas greater than 300 miles^2. In its Barotze mission, he crosses Africa twice and traveled by foot around 3,250 miles. He walked an average of 26 miles a day, during two consecutive months, observing in this period more than 3,000 pairs of stars. Six of these twenty two years were spent in the jungle, living outdoors and sleeping in tents. Coutinho would be also the major driver of geographical studies in Portugal. He proposed to establish the Geographer Engineer degree that started in Portugal in 1921. All the acquired knowledge would serve as a base for further studies. His special appreciation for the unknown, adventure and machines, that could change the world, were particularly inherited by the readings of Jules Verne works. His great spirit of adventure led him to travel around the world using all means of transport until he felt attracted by the great invention of the time, the airplane. Its first flight took place on February 23rd 1917 in a "Maurice Farman" airplane at the Military School of Aviation in Vila Nova da Rainha (Portugal), accompanied by the navigator Sacadura Cabral. Gago Coutinho thought that aviation was a vast area of new scientific discoveries, in which he wanted to apply all the knowledge and numerous researches that he had collected either at sea or at land. The almost daily employment of the sextant that he had done in Africa during his geographer missions and the detailed knowledge of the possibilities of this instrument in land and sea, were more than enough to justify his opinion. The sextant used by the navy could not be applied to aviation due to the difficulty of the definition of the sky-line at a normal flight altitude. So, he developed the "precision sextant", that was a new model of sextant that could be used to measure the altitude of a star without the need of the sea horizon.

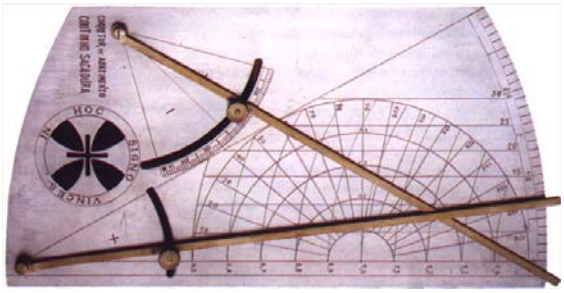

Fig. 6 The path corrector invented by Gago Coutinho.

He developed another instrument called "*path corrector*" (Fig. 6) to calculate graphically the angle between the longitudinal axis of an airplane and the direction of flight, taking into account the intensity and the direction of the winds. These navigation instruments were tested during short flights between July 21st 1920 and January 21st 1921. The use of these instruments was complemented by the use of *Auss* tables, or with the collection of *Houel* tables. In March 22nd 1921 an experimental flight was made from Lisbon to Madeira (520 nautical miles). Above all, he sought to prove that air navigation could be just as accurately pursued as sea navigation, by deploying sextants and other available astronomical devices. The trajectory should be a perfect straight line, and to verify the position of the aircraft three ships were used to control its position. The result was a complete success and he started to believe that they were prepared to initiate the transatlantic flight from Lisbon, Portugal to Rio de Janeiro, Brazil, through Cape Verde. This journey had to include several steps: Lisbon, Las Palmas, Gando, S. Vicente, S. Tiago, Penedos (St. Peter & St. Paul's Rocks), Fernando de Noronha, Recife, Baía, Porto Seguro, Vitória and Rio de Janeiro. Between March 30th to June 17th 1922, Gago Coutinho and Sacadura Cabral flew a Rolls Royce powered Fairey FIII-D flying boat "*Lusitania*" (Fig. 7). Notwithstanding their arrival at Penedos with hardly any fuel left, one of the aircraft floaters was destroyed by the crest of a wave and the hydroplane tilted and sank soon thereafter. There was still sufficient time to a cutter from "*República*" to arrive and the pilots were saved together with some books, the Gago Coutinho precision sextant, the chronograph and other

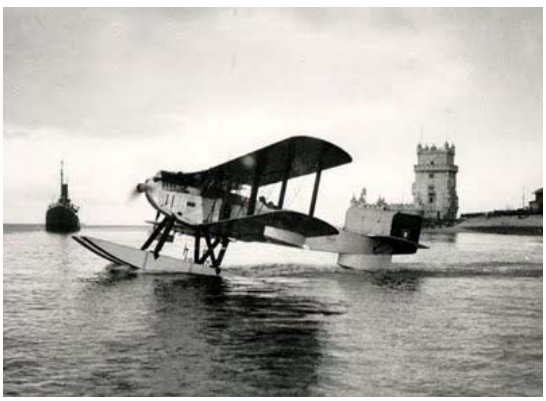

Fig. 7 Hydroplane Lusitania in Lisbon, near the Torre de Belem.

instruments. A second hydroplane named "*Portugal*" ended up in Fernando Noronha, because of weather related complications in the unloading attempts at St. Peter (& St. Paul's) Rocks. It was decided, therefore, to fly back from Fernando Noronha to St. Peter (& St. Paul's) Rocks where the "*Lusitania*" had sunk, and then proceed to Fernando Noronha and onwards to Recife. Five hours after take-off, the aviators saw St. Peter (& St. Paul's) Rocks from about 15 miles, but heavy rain made them decide to skip and turn back towards the refueling ship "*República*" located in route at azimuth 25 N, 70 miles from Fernando Noronha. About 1 hour and 50 minutes later, the engine stopped due to fuel carburetion hiccups, leading to a forced sea landing. They managed to restart the engine for some 55 minutes but, before they could take off, the engine stopped never to restart again. As the floaters began to sink slowly, one of the airmen sat on the engine to reduce the rear weight on the floaters. About 1 hour and 20 minutes later, when Coutinho and Cabral's hopes were vanishing under fatigue and sleepiness, a distant light in the dark emerged to which they responded with two gun shots. They were rescued by the freighter "*Paris City*" on its way from Cardiff to Rio de Janeiro. A third Fairey 17 named "*Santa Cruz*" was then shipped to Fernando Noronha in a Portuguese Navy ship "*Carvalho de Araújo*" and the journey was immediately continued without incidents. Finally, the 5,200 miles trip was concluded, only with internal means of navigation, after 62 hours of flight[9] (Fig. 8).

Fig. 8 Route of the first aircraft flight crossing the South Atlantic.

After 1922, Coutinho made a second crossing of the South Atlantic. In 1931 the Dornier manufacturer invited him to travel as a guest of honor, but he travels as co-navigator in the giant DO. X, a hydroplane with 12 engines of 610 hp each one, weighing more than 50 tons, where he found its own sextant on board. Other more important journeys on its own appointments are: Around the World cruiser Tour in 1898-1899 - Aden, Ceylon (Sri Lanka), Singapore, Timor, Macau, Hong Kong, Shanghai, Yokohama, Hawaii, S. Francisco, Chicago, Niagara, New York, Liverpool, Lisbon; 1927 – Lisbon, Funchal, Rio de Janeiro, New York, Paris, Lisbon; 1933 - Angola, Mozambique Train Crossing; 1935 – excursion to North Cape in the Milwaukee cruiser; 1939 – Lisbon, Rio de Janeiro, Pará, Panama Canal, Hollywood, Santa Fé, S. Francisco, Great Canyon, Kansas City, Chicago, Niagara, New York, Paris. He travels to Rio de Janeiro in 1923, 1925, 1927, 1929, 1931, 1932, 1934, 1936, 1938, 1939 (symbolically has commanded 22 civilian aircraft in the event that became known as *Revoada a Porto Seguro*), 1941, 1943, 1945 and 1946. In March 30th 1955, with 86 years, he makes its last flight Lisbon-Rio de Janeiro, traveling in a DC-4 of *Transportes Aéreos Portugueses* with the purpose of study the organization of regular flights to Brazil.

Gago Coutinho never patented his invention, which dates back to 1919. He used it successfully in 1921 and 1922. The sextant adoption has proved to be quite successfully, proved itself again a great precision in a first night crossing South Atlantic flight from Lisbon to Rio de Janeiro in 1927 with Captain Jorge Castilho as navigator. This journey was made with a Dornier Wal hydroplane named "*Argos*", which has been purchased with the aim of making the first circum navigation flight idealized by Coutinho and Cabral. Unfortunately Cabral lost his life in a plane crash in the North Sea on November 15th 1924, before realize this dream. Coutinho lost the circum navigation interest, because it was no longer meaningful without his friend. References to instruments and methods created in Portugal were published in almost all aeronautical magazines: *Nautical Magazine* (1923); *United States Naval Proceedings*; *Navigatione Aerea*, from Italy; *Icaro* and *Boletin Oficial de Aero Club de España*; *Conquete de l'air*, from Belgium; *L'air*; French revue; *Navigacion Aerea*, from J. Aymat, Barcelona, 1928 and *Avigation*, from Bradley Jones, London, 1931. In 1929 Captain Wittenman navigated the Graf Zeppelin around the world using a Coutinho sextant. With this spectacular record, the design was the hit of the 1930 Berlin Air Show. Until 1930, several countries had acquired this instrument: Portugal, Germany, Japan, France, Spain, U.S.A., Chile, Italy, Netherlands, Sweden, Argentina and Bolivia. The Deutsche Lufthansa created an air navigation course in the Naval School of Lubeck, where they thought the Coutinho´s sextant and its path corrector. Fr. Nissen managed to expand

the path corrector on air navigation above land, the *Coutinho-Fr. Nissen* path corrector. In the IV Congress of the International Air Navigation, Rome, 1927, Coutinho and Castilho, the Portuguese delegates presented and defended the Portuguese methods. In 1932 also in Rome, in the I International Congress of Transoceanic Aviators highest honors were given at the Portuguese crossings of the South Atlantic and their methods of navigation. It was used by many of the major airlines of the world throughout the 1930's.[12] The Portuguese Navy, who had rights to the development, contracted with the prestigious German firm of C. Plath for production. Coutinho regularly gave to them details for the improvement of the sextant until 1938. After the II World War, sextants evolved to become practical. The air transport aircraft came to be equipped with domes of transparent plastic, requiring no corrections to the readings, such as predicted by Coutinho.

Fig. 9 Frank Borman, the Apollo - 8 Commander on its visit to Portugal, honouring Gago Coutinho.

In February of 1969, by the Coutinho´s centenary birth, Frank Borman was in Portugal. The Commander of the Apollo-8, the first that orbited the Moon from 21st to 27th December 1968, gave a lecture at the Portuguese *National Laboratory of Civil Engineering*. He explained that the principle of Gago Coutinho was present in the Apollo-8 flight. In fact, "a sextant used in aeronautics for the first time in the world by the Portuguese genius" was mounted to a telescope. He detailed that these instruments was connected to a computer, which indicated that the final accuracy of the error was 0.001 degree. In 1971, Francis Millet Rogers, from Harvard University write a book entitled "*Precision Astrolabe; Portuguese Navigator and Transoceanic Aviation*" published in Lisbon by the *Academia Internacional da Cultura Portuguesa*, and distributed in the U.S.A. by W. S. Sullwold, Tauton, Mass. In 1973, Colter, H. C. publishes his work entitled "*An Early Portuguese Contribution to Air Navigation*", in the *Journal of Navigation*. In this paper, the author made references to Coutinho´s process of navigation "which made the calculations on the eve of the flight so that the line position was drawn in the flight chart nearly 5 minutes after the end of observation, and while crossing the Atlantic South, close to equator line, this time was reduced to 3 minutes" was an unprecedented simplification studied by Coutinho.

From 1925 to 1958 he dedicated himself to the history of navigation and discovery. His scientific, historical and literary work includes 1 book, 17 communications to the *Portuguese Sciences Academy*, 2 Communications to the *Portuguese Academy of History*, 2 communications to the *Geographic Society of Lisbon*, 6 International Congress Thesis, 3 National Congress Thesis, 23 Conferences, 25 Speeches, 2 Lectures, 5 Reports, 27 Collaborations with the *Geographic Society of Lisbon*, 16 Collaborations with *Naval Military Club*. However, he published numerous works in periodic publications, many of these works having been put together into two volumes organized and prefaced by Commander Moura Brás: *"A náutica dos descobrimentos."*; *"Os descobrimentos marítimos vistos por um navegador: colectânea de artigos, conferências e trabalhos inéditos do Almirante Gago Coutinho"*, Lisbon, Agência Geral do Ultramar, 1951-1952, in two volumes. Many other texts were published in two volumes edited by Teixeira da Mota: "*Obras completas de Gago Coutinho"*, Lisbon, Junta de Investigações do Ultramar, 1972. More works have been reported[3].

Admiral Gago Coutinho received the highest levels of national and international tributes. His Portuguese Military tributes included several insignias: The *"Grã-cruz da Ordem Militar da Torre, Espada, Valor, Lealdade e Mérito";* the "*Grã-cruz da Ordem Militar de Avis"*; the *"Grã-cruz da Ordem Militar de Cristo";* the *"Grã-cruz da Ordem Militar de Santiago da Espada"*; the "*Grã-cruz da Ordem do Império Colonial";* the *"Medalha de Ouro dos Serviços Distintos* and *Medalha Comemorativa do Exército Português com passadeira Timor, 1912-1913"* (Fig. 10).

His Foreign Military tributes included several insignias: the "*Grã-Cruz da Ordem de Mérito Aeronáutico"*, and the *"Grã-Cruz da Ordem Nacional do Cruzeiro do Sul"*, both from Brazil; the "*Gran Croce dell'Ordine della Corona d'Italia*"; the "*Grand Croix de l'Ordre du roi Léopold*", from Belgium; the *"Gran Cruz de la Orden Militar y Naval*", from Spain and the "*Commandeur de la Légion d'Honneur*", from France (Fig. 11).

Fig. 10 Some Portuguese Military Honoristic Insignias given to Gago Coutinho: from left to right, the "Grand Cross of the Ordem Militar da Torre, Espada, Valor, Lealdade e Mérito"; the "Grand Cross of Ordem Militar de Avis"; "Grand Cross of the Ordem Militar de Cristo" and the "Grand Cross of the Ordem Militar de Santiago da Espada".

Fig. 11 Some Foreign Military Honoristic insignias given to Gago Coutinho: On top, from left to right: "Grand Cross of the Ordem de Mérito Aeronáutico" (Brazil); "Commander Cross of the Legion 'Honneur" (France); "Grand Cross of the Ordine della Corona de Italia" (Italy); on bottom, from left to right: "Grand Cross of the Orden Militar" (Spain); "Grand Cross of the l´Orde du Roi Leopold" (Belgium) and "Grand Cross of the Ordem Nacional do Cruzeiros do Sul" (Brazil).

In 1923 he was commissioned to undertake the study of the experimental results of modern methods of aerial survey in Italy, France and Brazil. In 1926 was appointed Honorary Director of the Portuguese Naval Aviation, earning the right to use the pilot aviator distinctive topped with two palms. In 1928 he was appointed by the War Ministry to be the chairman of the Committee of Reorganization of Geographical, Cadastral and Cartographic Data. In the same year was commissioned to carry out mapping studies in France and Italy, and shortly thereafter sent to Brazil to take stock of cartographic documents relevant to the History of Portugal. In 1930 he collaborated in the Committee for the Navy Museum and the following year was appointed to the Committee responsible for organizing the Nuno Álvares Pereira centenary celebrations. He also published works on the theory of restricted relativity. He was a member of the "*Academia de Ciências de Lisboa*" (Lisbon Academy of Sciences, since 1928), member of the "*Academia de Ciências de Portugal*" (Portuguese Academy of Sciences), a member of the "*Academia de História*" (History Academy), a member of the "*Institute of History and Geography*" of Rio de Janeiro, honorary member and Gold Medal of the "*Sociedade Geográfica de Lisboa*" (Geographical Society of Lisbon, and member of the

"Sociedade Geográfica" (Geographical Society) of Rio de Janeiro, Pernambuco, Baía and Espírito Santo. He was Honorary Fellow of the Club de Engenharia of Rio de Janeiro. In 1933 he collaborated in the responsible committee for the study of the project of a monument to Infante D. Henrique at Sagres, Portugal. In the same year he returned to Mozambique for geographic work. In 1934 as Vice-Admiral he enters in reserve. He was Doctor Honoris Causa by the Universidade de Lisboa and Faculdade de Engenharia do Porto. In 1936 he was appointed to the Advisor Committee of the Historical Exhibition Occupation of the first Congress of the Portuguese Expansion in the world. Retired in 1944, was promoted to Admiral with distinction in 1958. During World War I (1914-1918), he drew secret routes allowing that ships could escape to the enemy submarines and aided the Allied blockade against the Kaiser´s Empire. It was an anonymous hero who saved thousands of lives. In 1958 the Combatants League of the Great World War made Coutinho his honorary member6. He died in Lisbon a day after completing ninety years, in February 18th 1959.

Fig. 12 Portuguese Navy christened two ships with the name of Gago Coutinho.

The Portuguese Navy, to honor the Admiral Gago Coutinho, christened two ships with his name: the ship A523, a ship of Investigation and Research working for the Hydrographic Institute, and the frigate F473 (Fig. 12).

Portugal has pays tribute to Coutinho in philately. In 1923, Portugal issue orders for a series of 16 stamps on the commemoration of the South Atlantic Crossing. In the centenary of Coutinho´s the birth (1969), four commemorative stamps were issued. These stamps circulated more than five years. In the fifty year of the first air crossing of the South Atlantic (1972), four stamps are issued to celebrate the occasion. These stamps circulated for more than ten years. Also in 1972, Angola, Macau, Mozambique, Sao Tome and Prince and East Timor - issued a stamp, celebrating that date. In 2009, by the fifty years of his death, Portugal issued a Postcard elusive to date. Spain, in 1930 in one of nine commemorative stamps of the Universal Exposition of Seville, honored the Portuguese navigators on the Crossing the South Atlantic.

Fig. 13 Some Portuguese philately tribute to Gago Coutinho: On the left, from top to bottom, the four stamps celebrating the centenary of his birth (1969); In the middle; three of the four stamps celebrating the fifty years of the South Atlantic Crossing (1972); On the right on top, a stamp from Cape Verde celebrating the south Atlantic Crossing, and at the bottom, one stamp celebrating the air transports in Portugal.

Portugal also pays tribute

Fig. 14 Some papermoney tribute to Gago Coutinho: On the left, one of the three bank notes issued in Mozambique, circulating from 1972 to 1975; On the right, a bank note issued in Portugal, circulating from 1978 to 1986.

to Coutinho in paper money. In Portugal, was issued a bank note allusive to the Admiral and the Crossing of the South Atlantic, circulating from 1978 to 1986. In Mozambique in 1972, three issued bank notes were issued. These bank notes circulated till the Country's independence.

Other kinds of honors were given to Coutinho: villages christened with his name. Several cities of Portugal and former colonies, paid tribute to the Admiral, by christening streets, avenues, squares, airports, with his name. He was several times an honorary citizen, also honorary member of charitable and recreation communities.

III. Conclusion

Gago Coutinho was born in Lisbon on the 17th February 1869. He served the Portuguese Navy almost exclusively as "officer in charge of navigation". He developed a new model of sextant that could be used to measure the altitude of a star when flying without the need of the sea horizon (the "precision sextant"). Due to his knowledge of Navigation, Astronomy, Geography and Mathematics, Gago Coutinho received several important official medals and prizes, including the PhD *Honoris Causa* from the Universities of Lisbon and Oporto, and authored several scientific publications. He had important missions in Africa and Asia where he employed his scientific knowledge. By 1919, he develops a new model of sextant that could be used to measure the altitude of a star without the need of the sea horizon, and used it successfully in the first Crossing of the South Atlantic in 1922. He continues his work by improving its sextant (called by Coutinho as "Precision Astrolabe") till 1938. Its work was successfully used in Astronautics fifty years after its first use in Aeronautics.

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