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ENGINEERS & STEM PARA PROFESORES:

INGENIEROS Y DESARROLLOS SOCIALES, CIENTÍFICOS Y TECNOLÓGICOS MUY CONOCIDOS / ENGINEERS AND WELL-KNOWN SOCIAL, SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENTS / ENGENHEIROS E DESENVOLVIMENTOS SOCIAIS, CIENTÍFICOS E TECNOLÓGICOS BEM CONHECIDOS / INGÉNIEURS ET DÉVELOPPEMENTS SOCIAUX, SCIENTIFIQUES ET TECHNOLOGIQUES BIEN CONNUS

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UNIVERSIDAD DE BURGOS

2025

Imagen de cubierta: Puente del ferrocarril sobre el río Forth, Edimburgo (Escocia), Reino Unido.
Autor de la fotografía, E. Montero. 06/12/2016

Edita: Servicio de Publicaciones e Imagen Institucional
UNIVERSIDAD DE BURGOS
Edificio de Administración y Servicios
C/ Don Juan de Austria, 1, 09001 BURGOS - ESPAÑA

ISBN: 978-84-18465-96-3

DOI: https://doi.org/10.36443/97884184657963

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Engineers&STEM para profesores:

https://projects.merlot.org/engineers&stem

Los autores, profesores de la Universidad de Burgos (España), Pontifícia Universidade Católica do Rio de Janeiro (Brasil), y Université Abdelmalek Esaadi en Tetuán, (Marruecos) han desarrollado, entre 2022 y 2024, el proyecto Engineers & STEM. Este proyecto ha sido promovido por la biblioteca digital MERLOT (Multimedia Education Resource for Learning and Online Teaching, www.merlot.org), de la California State University en los Estados Unidos. Los autores, editores del Engineering Board de MERLOT, agradecen a MERLOT el apoyo dado a este proyecto.

The authors, lecturers at the University of Burgos (Spain), Pontifícia Universidade Católica do Rio de Janeiro (Brazil), and Université Abdelmalek Esaadi in Tetouan, (Morocco) have developed, between 2022 and 2024, the Engineers & STEM project. This project has been promoted by the digital library MERLOT (Multimedia Education Resource for Learning and Online Teaching, www.merlot.org) of the California State University in the United States. The authors, editors of the MERLOT Engineering Board, thank MERLOT for the support given to this project.

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Cómo usar el proyecto Engineers & STEM / How to use the project Engineers & STEM / Como usar o projeto Engineers & STEM / Comment utiliser le projet Engineers & STEM

CÓMO USAR EL PROYECTO ENGINEERS & STEM

https://www.merlot.org/merlot/viewSite.htm?id=9165333&pageid=9190915

¿Cuál es el objetivo del proyecto Engineers & STEM?

El objetivo de este proyecto es contribuir a una mejor comprensión de la E de STEM en todo el mundo destacando el papel de la contribución de los ingenieros a desarrollos sociales, científicos y tecnológicos muy conocidos.

¿El proyecto Engineers & STEM está dirigido solo a ingenieros?

El proyecto está dirigido a maestros y estudiantes de educación primaria, educación secundaria (K-12) y educación en ingeniería, para proporcionarles un conjunto de casos de estudio que se pueden utilizar para tareas en el aula o discusión abierta dentro del marco de cualquier programa de educación STEM.

¿Quién puede utilizar los materiales del proyecto Engineers & STEM?

Los materiales del sitio web pueden ser utilizados gratuitamente por profesores y estudiantes de cualquier nivel, y pueden decidir cómo integrarlos en sus respectivos enfoques de enseñanza y aprendizaje.

¿Cuántos idiomas están disponibles en el sitio web del proyecto Engineers & STEM?

Como el proyecto tiene un alcance internacional, hemos desarrollado cada caso de estudio en inglés, español, portugués y francés.

¿Qué tipo de contenido incluye cada caso de estudio?

Cada caso de estudio contiene hechos y realizaciones que vinculan los usos comunes de la sociedad y aspectos educativos con los ingenieros que contribuyeron de alguna manera a su creación y desarrollo. Cada caso incluye:

- El contexto de hechos sociales, científicos y tecnológicos bien conocidos
- Un ejemplo que ilustra el contexto
- Una lista de sugerencias de temas para una discusión abierta
- Un video con una breve explicación del vínculo entre una invención o un hecho social conocido y el ingeniero que contribuyó a su desarrollo
- Una lista de enlaces externos de ampliación de la información para los lectores interesados
- Un enlace a un cuestionario de autoevaluación

¿Cómo puede utilizar un profesor los contenidos de cada caso?

Los maestros pueden proponer sesiones de discusión abiertas o escribir informes sobre el tema. Por ejemplo, los maestros pueden evaluar si los estudiantes han adquirido con éxito las ideas comparando su percepción antes y después de usar los materiales o ver los videos. Es el profesor quien decidirá cuándo y cómo utilizar los materiales disponibles para integrarlos en su programa educativo del curso: como trabajo antes de clase; en clase, como una forma de captar la atención de los alumnos o como un caso de estudio para la discusión; o como un recurso de estudio después de la clase.

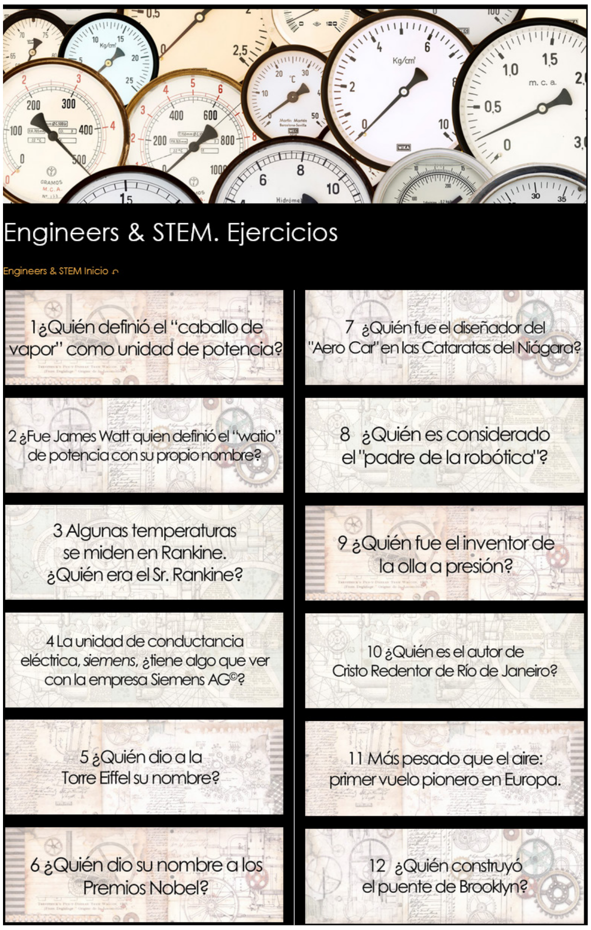
¿Cómo puede utilizar un estudiante el contenido de cada caso?

Los estudiantes pueden usar los materiales no solo para realizar tareas o escribir informes, sino también usar los cuestionarios de autoevaluación para evaluar su comprensión.

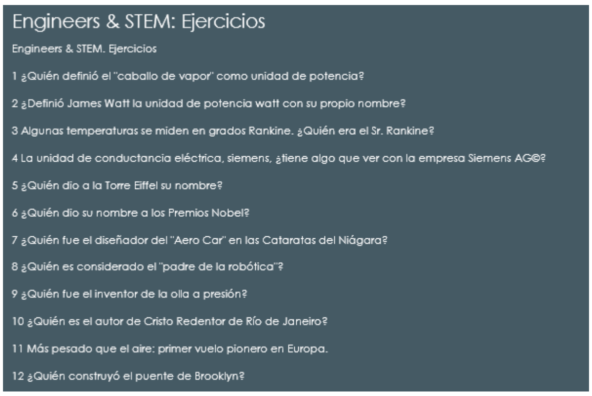
¿Cómo podemos navegar entre la variedad de casos?

Una vez que esté en la página principal del sitio web, y después de seleccionar el idioma, encontrará allí la imagen «Ir a Ejercicios y ejemplos».

Después de hacer clic en este icono, llegará a la página de ejercicios, con un conjunto de cuadros de texto vinculados al caso respectivo:



Además, en el menú de navegación superior, hay un menú contraído (símbolo:) que se puede expandir para mostrar la lista de enlaces a los casos respectivos.



HOW TO USE THE PROJECT ENGINEERS & STEM

https://www.merlot.org/merlot/viewSite.htm?id=9165333&pageid=9190914

What is the aim of the Engineers & STEM project?

The aim of this project is to contribute to a better understanding of the E of STEM worldwide by highlighting the role of engineers' contribution to well-known social, scientific, and technological developments.

Is the Engineers & STEM project addressed only to engineers?

The project is addressed to teachers and students of primary education, secondary education (K-12), and engineering education, providing them with a set of case studies that can be used for classroom assignments or open discussion within the frame of any STEM education program.

Who can use the materials of the Engineers & STEM project?

The website materials can be used for free by teachers and students at any level, as they could decide how to integrate them into their respective teaching and learning approaches.

How many languages are available on the Engineers & STEM project website?

As the project has an international scope, we have developed every case study in English, Spanish, Portuguese, and French.

Which type of content includes every case study?

Every case study contains facts and realizations that link common uses of society and educational issues with the engineers who contributed in some way to its creation and development.

Every case includes:

- the context of well-known social, scientific, and technological facts
- an example that illustrates the context
- a list of topic suggestions for open discussion
- a video with a short explanation of the link between a well-known social fact or invention and the engineer who contributed to its development
- a list of external links to broaden information for interested readers
- a link to a self-assessment questionnaire

How can a teacher use the contents of every case?

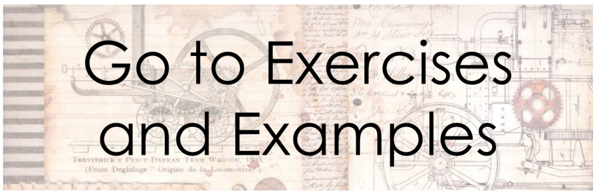
Teachers can propose open discussion sessions or writing reports on the topic. For instance, teachers can evaluate if the students have successfully conveyed the ideas by comparing their perceptions before and after using the materials or watching the videos. It is the teacher who will decide when and how to use the available materials to integrate them into his or her course map of the education program: as pre-work before class; in-class, as a way to gain the attention of the class or as a case study for discussion; or as a study resource after the class.

How can a student use the contents of every case?

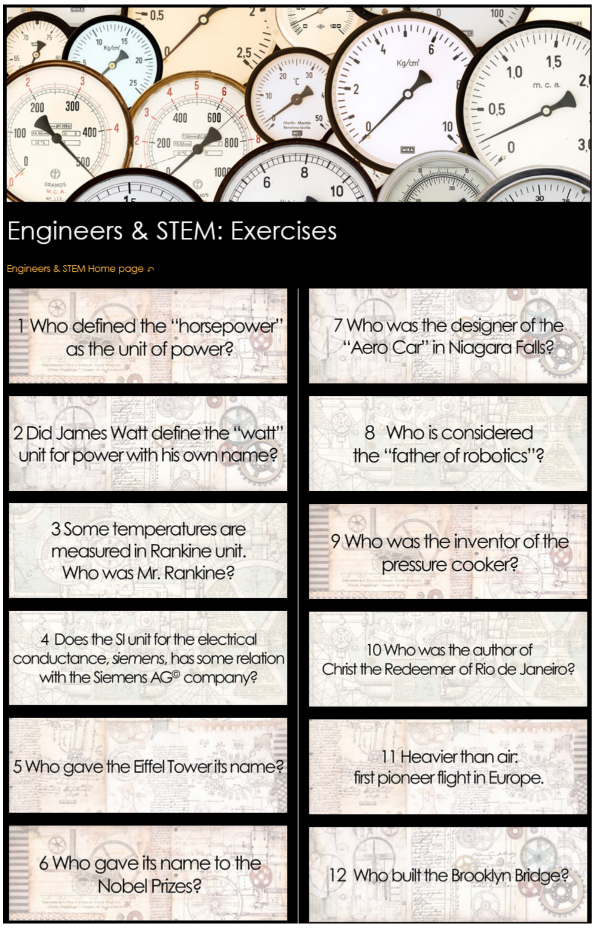
Students can use the materials not only to accomplish assignments or write reports but also use the self-assessment questionnaires to evaluate their understanding.

How can we navigate among the variety of cases?

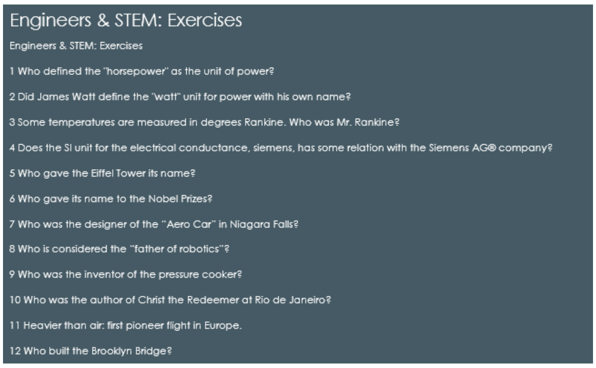
Once you are on the main page of the website, and have selected the language, you will find there the picture "Go to Exercises and Examples".



After clicking on this icon, you will reach the exercises page, with a set of textboxes linked to the respective case:



Additionally, in the upper navigation menu, there is a collapsed menu (symbol:) which can be expanded to show the list of links to the respective cases.



COMO USAR O PROJETO ENGINEERS & STEM

https://www.merlot.org/merlot/viewSite.htm?id=9165333&pageid=9193105

Qual é o objetivo do projeto Engineers & STEM?

O objetivo deste projeto é contribuir para uma melhor compreensão do E do STEM em todo o mundo, destacando o papel dos engenheiros para os conhecidos desenvolvimentos sociais, científicos e tecnológicos.

O projeto Engineers & STEM é dirigido apenas a engenheiros?

O projeto destina-se a professores e alunos do ensino primário, ensino secundário (K-12) e educação em engenharia, proporcionando-lhes um conjunto de casos de estudo que podem ser utilizados para ministrar aulas ou discussão aberta no âmbito de qualquer programa de educação STEM.

Quem pode usar os materiais do projeto Engineers & STEM?

O site e seus materiais podem ser usados gratuitamente por professores e alunos em qualquer nível, uma vez que podem decidir como integrá-los nas suas respetivas abordagens de ensino e aprendizagem.

Quantos idiomas estão disponíveis no site do projeto Engineers & STEM?

Como o projeto tem um âmbito internacional, desenvolvemos todos os estudos de caso em inglês, espanhol, português e francês.

Que tipo de conteúdo inclui cada caso de estudo?

Cada caso de estudo contém fatos e realizações que ligam os usos comuns da sociedade e as questões educativas com os engenheiros que contribuíram de alguma forma para a sua criação e desenvolvimento. Todos os casos incluem:

- o contexto de fatos sociais, científicos e tecnológicos bem conhecidos
- um exemplo que ilustra o contexto
- uma lista de sugestões de tópicos para discussão aberta
- um vídeo com uma breve explicação da ligação entre um fato social ou invenção bem conhecido e o engenheiro que contribuiu para o seu desenvolvimento
- uma lista de links externos para alargar a informação para os leitores interessados
- uma ligação a um questionário de autoavaliação

Como pode um professor usar o conteúdo de cada caso?

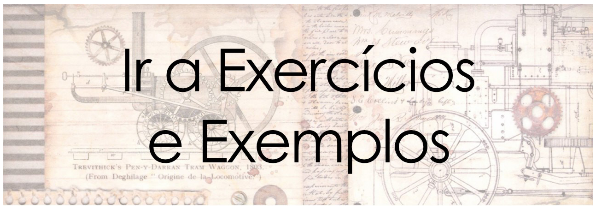
Os professores podem propor sessões abertas de discussão ou escrever relatórios sobre o tema. Por exemplo, os professores podem avaliar se os alunos adquiriram com sucesso as ideias comparando a sua perceção antes e depois de usar os materiais ou assistir aos vídeos. É o professor que decidirá quando e como usar os materiais disponíveis para integrá-los no seu cronograma de curso do programa de educação: como trabalho antes das aulas; na aula, como forma de chamar a atenção da classe ou como um estudo de caso para discussão; ou como um recurso de estudo após a aula.

Como pode um aluno usar o conteúdo de cada caso?

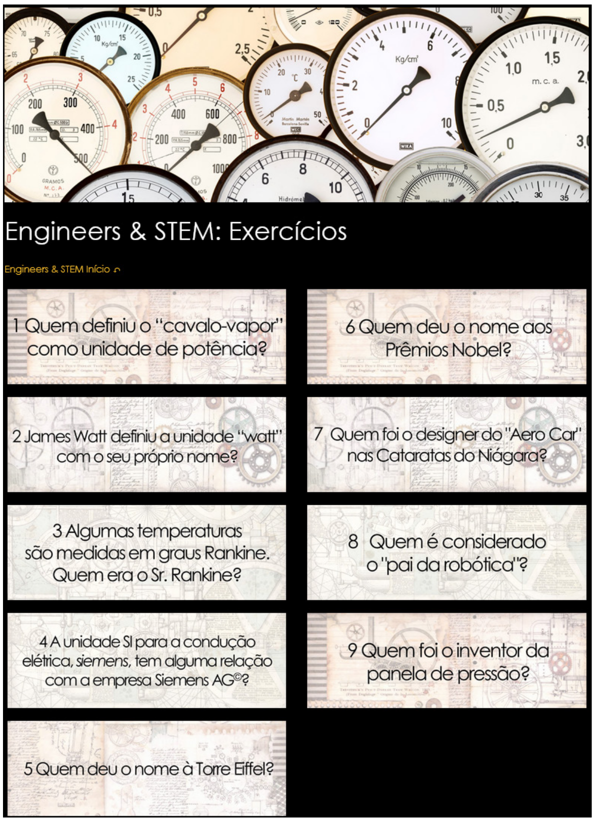
Os alunos podem usar os materiais não só para realizar tarefas ou escrever relatórios, mas usar os questionários de autoavaliação para avaliar a sua compreensão.

Como podemos navegar entre a variedade de casos?

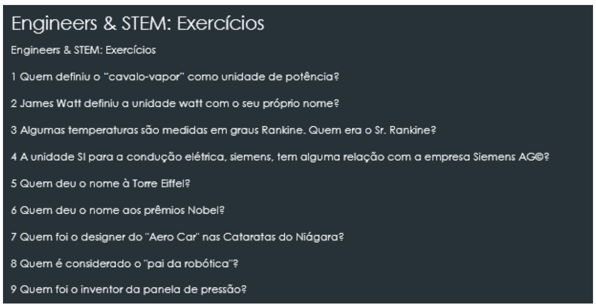
Uma vez que você está na página principal do site, e depois de selecionar o idioma, você vai encontrar lá a imagem «Ir a Exercícios e Exemplos».



Depois de clicar neste ícone, você chegará à página de exercícios, com um conjunto de caixas de texto ligadas ao respetivo caso:



Além disso, no menu superior de navegação, há um menu em colapso (símbolo:) que pode ser expandido para mostrar a lista de links para os respetivos casos.



COMMENT UTILISER LE PROJET ENGINEERS & STEM

https://www.merlot.org/merlot/viewSite.htm?id=9165333&pageid=9190921

Quel est l'objectif du projet Engineers & STEM ?

L'objectif de ce projet est de contribuer à une meilleure compréhension de l'E des STEM dans le monde entier en soulignant le rôle de la contribution des ingénieurs aux développements sociaux, scientifiques et technologiques bien connus.

Le projet Engineers & STEM s'adresse-t-il uniquement aux ingénieurs ?

Le projet s'adresse aux enseignants et aux élèves de l'enseignement primaire, secondaire (K-12) et de l'enseignement de l'ingénierie, en leur fournissant un ensemble de cas d'étude qui peuvent être utilisées pour des travaux en classe ou des discussions ouvertes dans le cadre de tout programme d'éducation STEM.

Qui peut utiliser les matériaux du projet Engineers & STEM ?

Le matériel du site Web peut être utilisé gratuitement par les enseignants et les étudiants à tous les niveaux, car ils peuvent décider comment les intégrer dans leurs approches d'enseignement et d'apprentissage respectives.

Combien de langues sont disponibles sur le site web du projet Engineers & STEM ?

Comme le projet a une portée internationale, nous avons développé chaque cas d'étude en anglais, espagnol, portugais et français.

Quel type de contenu inclut chaque étude de cas ?

Chaque étude de cas contient des faits et des réalisations qui relient les usages communs de la société et les aspects éducatifs avec les ingénieurs qui ont contribué d'une manière ou d'une autre à sa création et à son développement. Chaque cas comprend :

- Le contexte de faits sociaux, scientifiques et technologiques bien connus.
- Un exemple qui illustre le contexte
- Une liste de suggestions de sujets pour une discussion ouverte.
- Une vidéo avec une brève explication du lien entre une invention ou un fait social bien connu et l'ingénieur qui a contribué à son développement.
- Une liste de liens externes pour élargir l'information pour les lecteurs intéressés.
- Un lien vers un questionnaire d'auto-évaluation.

Comment un enseignant peut-il utiliser le contenu de chaque cas ?

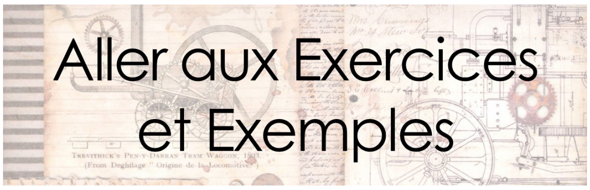
Les enseignants peuvent proposer des séances de discussion ouvertes ou rédiger des rapports sur le sujet. Par exemple, les enseignants peuvent évaluer si les élèves ont réussi à apprendre les idées en comparant leur perception avant et après avoir utilisé le matériel ou regardé les vidéos. C'est l'enseignant qui décidera quand et comment utiliser le matériel disponible pour l'intégrer dans son programme de cours : comme pré-travail avant le cours ; en classe, comme moyen d'attirer l'attention de la classe ou comme étude de cas pour la discussion ; ou comme ressource d'étude après le cours.

Comment un étudiant peut-il utiliser le contenu de chaque cas ?

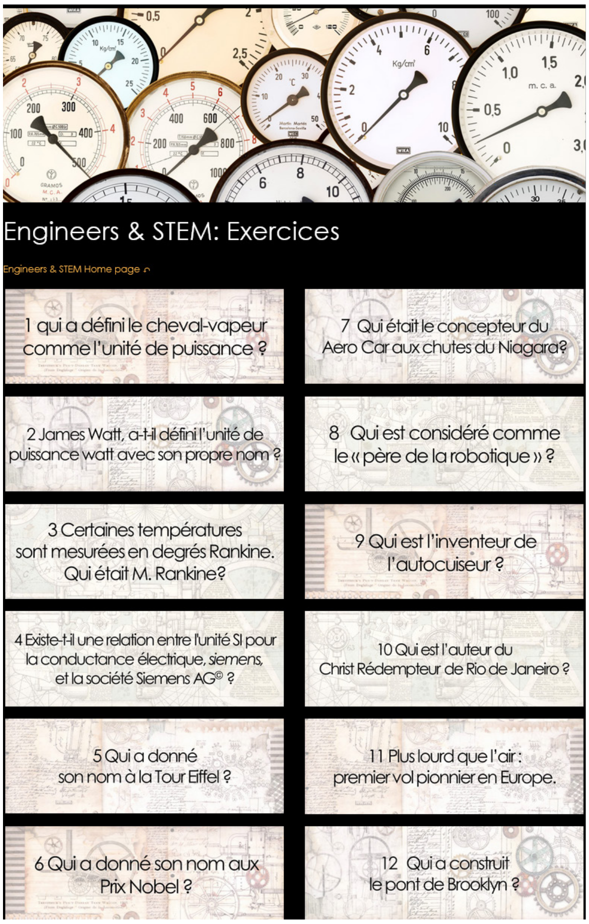
Les élèves peuvent utiliser le matériel non seulement pour accomplir des travaux ou rédiger des rapports, mais aussi pour évaluer leur compréhension.

Comment pouvons-nous naviguer parmi la variété des cas ?

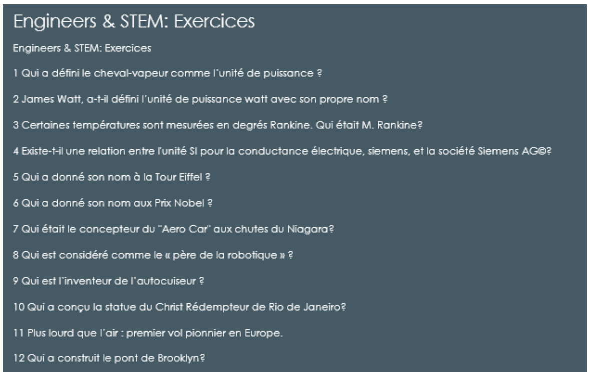
Une fois que vous êtes sur la page principale du site, et après avoir sélectionné la langue, vous y trouverez l'image « Aller aux exercices et exemples ».



Après avoir cliqué sur cette icône, vous accéderez à la page des exercices, avec un ensemble de zones de texte liées au cas respectif :



De plus, dans le menu de navigation supérieur, il y a un menu réduit (symbole :) qui peut être développé pour afficher la liste des liens vers les cas respectifs.



Caso de Estudio *Edición en español*

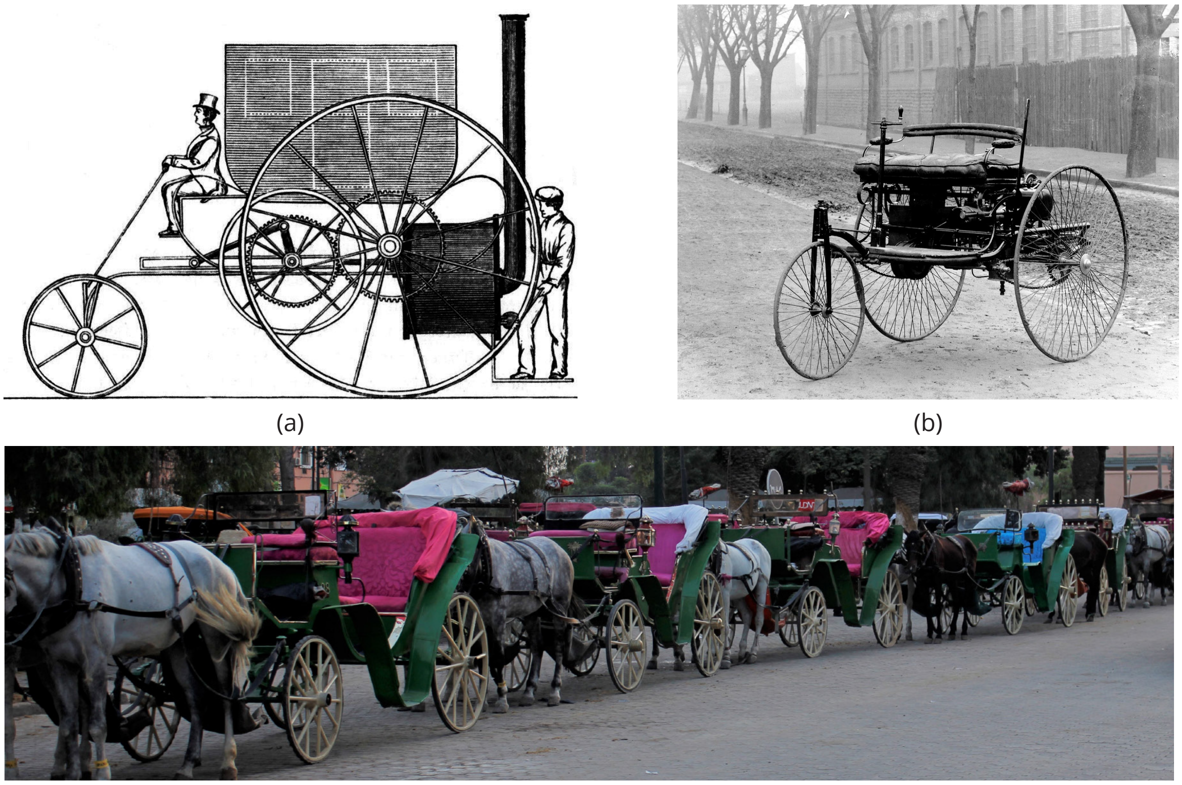
CASO DE ESTUDIO

Edición en español

https://www.merlot.org/merlot/viewSite.htm?id=9164311

1. ¿Quién definió el "caballo de vapor" como la unidad de potencia?

En los primeros años del automóvil podemos imaginar unos caballos tirando del automóvil de vapor de Richard Trevithick en 1801, que justamente podría subir una cuesta arriba, o el automóvil de gas de Karl Benz en 1886. Los primeros vehículos a motor mantuvieron la estructura de los coches de caballos, en los que el caballo era sustituido por un motor. El "caballo de vapor" resultaba ser una unidad apropiada y significativa.



(a) (b) (c)

Figura 1.1. (a) automóvil de vapor de Richard Trevithick en 1801; (b) automóvil de gas de Karl Benz en 1886; (c) coches de caballos.

¿Quién definió el "caballo de vapor" como la unidad de potencia? La respuesta es que la definición fue realizada por un ingeniero. El ingeniero escocés James Watt (1736 – 1819) comenzó su carrera profesional como constructo de instrumento, después trabajó como ingeniero civil y, finalmente, fundó la compañía Boulton y Watt para fabricar máquinas de vapor. Mejoró la eficiencia de la máquina y fue propietario de varias patentes sobre ella.

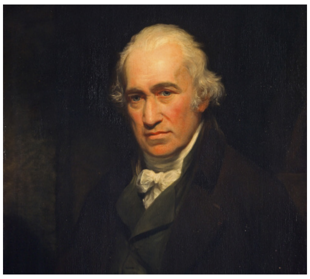
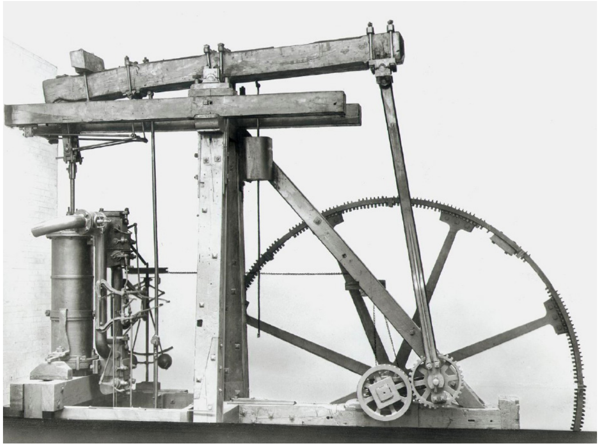
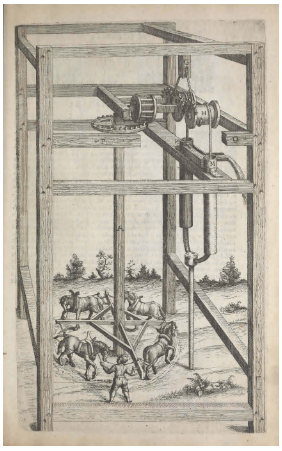


Figura 1.2. Retrato de James Watt.

Watt definió el motor y sus cualidades de una manera comercial e inteligente. Puesto que, en aquel tiempo, la máquina de vapor tenía que competir con el caballo como fuente de energía en la industria minera, decidió usar el caballo como unidad de medida.



(a)



(b)

Figura 1.3. (a) Máquina de vapor de Boulton&Watt, 1788.
(b) Bomba hidráulica para una mina, de Salomon de Caus en 1615.

¿Había una forma mejor de definir de presentar la ventaja de la máquina de vapor que indicando el número de caballos a los que podía sustituir? La cuestión pendiente era encontrar la equivalencia numérica para lograrlo.

Watt supuso que un caballo estándar podía tirar de 180 libras haciendo girar una rueda de molino 144 veces en una hora (o 2,4 veces por minuto). La rueda tenía un radio de 12 pies y, por tanto, el caballo recorrería 2,4 × 2π × 12 pies en un minuto. La potencia se calcula como el producto de la fuerza por la distancia dividido por el tiempo.

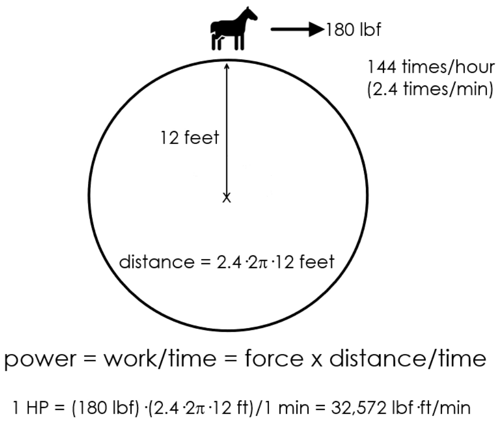


Figura 1.4. Definición del "caballo de vapor" (*horsepower*, HP) por James Watt.

1 HP (Watt) = fuerza x distancia/tiempo = (180 lbf) x (2,4 x 2π x 12 ft) / 1 min = 32,572 ft·lbf/min)

El resultado se redondeó a 33.000 libras·pie/minuto. La definición formal del "caballo de vapor" (*horsepower* en inglés, iniciales HP) fue publicada en 1809 por James Watt.

La idea fue no solo brillante, sino que la unidad resultante, el "caballo de vapor", era profundamente significativa para sus conciudadanos. Watt no solo mejoró la máquina de vapor como una alternativa técnica para la industria de la minería, sino que facilitó su comprensión para la gente común.

Los sistemas de medida que nacieron próximos a la experiencia de la gente son profundamente significativos, porque por medio de la medida de las cosas establecen un diálogo entre el hombre y la naturaleza. La significancia de las medidas tradicionales, como el "caballo de vapor", constituye una de virtudes más destacadas.

2. ¿Definió James Watt la unidad de potencia "watt" con su propio nombre?

Estamos acostumbrados a disponer de multitud de electrodomésticos que nos hacen la vida más fácil. Si damos la vuelta a estos aparatos encontraremos una etiqueta técnica. En todas ellas podemos leer una línea con el símbolo W, y solemos denominarlo vatios o "watt". Ello nos informa acerca de la potencia del aparato. ¿Cuál es el origen de este nombre?

(a) (b)

Figura 2.1. (a) cafetera y (b) tostadora, con sus etiquetas técnicas.

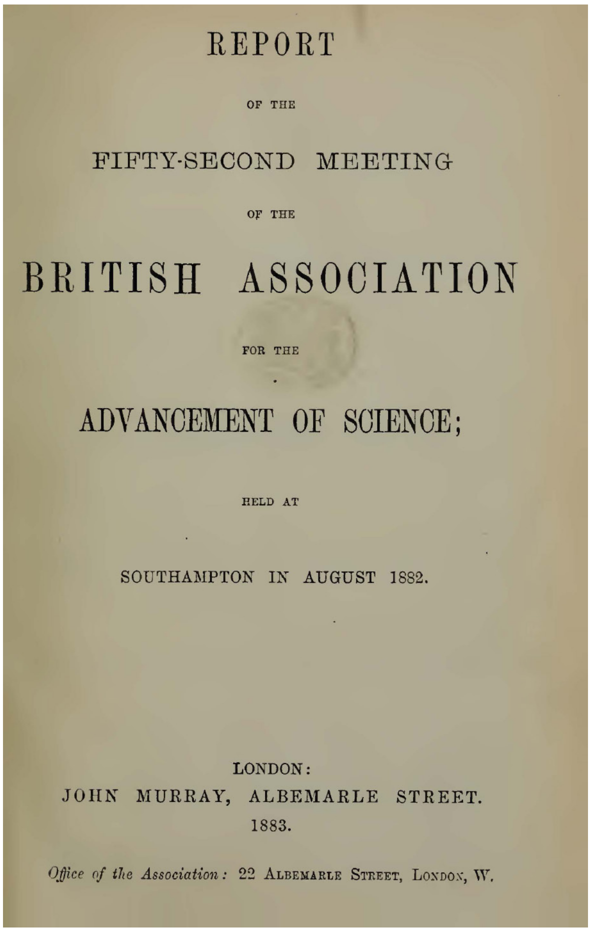
Como es muy famoso en el mundo entero, muchas personas podrían asociar este nombre con el ingeniero escocés James Watt. Pero ¿definió James Watt la unidad de potencia "watt" con su propio nombre?

James Watt definió el "caballo de vapor" HP, pero no definió la unidad de potencia del Sistema Internacional de unidades, el vatio o "watt" (W). El vatio como unidad de potencia fue propuesto y definido por el ingeniero eléctrico alemán Carl Wilhem Siemens.

Sir Carl Wilhelm Siemens (1823 – 1883) fue un ingeniero y hombre de negocios germano-británico. Es también conocido como Charles William Siemens ya que se nacionalizó como ciudadano británico. Fue un brillante emprendedor y hombre de negocios y, al mismo tiempo un afamado investigador científico. Trabajó en varias actividades industriales y obtuvo reconocimiento internacional como científico.

Figura 2.2. El ingeniero germano-británico Carl Wilhelm Siemens.

Durante el siglo XIX se generalizó el uso de dinamos para producir electricidad y de motores eléctricos para transformar la potencia eléctrica en mecánica. La necesidad de una unidad de potencia relacionada con las magnitudes eléctricas (voltio, amperio, ohmio) fue creciendo con los años. En 1882 Carl Wilhelm Siemens, presidente de la British Association for the Advancement of Science, propuso la adopción del vatio o "watt" en su informe presidencial anual para la Asociación. La unidad de potencia propuesta en el sistema CGS se denominó "watt" en honor del ingeniero James Watt.



REPORT

OF THE

FIFTY-SECOND MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

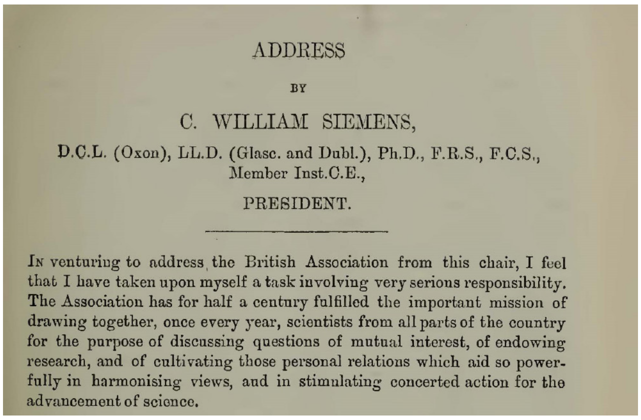
HELD AT

SOUTHAMPTON IN AUGUST 1882.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1883.

Office of the Association: 22 ALBEMARLE STREET, LONDON, W.

(a)



ADDRESS

BY

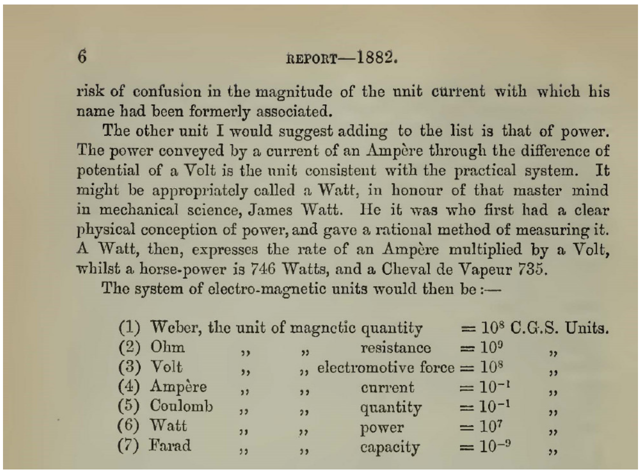
C. WILLIAM SIEMENS,

D.C.L. (Oxon), LL.D. (Glasc. and Dubl.), Ph.D., F.R.S., F.C.S., Member Inst.C.E.,

PRESIDENT.

IN venturing to address the British Association from this chair, I feel that I have taken upon myself a task involving very serious responsibility. The Association has for half a century fulfilled the important mission of drawing together, once every year, scientists from all parts of the country for the purpose of discussing questions of mutual interest, of endowing research, and of cultivating those personal relations which aid so powerfully in harmonising views, and in stimulating concerted action for the advancement of science.

(b)



6 REPORT—1882.

risk of confusion in the magnitude of the unit current with which his name had been formerly associated.

The other unit I would suggest adding to the list is that of power. The power conveyed by a current of an Ampère through the difference of potential of a Volt is the unit consistent with the practical system. It might be appropriately called a Watt, in honour of that master mind in mechanical science, James Watt. He it was who first had a clear physical conception of power, and gave a rational method of measuring it. A Watt, then, expresses the rate of an Ampère multiplied by a Volt, whilst a horse-power is 746 Watts, and a Cheval de Vapeur 735.

The system of electro-magnetic units would then be :—

(1) Weber,	the unit of	magnetic quantity	$= 10^8$	C.G.S. Units.
(2) Ohm	,,	,, resistance	$= 10^9$	,,
(3) Volt	,,	,, electromotive force	$= 10^8$	,,
(4) Ampère	,,	,, current	$= 10^{-1}$	,,
(5) Coulomb	,,	,, quantity	$= 10^{-1}$	,,
(6) Watt	,,	,, power	$= 10^7$	,,
(7) Farad	,,	,, capacity	$= 10^{-9}$	,,

(c)

Figura 2.3. (a) Ejemplar de agosto de 1882 de la British Association for the Advancement of Science. (b) comunicación del presidente de la asociación, C. William Siemens, a los asociados, (c) propuesta de C. William Siemens de, entre otras, la unidad de potencia "watt" en honor de James Watt.

El vatio o "watt" se definió de esta manera:

1 *watt* = 1 *ampere* x 1 *volt*

El reconocimiento internacional de esta unidad se alcanzó antes de finalizar el siglo XIX. En el mismo informe de 1882, Siemens había propuesto el julio o *joule* (J) como la unidad de energía y trabajo, que fue definitivamente aceptada por la British Association en 1888. Desde 1908 hasta 1948 la definición del vatio o "watt" estuvo relacionada con las magnitudes eléctricas. Desde 1948 la definición del vatio o "watt" se basa en el julio o *joule* de energía:

1 *watt* = 1 *joule/second*

Existen muchas unidades científicas denominadas con el nombre de personas, siendo la mayoría de ellas nombradas hace mucho tiempo. La mayoría de las denominaciones ocurrieron en la década 1860-70 para el sistema CGS y en la 1870-80 para el Sistema Internacional. El caso más frecuente es que la unidad recibiera su nombre de parte de alguien para homenajear al descubridor o porque nadie podía proponer un nombre mejor. Por convenio, el nombre de la unidad se escribe con minúscula, pero su abreviación con mayúscula.

3. Algunas temperaturas se miden en grados Rankine. ¿Quién era el Sr. Rankine?

En algunos libros de texto de ingeniería anglosajones que tratan temas de temperatura, se encuentra la mención a una temperatura medida en una escala denominada Rankine (R). A menudo se describen las relaciones entre esta escala y las de Celsius (ºC), Fahrenheit (ºF) y Kelvin (K) mediante los respectivos factores de conversión:

$$K = (5/9)R = (5/9)(^{o}F + 459.67) = {^{o}C} + 273.15$$

Al igual que con las otras muy conocidas escalas de temperatura, parece que esta escala fue nombrada con el apellido de un tal Sr. Rankine. ¿Quién era el Sr. Rankine?

La escala Rankine recibió su nombre del ingeniero escocés William John Macquorn Rankine (1820 - 1872). William Rankine trabajó como ingeniero mecánico y civil-. Aparte de su carrera profesional como ingeniero, desde 1855 fue profesor de Ingeniería Civil y Mecánica en la Universidad de Glasgow. Sus aportaciones a la ciencia de la Termodinámica fueron muy relevantes. Muchos de sus estudios se enfocaron hacia la eficiencia de los motores térmicos y la ciencia de la energía.

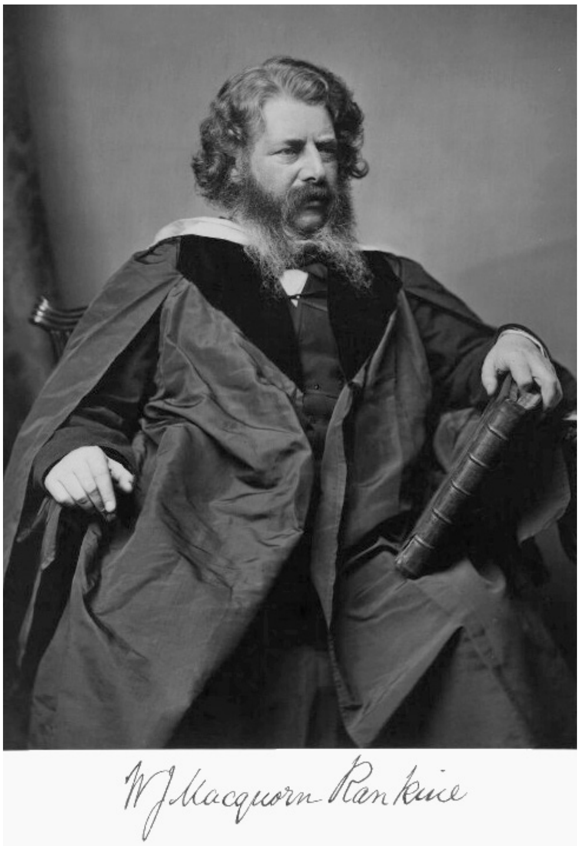


Figura 3.1. El ingeniero escocés William John Macquorn Rankine.

Escribió varios tratados de ingeniería, siendo el dedicado a las máquinas de vapor y otros motores primarios un manual de referencia durante muchos años en el siglo XIX. Obtuvo reconocimiento internacional de sus méritos y perteneció a instituciones muy prestigiosas como la Royal Society of Edinburgh y la Royal Society of London.

William Rankine publicó en 1859 su Manual de las Máquinas de Vapor y otros Motores Primarios. En la parte III, Rankine describe primero los hornos y calderas que suministran calor procedente de combustible quemado y, después, el motor por el cual el fluido calentado realiza trabajo mediante un mecanismo. Previamente, presenta las leyes y relaciones entre los fenómenos de calor y energía mecánica, que constituyen los principios de la termodinámica, de las que depende el trabajo y eficiencia de las máquinas térmicas.

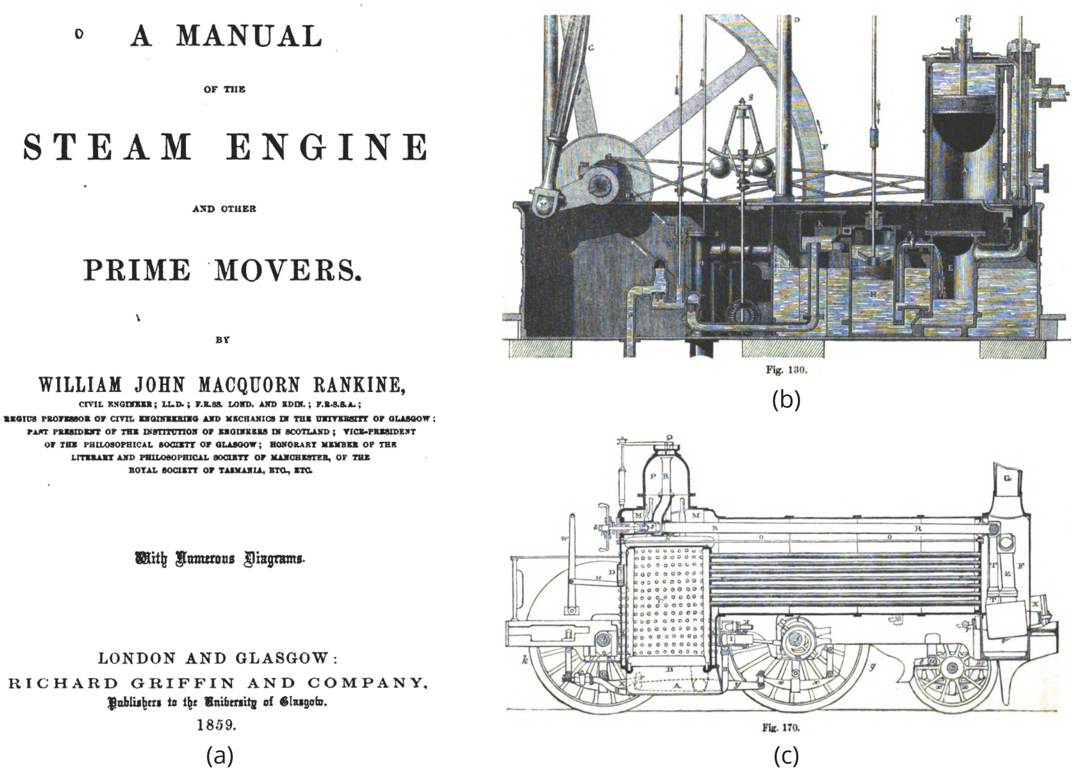


Figura 3.2. (a) Portada del libro *Steam Engine and Other Prime Movers (1859)*. (b) sección longitudinal de una máquina de vapor de vapor rotativa de doble acción, por W. Rankine. (c) sección longitudinal de una locomotora de vapor de seis ruedas, por W. Rankine.

Al presentar los conceptos e ideas sobre la temperatura, Rankine introduce la definición de escalas de Temperatura Absoluta, en relación con las escalas de temperatura ordinarias. Así, en relación con la escala Fahrenheit, propone la respectiva Temperatura Absoluta donde el cero absoluto corresponde a -461.2ºF. Esta escala de temperatura absoluta se denominará posteriormente escala Rankine.

De acuerdo con los datos disponibles en 1859, los cálculos de Rankine para el cero absoluto de la escala Celsius le condujeron al valor de -274, muy cercano al -273.15 de los cálculos actuales. Esta escala corresponde a la actual escala Kelvin, propuesta en 1848 por William Thomson (Lord Kelvin). Los cálculos de Rankine para el cero absoluto de la escala Fahrenheit condujeron al valor de -461.2. El valor actual es -459.67.

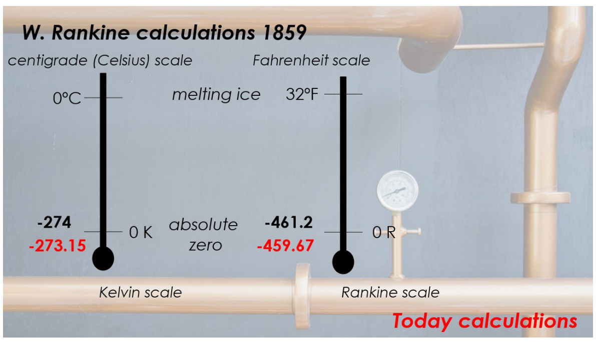


Figura 3.3. Comparación de las escalas de temperatura Celsius, Fahrenheit, Kelvin y Rankine.

No obstante, la escala Rankine tiene un uso muy limitado. Parece que, durante la segunda mitad del siglo XX, se crearon en los Estados Unidos de América programas informáticos que usaban ecuaciones que necesitaban una temperatura absoluta, y eligieron la Rankine antes de que la Kelvin se convirtiera en dominante para cálculos científicos. La razón por la que aún se usa en la industria aeroespacial es que existen muchos programas informáticos que se desarrollaron usando Rankine y, así, para ser compatible con los programas anteriores, es a menudo más simple seguir usando Rankine en los nuevos programas.

4. La unidad de conductancia eléctrica, "siemens", ¿tiene algo que ver con la empresa Siemens AG©?

En el Sistema Internacional de Unidades hay conjunto de unidades derivadas. Entre ellas podemos encontrar una denominada "siemens", cuyo símbolo es la letra S mayúscula, y que corresponde con la propiedad conductancia eléctrica.

SI derived units with special names and symbols[3]:15

Name	Symbol	Quantity	In SI base units	In other SI units
radian[N 1]	rad	plane angle	m/m	1
steradian[N 1]	sr	solid angle	m^2/m^2	1
hertz	Hz	frequency	s^{-1}	
newton	N	force, weight	$kg{\cdot}m{\cdot}s^{-2}$	
pascal	Pa	pressure, stress	$kg{\cdot}m^{-1}{\cdot}s^{-2}$	N/m^2
joule	J	energy, work, heat	$kg{\cdot}m^2{\cdot}s^{-2}$	$N{\cdot}m = Pa{\cdot}m^3$
watt	W	power, radiant flux	$kg{\cdot}m^2{\cdot}s^{-3}$	J/s
coulomb	C	electric charge	$s{\cdot}A$	
volt	V	electrical potential difference (voltage), emf	$kg{\cdot}m^2{\cdot}s^{-3}{\cdot}A^{-1}$	W/A = J/C
farad	F	capacitance	$kg^{-1}{\cdot}m^{-2}{\cdot}s^4{\cdot}A^2$	$C/V = C^2/J$
ohm	Ω	resistance, impedance, reactance	$kg{\cdot}m^2{\cdot}s^{-3}{\cdot}A^{-2}$	$V/A = J{\cdot}s/C^2$
siemens	S	electrical conductance	$kg^{-1}{\cdot}m^{-2}{\cdot}s^3{\cdot}A^2$	Ω^{-1}
weber	Wb	magnetic flux	$kg{\cdot}m^2{\cdot}s^{-2}{\cdot}A^{-1}$	$V{\cdot}s$
tesla	T	magnetic flux density	$kg{\cdot}s^{-2}{\cdot}A^{-1}$	Wb/m^2
henry	H	inductance	$kg{\cdot}m^2{\cdot}s^{-2}{\cdot}A^{-2}$	Wb/A
degree Celsius	°C	temperature relative to 273.15 K	K	
lumen	lm	luminous flux	$cd{\cdot}sr$	$cd{\cdot}sr$
lux	lx	illuminance	$cd{\cdot}sr{\cdot}m^{-2}$	lm/m^2
becquerel	Bq	activity referred to a radionuclide (decays per unit time)	s^{-1}	
gray	Gy	absorbed dose (of ionising radiation)	$m^2{\cdot}s^{-2}$	J/kg
sievert	Sv	equivalent dose (of ionising radiation)	$m^2{\cdot}s^{-2}$	J/kg
katal	kat	catalytic activity	$mol{\cdot}s^{-1}$	

Notes

1. ^ a b The radian and steradian are defined as dimensionless derived units.

Figura 4.1. Unidades derivadas del Sistema Internacional.

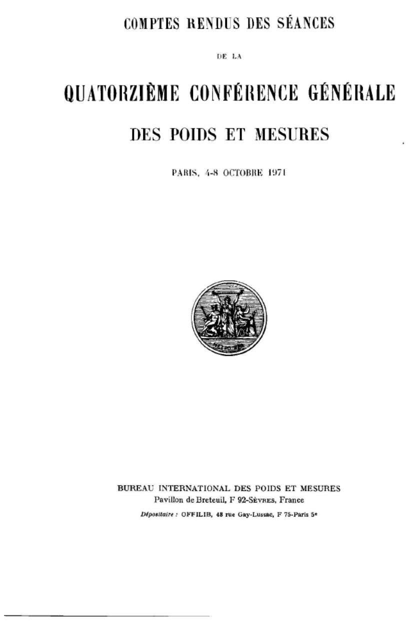
Por otra parte, casi en todo el mundo podemos encontrar el nombre Siemens asociado a, por ejemplo, electrodomésticos, motores eléctricos, trenes o sistemas de automatización industrial.

(a) (b) (c)

Figura 4.2. Productos de la compañía Siemens AG©. (a) motores eléctricos; (b) sistemas de automatización industrial; (c) trenes.

La unidad de conductancia eléctrica del Sistema Internacional de unidades, "siemens", ¿tiene alguna relación con la empresa Siemens AG©?

La decimocuarta Conferencia General de Pesos y Medidas aprobó, en 1971, la incorporación del "siemens" como unidad derivada.


COMPTES RENDUS DES SÉANCES
DE LA
QUATORZIÈME CONFÉRENCE GÉNÉRALE
DES POIDS ET MESURES
PARIS, 4-8 OCTOBRE 1971

BUREAU INTERNATIONAL DES POIDS ET MESURES
Pavillon de Breteuil, F 92-Sèvres, France
Dépositaire : OFFILIB, 48 rue Gay-Lussac, F 75-Paris 5e

(a)

Tableau 4. Les 22 unités SI ayant un nom spécial et un symbole particulier

Grandeur dérivée	Nom spécial de l'unité	Expression de l'unité en unités de base [(a)]	Expression de l'unité en d'autres unités SI
angle plan	radian [(b)]	rad = m/m	
angle solide	stéradian [(c)]	sr = m^2/m^2	
fréquence	hertz [(d)]	Hz = s^{-1}	
force	newton	N = kg m s^{-2}	
pression, contrainte	pascal	Pa = kg m^{-1} s^{-2}	
énergie, travail, quantité de chaleur	joule	J = kg m^2 s^{-2}	N m
puissance, flux énergétique	watt	W = kg m^2 s^{-3}	J/s
charge électrique	coulomb	C = A s	
différence de potentiel électrique [(e)]	volt	V = kg m^2 s^{-3} A^{-1}	W/A
capacité électrique	farad	F = kg^{-1} m^{-2} s^4 A^2	C/V
résistance électrique	ohm	Ω = kg m^2 s^{-3} A^{-2}	V/A
conductance électrique	siemens	S = kg^{-1} m^{-2} s^3 A^2	A/V
flux d'induction magnétique	weber	Wb = kg m^2 s^{-2} A^{-1}	V s
induction magnétique	tesla	T = kg s^{-2} A^{-1}	Wb/m^2
inductance	henry	H = kg m^2 s^{-2} A^{-2}	Wb/A
température Celsius	degré Celsius [(f)]	°C = K	
flux lumineux	lumen	lm = cd sr [(g)]	cd sr
éclairement lumineux	lux	lx = cd sr m^{-2}	lm/m^2
activité d'un radionucléide [(d, h)]	becquerel	Bq = s^{-1}	
dose absorbée, kerma	gray	Gy = m^2 s^{-2}	J/kg
équivalent de dose	sievert [(i)]	Sv = m^2 s^{-2}	J/kg
activité catalytique	katal	kat = mol s^{-1}	

(b)

Figura 4.3. (a) Publicación de la decimocuarta Conferencia General de Pesos y Medidas, 4-8 de octubre de 1971; (b) Tabla 4, con las unidades derivadas del Sistema Internacional.

El "siemens" (símbolo S) es la unidad derivada de conductancia eléctrica. En las ecuaciones, la conductancia se representa con la letra G. Un conductor tiene una conductancia de 1 *siemens* si una diferencia de potencial de 1 voltio produce una corriente de 1 amperio en él. Es la inversa de la resistencia eléctrica. Por ello, 1 *siemens* es igual al inverso de 1 ohm (Ω^{-1}).

$$G = 1/R = I/V$$

Unit: *siemens;* [S] = [A/V] = [Ω^{-1}], Ω, *ohm*; A, *ampere*; V, *volt*

Puede expresarse también en términos de las unidades base del Sistema Internacional. La misma palabra "siemens" se usa tanto para el singular como para el plural. La unidad "siemens" recibió su nombre por el ingeniero Ernst Werner Siemens.

Figura 4.4. Werner von Siemens.

Werner von Siemens (1816 - 1892) fue un brillante ingeniero eléctrico alemán, hombre de negocios y un inventor y científico de talento. En 1847 fundó la empresa Siemens y Halske, la compañía de construcción de telégrafos tras su invención del telégrafo de puntero. En unas décadas, la empresa se convirtió en líder de fabricación de equipamiento eléctrico operando internacionalmente. Esta compañía es la actual Siemens AG©. Además, Siemens se dedicó intensivamente a la investigación científica. Descubrió el principio dinamoeléctrico y sentó las bases para el uso de la energía eléctrica como fuente de potencia. Durante su vida, este pionero de la ingeniería eléctrica recibió números honores en reconocimiento de sus aportaciones a la ciencia y la sociedad.

En 1971, la unidad "siemens" no era totalmente nueva. Se usaba como unidad de conductancia eléctrica desde 1935, cuando la Comisión Electrotécnica Internacional recomendó su uso en la reunión plenaria que tuvo lugar en Scheveningen, Bruselas. Debe destacarse que Werner von Siemens contribuyó enormemente a los estudios técnicos y científicos sobre la resistencia eléctrica durante el siglo XIX.

12. Transmission Circuits for Telephonic Communication (a book), K. S. Johnson. D. Van Nostrand Company, Inc., 1927.
13. Transmission Networks and Wave Filters (a book), T. E. Shea. D. Van Nostrand Company, Inc., 1929.
14. Phase Distortion in Telephone Apparatus, C. E. Lane. *Bell System Tech. Jl.*, v. 9, July 1930, p. 493–521.
15. Harmonic Production in Ferromagnetic Materials, Eugene Peterson. *Bell System Tech. Jl.*, v. 7, Oct. 1928, p. 762–96.

I.E.C. Adopts MKS System of Units

At its plenary meeting of June 1935 at Scheveningen-Bruxelles, the International Electrotechnical Commission unanimously adopted the meter-kilogram-second (mks) or Giorgi system of units, 15 of the 25 constituent countries being represented. In this paper the principal historical antecedents of this action by the I.E.C. are outlined, and its principal import to electrical engineering is indicated. Since the preparation of this paper there have been further important developments in connection with the adoption of this system; reports of these developments, as translated from the original French texts, are given in appendixes I and II.

By
ARTHUR E. KENNELLY
HONORARY MEMBER A.I.E.E.
Harvard University, Cambridge, Mass.

As IS WELL KNOWN, the International Electrotechnical Commission is an international organization maintained by 25 countries. It was called into existence under the leadership of R. E. Crompton, in response to a recommendation of the International Electrical Congress of St. Louis (Mo.) in 1904. It was organized in 1906 with its secretariat in London, and C. LeMaistre has been its general secretary since that time. It comprises 24 advisory committees, each dealing with a particular electrotechnical subject, and it has held plenary meetings in London, Paris, Brussels, The Hague, Berlin, Cologne, Turin, Zurich, Bellagio-Rome, Geneva, Denmark, Scandinavia, and New York. It has accomplished much international electrotechnical work during its 29 years of activity.

At its plenary meeting, in June 1935, at Scheveningen-Bruxelles, the I.E.C. unanimously adopted the Giorgi System of meter-kilogram-second (mks) units, 15 countries being represented by the delegates present. Every electrical engineer should make himself acquainted with the significance of this decision. In effect, it replaces the 3 systems at present in use (namely, the absolute electromagnetic cgs system, the absolute electrostatic cgs system, and the practical series) by one practical system.

The fundamental units are so chosen that the present practical series or system becomes at once an absolute system. This brings about a great simplification in the teaching of units and in practical calculations.

For the present, the question of rationalization has been left for future consideration. As the permeability and permittivity of space are no longer unity, it would be an easy matter to fix their values so as to rationalize all calculations; that is to say, to arrange matters so that the multiplier 4π comes into those formulas only where it would be expected to enter.

Not since the International Congress of Electricians, at Paris[7] in 1881, has there been made a decision of similar international significance. It is the purpose of this paper to outline the principal historical antecedents of this I.E.C. action, to indicate its main import to electrical engineering, and to suggest a few of the implications it may involve. The account here given is, however, necessarily subsidiary to the official minutes of the meeting, which should be consulted by interested readers.

History of CGS and Practical Units

As early as 1848, resistance boxes had been produced in Germany, calibrated to correspond to the linear resistance of particular sizes of telegraph wire. Gauss and Weber, about 1850, showed how to make certain electric and magnetic measurements in absolute measure, adopting for this purpose the millimeter-milligram-second system (mms). In 1860, Werner Siemens introduced his mercury unit of resistance; i. e., a glass tube of one square millimeter cross sectional area and one meter long, filled with pure mercury, at zero degrees centigrade.

The British Association for the Advancement of Science (commonly abbreviated to B.A.), at its meeting in Manchester, of 1861, established a committee to report upon "standards of electrical resistance." This B.A. committee became famous for its pioneer work. It made annual reports[1] until 1867. It recommended the adoption of an absolute fundamental system of scientific units, and after trying the foot-grain-second system (fgs) advocated the meter-gram-second system (mgs). It computed theoretically, and worked out practically, approximate electric standards, especially that of electrical resistance, for which Latimer Clark suggested the name *ohm*. Because the mgs absolute electromag-

A paper recommended for publication by the A.I.E.E. committee on electrophysics, and scheduled for discussion at the A.I.E.E. winter convention, New York, N. Y., Jan. 28–31, 1936. Manuscript submitted Sept. 30, 1935; released for publication Nov. 1, 1935.

Scheduled for republication by the Institution of Electrical Engineers, London.

7. For all numbered references see list at end of paper.

December 1935 1373

(a)

Table I—Incomplete List of MKS Units and of Corresponding CGS Units

No.	Quantity	Symbol	MKS Unit	CGS Unit	CGS Units in One MKS Unit
	Mechanical				
1	Length	L	meter	centimeter	10^2
2	Mass	M	kilogram	gram	10^3
3	Time	T	second	second	1
4	Area	S	square meter	square centimeter	10^4
5	Volume	V	cubic meter (stere)	cubic centimeter	10^6
6	Frequency	f	hertz (cycle per second)	cycle per second	1
7	Density	d	kilogram per meter	gram per cubic centimeter	10^{-3}
8	Specific gravity		numeric	numeric	1
9	Velocity	v	meter per second	centimeter per second	10^2
10	Slowness		second per meter	second per centimeter	10^{-2}
11	Acceleration	a	meter per second per second	centimeter per second per second	10^2
12	Force	F	—— (joule per meter)	dyne	10^5
13	Pressure	p	—— (joule per cubic meter)	dyne per square centimeter, barye	10
14	Angle	α, β	radian	radian	1
15	Angular velocity	ω	radian per second	radian per second	1
16	Torque	τ	—— (joule per radian)	dyne ⊥ centimeter	10^7
17	Moment of inertia	J	kilogram-square meter	gram-square centimeter	10^7
	Energetics				
18	Work or energy	W	joule	erg	10^7
19	Angular work, $\tau\alpha$	W	joule	erg	10^7
20	Volume energy	w	joule per cubic meter	erg per cubic centimeter	10
21	Active power	P	watt	erg per second	10^7
22	Reactive power	jQ	var	erg per second	10^7
23	Vector power, $P \pm jQ$		watt ∠	erg per second	10^7
	Thermal				
24	Quantity of heat	Q	kilogram-calorie	gram-calorie	10^3
25	Temperature	θ	degree centigrade or Kelvin	degree centigrade or Kelvin	1
	Luminous				
26	Intensity	I	candle	candle	1
27	Luminous flux	ψ	lumen	lumen	1
28	Illumination	E	lux	phot	10^{-4}
29	Brightness	b	candle per square meter	stilb	10^{-4}
30	Focal power		diopter		10^{-2}
	Electrical				
31	Electromotive force	E	volt		10^8
32	Potential gradient	$\mathcal{E}$	volt per meter		10^6
33	Resistance	R	ohm		10^9
34	Resistivity	ρ	ohm-meter		10^{11}
35	Conductance	G	siemens, mho		10^{-9}
36	Conductivity	γ	siemens per meter, mho per meter		10^{-11}
37	Reactance	jX	ohm		10^9
38	Impedance, $R \pm jX$	Z	ohm ∠		10^9
39	Quantity	Q	coulomb		10^{-1}
40	Displacement	Q	coulomb		10^{-1}
41	Current	I	ampere		10^{-1}
42	Current density	i	ampere per square meter		10^{-5}
43	Capacitance	C	farad		10^{-9}
44	Specific inductive capacity	ϵ/ϵ_0	numeric	numeric	1
	Magnetic				
45	Magnetic flux	Φ	weber	maxwell	10^8
46	Flux density	B	weber per square meter	gauss	10^4
47	Inductance	L	henry		10^9
48	Relative permeability	μ/μ_0	numeric	numeric	1

(b)

Figura 4.5. (a) Publicación de los acuerdos de la Comisión Electrotécnica Internacional de 1935; (b) Tabla I, con las unidades MKS (Kenelly, 1935).

Como la conductancia eléctrica es la inversa de la resistencia eléctrica, (Ω^{-1}), el primer nombre propuesto para esta unidad fue el "mho", antes de que se denominara "siemens" en 1971. Como el inverso de un ohm, "mho" es la palabra ohm leída al revés, según la sugerencia hecha por William Thomson (Lord Kelvin) en 1883. Thomson propuso de la pronunciación adecuada de "mho" podría obtenerse tomando una grabación de fonógrafo y girándola al revés. Su símbolo es una letra griega omega invertida.

THOMSON ON ELECTRICAL UNITS OF MEASUREMENT. 149

3 May, 1883.

JAMES BRUNLEES, F.R.S.E, President, in the Chair.

Electrical Units of Measurement.

By Sir William Thomson, F.R.S., M. Inst. C.E.

In physical science a first essential step in the direction of learning any subject, is to find principles of numerical reckoning, and methods for practicably measuring, some quality connected with it.

(a)

in series. For the reciprocal of an ohm in the measurement of resisting power—for the unit reckoning of conductivity which will agree with the ohm—it is suggested to take a phonograph and turn it backwards, and see what it will make of the word "ohm." I admire the suggestion, and I wish some one would take the responsibility of adopting it; we should then have *mho* boxes of coils at once in general use. With respect to electric light,

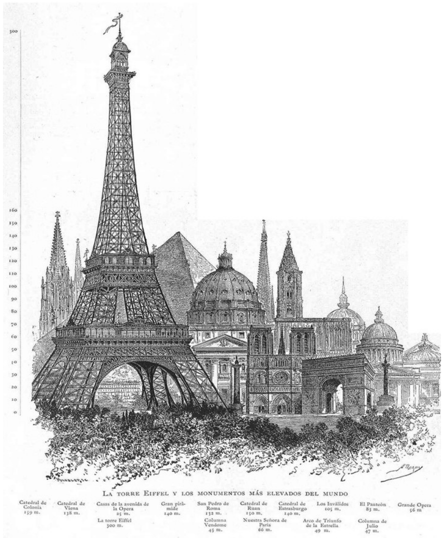
(b)

Figura 4.6. (a) Propuesta de William Thomson (Lord Kelvin) sobre las unidades eléctricas, 1883; (b) propuesta de denominación de la unidad de conductancia eléctrica.

5. ¿Quién dio a la Torre Eiffel su nombre?

Probablemente usted haya oído hablar de la Torre Eiffel, la famosa torre en París, Francia. Es una torre de piezas de acero en celosía, y era la obra principal de la Exposición Universal de 1889. La torre tiene 330 metros de altura, aproximadamente la misma altura que un edificio de 81 pisos. Fue la estructura más alta construida hasta 1930. La torre fue declarada Patrimonio Mundial de la UNESCO en 1991.

(a)

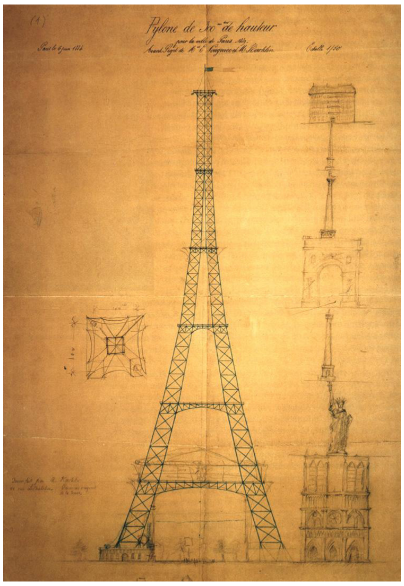


(b)

Figura 5.1. (a) Cartel de la Feria Universal de París, 1889; (b) Comparación de alturas de edificios muy conocidos en la publicación La Ilustración Artística, 1889, 367, pp.3.

El diseño de la torre se atribuye a Maurice Koechlin y Émile Nouguier, dos ingenieros, y Stephen Sauvestre, un arquitecto. Se concibió como "un gran pilón, que consiste en cuatro vigas de celosía separadas en la base y que se unen en la parte superior, unidas entre sí por cerchas de metal a intervalos regulares", en palabras de Koechlin. Nótese la pila de edificios esbozada en la Figura 5.2a, con Notre Dame en la parte inferior, indicando la escala de la torre propuesta.

La patente fue presentada en 1884. La torre fue construida entre 1887 y 1889.



(a)

(b)

Figura 5.2. (a) Croquis de Maurice Koechlin y Émile Nouguier y comparación el apilamiento de edificios conocidos; (b) Torre Eiffel, Patrimonio Mundial de la UNESCO en 1991.

Sus diseñadores trabajaban para la Compagnie des Établissements Eiffel, la empresa del ingeniero Gustave Eiffel. La Torre Eiffel recibió su nombre por Alexandre Gustave Eiffel (1832 - 1923), un ingeniero civil francés.

Figura 5.3. Gustave Eiffel, 1890.

Graduado de la École Centrale des Arts et Manufactures en Paris, se hizo un nombre como ingeniero con varios puentes para la compañía de ferrocarril francés. En 1868 fue cofundador de la empresa Eiffel and Company y comenzó a realizar trabajos en otros países de Europa y del extranjero.

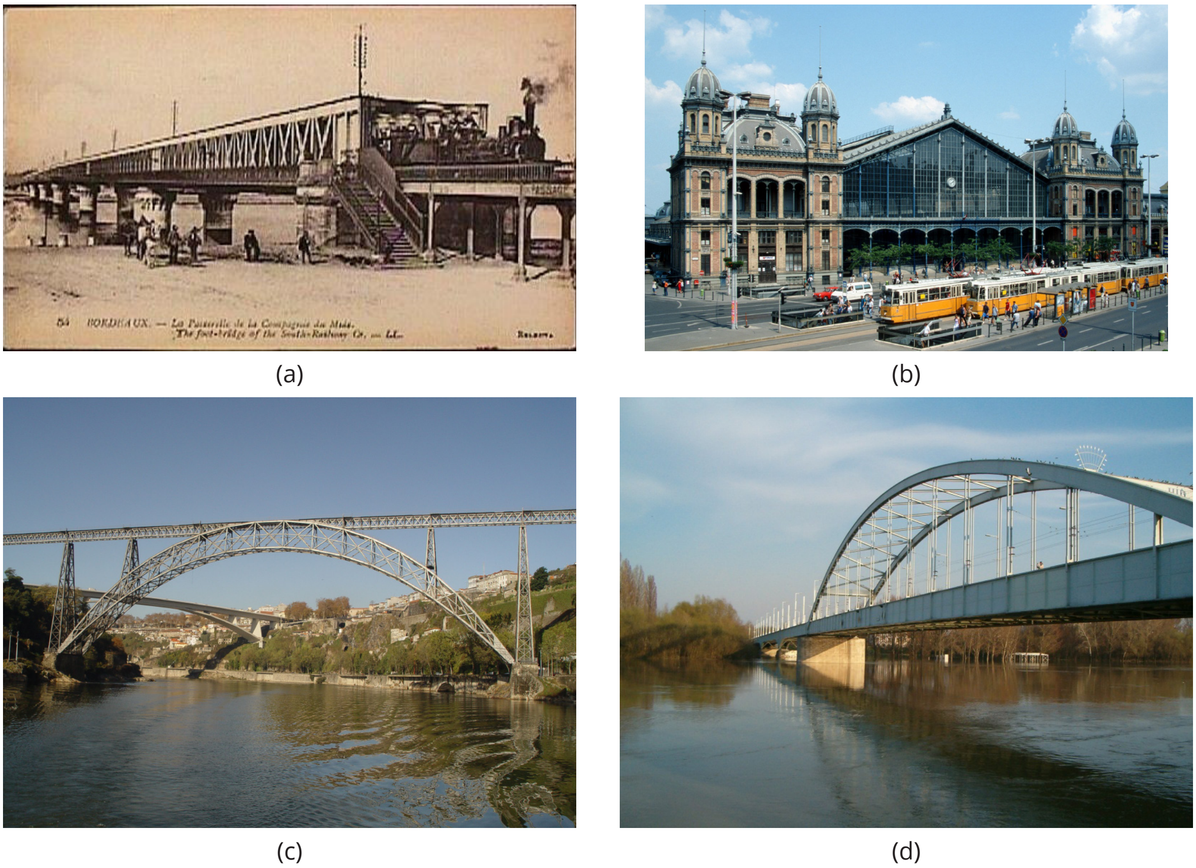


Figura 5.4. (a) Puente de Burdeos, Francia, 1861; (b) Estación de ferrocarril, Budapest, 1877; (c) Puente de Maria Pia en Oporto, Portugal, 1877; (d) Puente Belvárosi en Szeged, Hungría, 1881.

En 1881, Eiffel ideó una estructura que consistía en un pilón de cuatro patas para soportar la lámina de cobre que formaba el cuerpo de la Estatua de la Libertad en Nueva York. Toda la estatua fue erigida en los talleres de Eiffel en París antes de ser desmontada y enviada a los Estados Unidos.


(a)

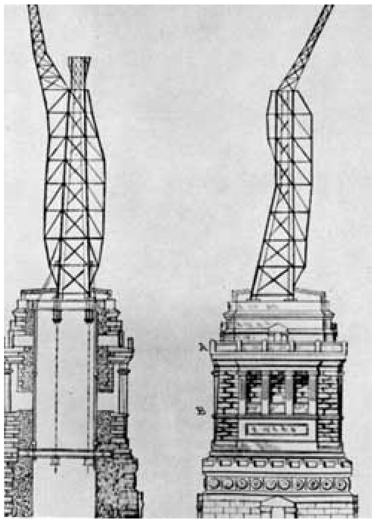
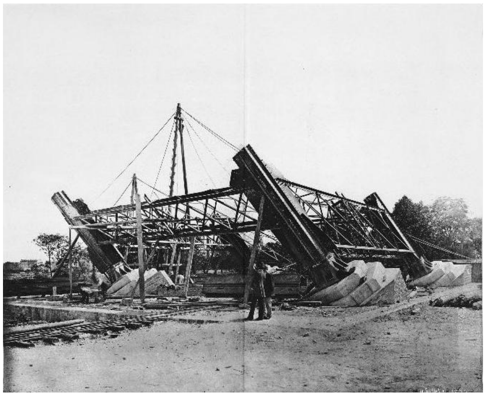
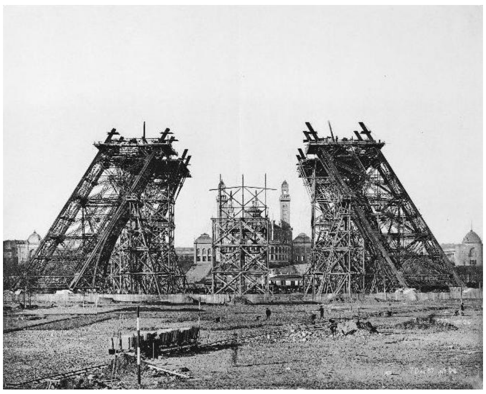

(b)

Figura 5.5. (a) Estatua de La Libertad, New York; (b) Estructura interna de la estatua de La Libertad.

La Torre Eiffel es la obra más famosa de Gustave Eiffel. La patente 164 364 fue presentada el 18 de septiembre de 1884. La torre fue construida entre 1887 y 1889. El trabajo estructural principal se completó a fines de marzo de 1889 y, el 31 de marzo, Eiffel celebró su finalización subiendo a un grupo de funcionarios del gobierno y representantes de la prensa a la cima de la torre. Como los ascensores aún no estaban en funcionamiento, el ascenso se realizó a pie y duró más de una hora.


(a)


(b)


(c)


(d)

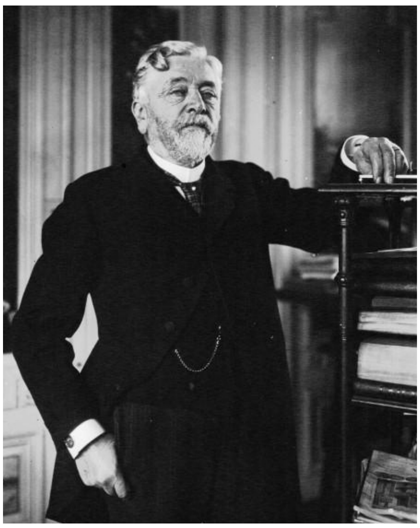

(e)


(f)


(g)

Figura 5.6. Construcción de la Torre Eiffel (a) 1 julio 1887; (b) 2 diciembre 1887; (c) 3 marzo 1888; (d) 4 mayo 1888; (e) 5 agosto 1888; (f) 6 diciembre 1888; (g) 7 marzo 1889.

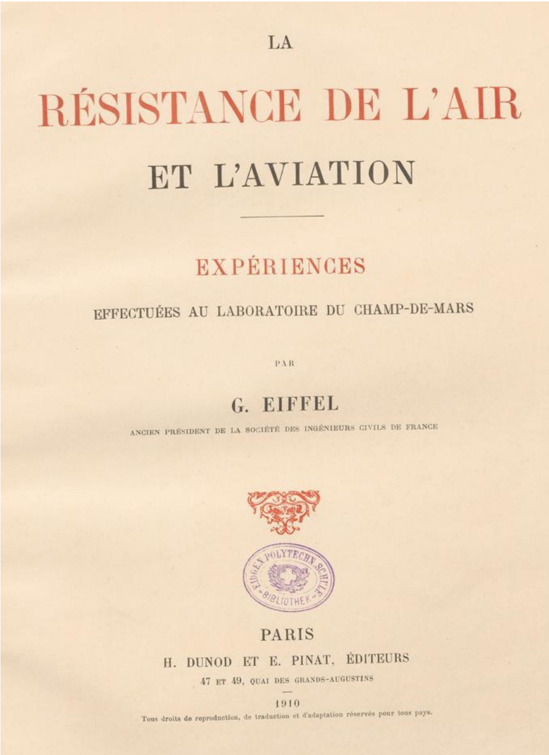
En 1893 Eiffel renunció a la dirección de la Compagnie des Établissements Eiffel y su nombre desapareció del título de la compañía. Luego comenzó una carrera como investigador en aerodinámica y su contribución en este campo es probablemente de igual importancia que su trabajo como ingeniero, aunque mucho menos conocida. En ese momento tiene más de 70 años. Comienza para él una nueva carrera de científico, que durará veinte años.

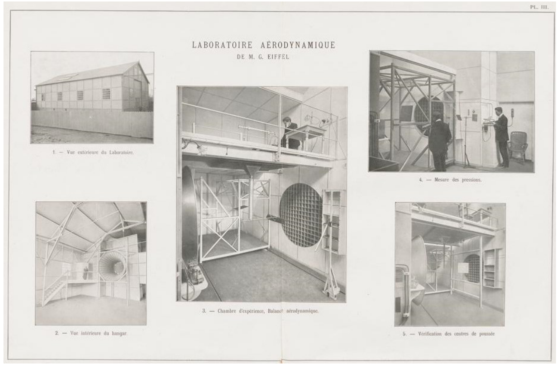

(a)


(b)

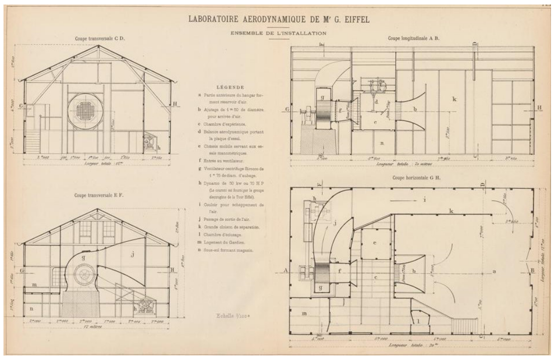
Figura 5.7. (a) Gustave Eiffel, 1910; (b) Eiffel con una maqueta de avión.

En 1909, Eiffel construyó su primer túnel de viento al pie de la Torre Eiffel en el Campo de Marte. Esta instalación estuvo operativa hasta 1911 para estudiar aerodinámica. A principios de 1912, instala en el distrito de Auteuil un nuevo túnel de viento con mayor rendimiento. Habiendo tenido éxito con su primer conjunto de pruebas, el túnel de viento de Eiffel estaba disponible para los pioneros en su conquista del aire: Farman, Bleriot, Voisin, Bréguet.





(b)



(a) (c)

Figura 5.8. (a) Portada del libro de Eiffel sobre aerodinámica, 1910; (b) Fotografías del laboratorio de Eiffel; (c) Planos del laboratorio de Eiffel

Una de las principales innovaciones de Eiffel fue la adición de un difusor al túnel de viento. Fue objeto de una patente fechada el 28 de noviembre de 1911. Este invento fue rico en consecuencias, ya que permitió a Eiffel reducir drásticamente la energía eléctrica requerida para tal instalación. A partir de esa fecha todos los túneles de viento han sido equipados con un difusor.

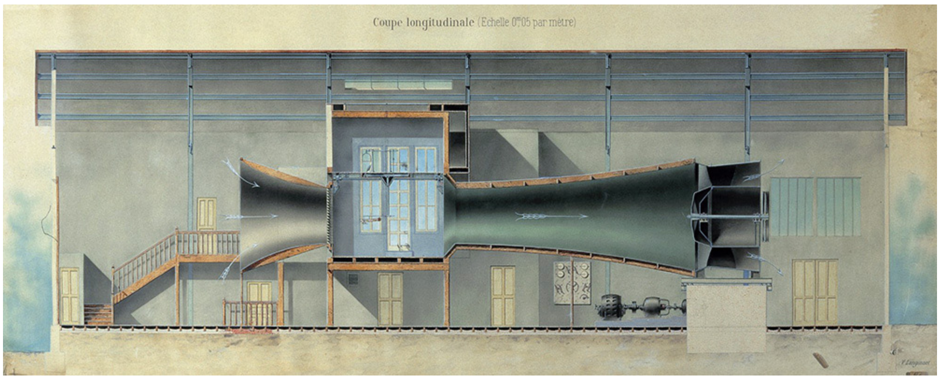


Figura 5.9. Túnel de viento de Eiffel.

Sus estudios sobre el rendimiento de los aviones fueron publicados en varios libros y revistas. En 1917 incluso presentó una patente para un avión de combate de alta velocidad.

La contribución de Eiffel a esta ciencia emergente de la aerodinámica fue reconocida en los Estados Unidos, donde recibió la medalla de oro de Langley en 1913, que solo había sido otorgada con anterioridad a Wilbur y Orville Wright.

6. ¿Quién dio su nombre a los Premios Nobel?

Los Premios Nobel, conocidos en todo el mundo, son cinco premios otorgados a aquellas personas que han conferido un gran beneficio a la humanidad. Los premios Nobel se otorgan en los campos de la Física, la Química, la Fisiología o Medicina, la Literatura y la Paz desde 1901. El Premio de Ciencias Económicas se añadió en 1969. Los premios Nobel son ampliamente considerados como los premios más prestigiosos existentes en sus respectivos campos.

Entre 1901 y 2017 los Premios Nobel fueron otorgados 585 veces a 923 personas y organizaciones. El Premio Nobel no fue otorgado entre 1940 y 1942 debido al estallido de la Segunda Guerra Mundial. Cada laureado recibe una medalla de oro, un diploma y un premio monetario.

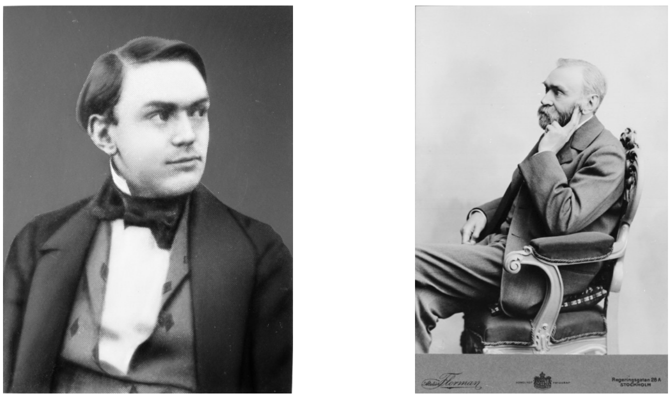
(a) (b)

Figura 6.1. (a) Medalla de los Premios Nobel; (b) Diploma de los Premios Nobel.

Entre los galardonados, hay algunas curiosidades. Seis galardonados han recibido más de un premio. El Comité Internacional de la Cruz Roja ha recibido el Premio Nobel de la Paz tres veces, más que cualquier otro. El Alto Comisionado de las Naciones Unidas para los Refugiados (ACNUR) ha sido galardonado con el Premio Nobel de la Paz en dos ocasiones. En Física, fue otorgado a John Bardeen dos veces. Lo mismo en Química, a Frederick Sanger. Dos galardonados han sido galardonados dos veces, pero no en el mismo campo: Marie Curie (Física y Química) y Linus Pauling (Química y Paz). Entre 892 premios Nobel, 48 han sido mujeres (hasta 2021). A seis premios Nobel sus gobiernos les impidieron aceptar el Premio Nobel: cuatro alemanes (1936-1939), un chino (2010) y un ruso (1958). Dos premios Nobel, Jean-Paul Sartre (Literatura, 1964) y Lê Đức Thọ (Paz, 1973), declinaron el premio.

¿Quién dio su nombre a los Premios Nobel?

Los Premios Nobel fueron nombrados por su creador, Alfred Bernhard Nobel (1833 - 1896). Nobel fue un químico, ingeniero, inventor, empresario y filántropo sueco. Nació en Estocolmo, donde vivió su primera infancia. En 1842 se mudó con su familia a San Petersburgo, donde la familia tenía un negocio de fabricación de máquinas herramienta y explosivos. El interés de Alfred Nobel en la tecnología y la ingeniería lo heredó de su padre.

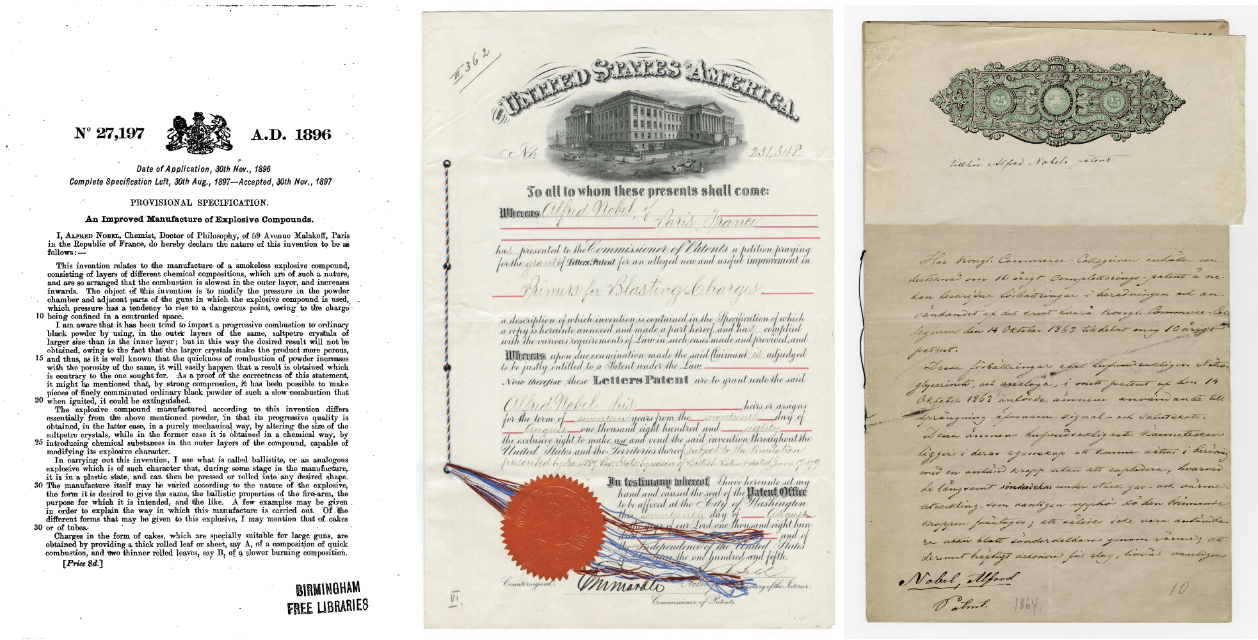


(a) (b)

Figura 6.2. (a) Alfred Nobel, joven (b) Alfred Nobel, adulto.

Nobel se convirtió en un excelente inventor e ingeniero. Presentó su primera patente para un medidor de gas en 1857. A lo largo de su vida, Nobel obtuvo 355 patentes a nivel internacional.

De vuelta a Suecia en 1859, Nobel se dedicó al estudio de los explosivos e inventó un detonador en 1863 y la dinamita en 1867, una sustancia más fácil y segura de manejar que la nitroglicerina más inestable. La dinamita fue patentada en los Estados Unidos y el Reino Unido y se utilizó ampliamente en la minería y la construcción de redes de transporte a nivel internacional.



Nº 27,197 A.D. 1896

Date of Application, 30th Nov., 1896
Complete Specification Left, 30th Aug., 1897—Accepted, 30th Nov., 1897

PROVISIONAL SPECIFICATION.

An Improved Manufacture of Explosive Compounds.

I, ALFRED NOBEL, Chemist, Doctor of Philosophy, of 59 Avenue Malakoff, Paris in the Republic of France, do hereby declare the nature of this invention to be as follows:—

This invention relates to the manufacture of a smokeless explosive compound, consisting of layers of different chemical compositions, which are of such a nature, and are so arranged that the combustion is slowest in the outer layer, and increases inwards. The object of this invention is to modify the pressure in the powder chamber and adjacent parts of the guns in which the explosive compound is used, which pressure has a tendency to rise to a dangerous point, owing to the charge being confined in a contracted space.

I am aware that it has been tried to impart a progressive combustion to ordinary black powder by using, in the outer layers of the same, saltpetre crystals of larger size than in the inner layer; but in this way the desired result will not be obtained, owing to the fact that the larger crystals make the product more porous, and thus, as it is well known that the quickness of combustion of powder increases with the porosity of the same, it will easily happen that a result is obtained which is contrary to the one sought for. As a proof of the correctness of this statement, it might be mentioned that, by strong compression, it has been possible to make pieces of finely comminuted ordinary black powder of such a slow combustion that when ignited, it could be extinguished.

The explosive compound manufactured according to this invention differs essentially from the above mentioned powder, in that its progressive quality is obtained, in the latter case, in a purely mechanical way, by altering the size of the saltpetre crystals, while in the former case it is obtained in a chemical way, by introducing chemical substances in the outer layers of the compound, capable of modifying its explosive character.

In carrying out this invention, I use what is called ballistite, or an analogous explosive which is of such character that, during some stage in the manufacture, it is in a plastic state, and can then be pressed or rolled into any desired shape. The manufacture itself may be varied according to the nature of the explosive, the form it is desired to give the same, the ballistic properties of the fire-arm, the purpose for which it is intended, and the like. A few examples may be given in order to explain the way in which this manufacture is carried out. Of the different forms that may be given to this explosive, I may mention that of cakes or of tubes.

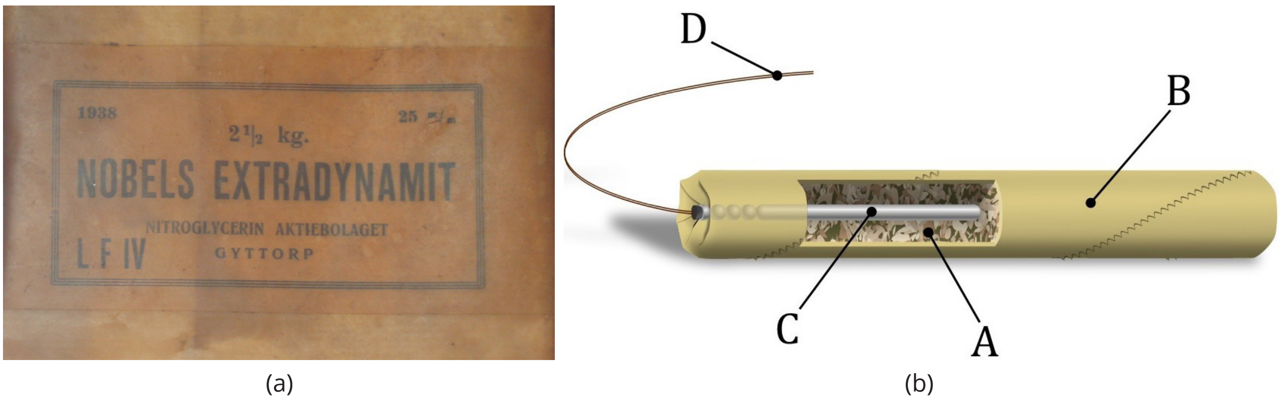
Charges in the form of cakes, which are specially suitable for large guns, are obtained by providing a thick rolled leaf or sheet, say A, of a composition of quick combustion, and two thinner rolled leaves, say B, of a slower burning composition.

[*Price 8d.*]

(a) (b) (d)

Figura 6.3. Patentes de explosivos de Alfred Nobel (a) Gran Bretaña (b) Estados Unidos de América; (c) Suecia.

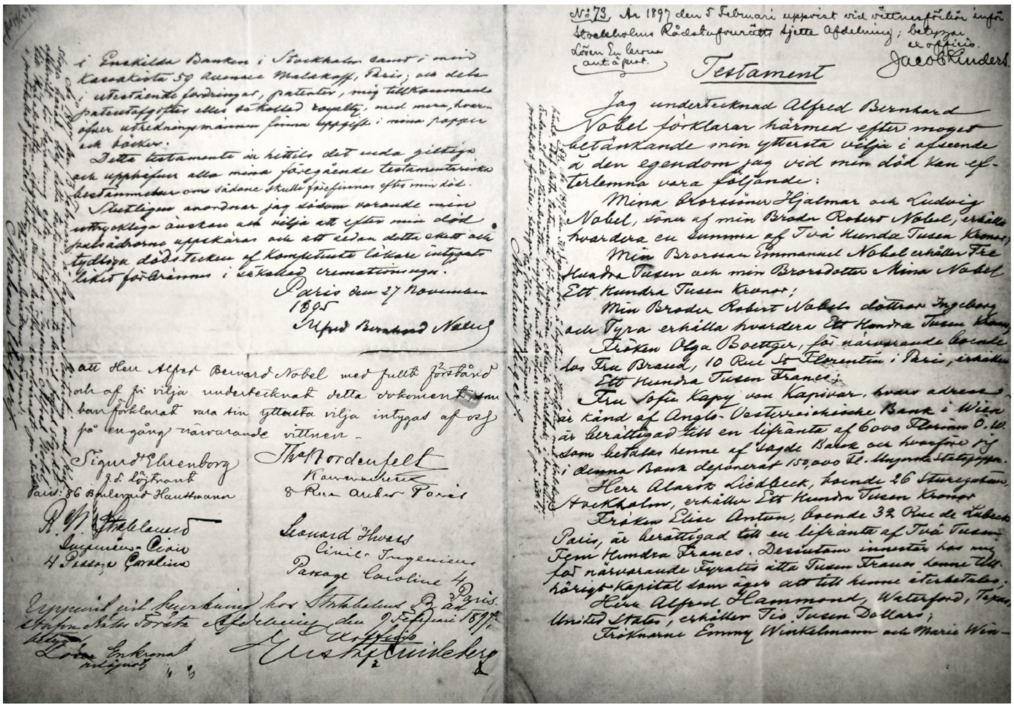
Con el fin de mejorar la imagen de su negocio por las controversias asociadas con explosivos peligrosos y la guerra, Nobel también había considerado nombrar la sustancia tan poderosa como “Polvo de seguridad de Nobel”, pero se conformó con dinamita en su lugar, refiriéndose a la palabra griega para “poder” (δύναμις). Al final de su vida, su negocio había establecido más de 90 fábricas de armamento, a pesar de su carácter aparentemente pacifista.



(a) (b)

Figura 6.4. (a) caja de dinamita Nobel (b) cartucho de dinamita: [A]Tierra de diatomeas (o cualquier otro tipo de material absorbente) empapada en nitroglicerina, [B] Recubrimiento protector que rodea el material explosivo, [C] Detonador, [D] Cable conectado al detonador.

Finalmente, Nobel decidió donar la mayor parte de su riqueza para fundar el Premio Nobel como su mejor legado. En 1895 firmó su último testamento y reservó la mayor parte de su patrimonio para establecer los Premios Nobel, que se otorgarían anualmente sin distinción de nacionalidad.


Testament

Jag undertecknad Alfred Bernhard Nobel förklarar härmed efter moget betänkande min yttersta vilja i afseende å den egendom jag vid min död kan efterlemna vara följande:

Paris den 27 November 1895

Alfred Bernhard Nobel

Figura 6.5. Testamento de Alfred Nobel, 1895.

Nobel fue elegido miembro de la Real Academia Sueca de Ciencias en 1884, la misma institución que más tarde seleccionaría a los galardonados parados de los Premios Nobel, y recibió un doctorado honorífico de la Universidad de Uppsala en 1893. El elemento químico Nobelio, con el símbolo No y el número atómico 102, fue nombrado en honor de Alfred Nobel. Como todos los elementos con un número atómico superior a 100, el nobelio solo se puede producir en aceleradores de partículas.

Nobel fue también poeta y dramaturgo, con un gusto por lo melodramático, aunque la mayoría de sus escritos permanecieron inéditos. Nobel escribió el drama Némesis en el último año de su vida y el guion tuvo una publicación limitada después de su muerte en 1896. Después de un siglo, la primera, y hasta ahora la única producción fue en el teatro Intima de Strindberg en Estocolmo en 2005.

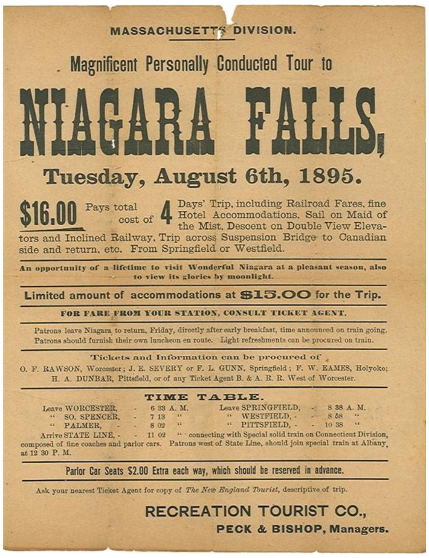
(a) (b)

Figura 6.6. (a) Intima Theater de Strindberg en Estocolmo; (b) Biblioteca privada de Alfred Nobel en Björkborn Manor, Karlskoga, Sweden.

El enorme interés de Alfred Nobel en la literatura y la escritura se refleja en sus colecciones de libros. Después de su muerte dejó una biblioteca privada de más de 1500 volúmenes, en su mayoría ficción en el idioma original, obras de los grandes escritores del siglo XIX, pero también los clásicos y obras de filósofos, teólogos, historiadores y otros científicos.

7. ¿Quién fue el diseñador del "Aero Car" en las Cataratas del Niágara?

Las Cataratas del Niágara son algunas de las cascadas más grandes, hermosas y famosas del mundo. Consiste en un grupo de tres cascadas en el extremo sur de la Garganta del Niágara, que abarca la frontera entre la provincia de Ontario en Canadá y el estado de Nueva York en los Estados Unidos. Las cataratas están formadas por el río Niágara, que drena el lago Erie en el lago Ontario. Las Cataratas del Niágara son famosas por su belleza y son una valiosa fuente de energía hidroeléctrica. Equilibrar los usos recreativos, comerciales e industriales ha sido un desafío para los administradores de las cataratas desde el siglo XIX.



(a)

(b)

Figura 7.1. (a) Anuncio de las Cataratas del Niágara, 1895; (b) Vista panorámica de las Cataratas del Niágara.

Una de las principales atracciones turísticas de las Cataratas del Niágara es el Whirlpool Aero Car, un paseo inolvidable sobre las vibrantes aguas del río Niágara. Sea testigo de las espectaculares vistas del remolino del Niágara y los rápidos del río.

(a)

(b)

Figura 7.2. (a) Vista panorámica del Aero-Car; (b) Carro del Aero-Car.

En 1913, Niagara Parks fue abordado por un grupo de empresarios españoles interesados en construir un nuevo teleférico que llevaría a los visitantes a través del Niagara Whirlpool. Proporcionaría una perspectiva completamente nueva de la garganta con vistas del fenómeno natural sin obstáculos.

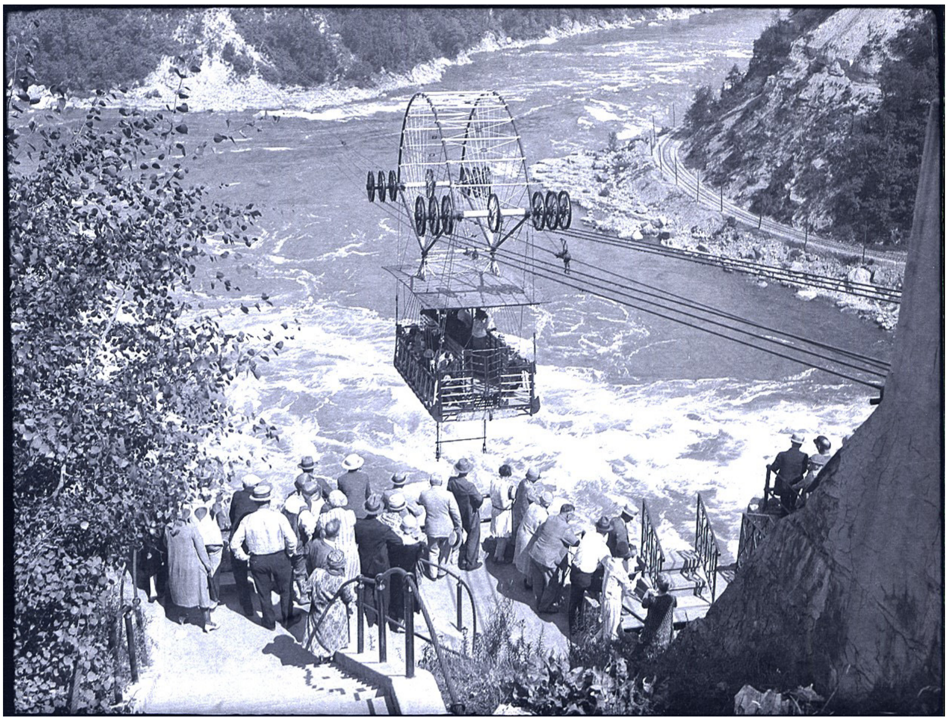
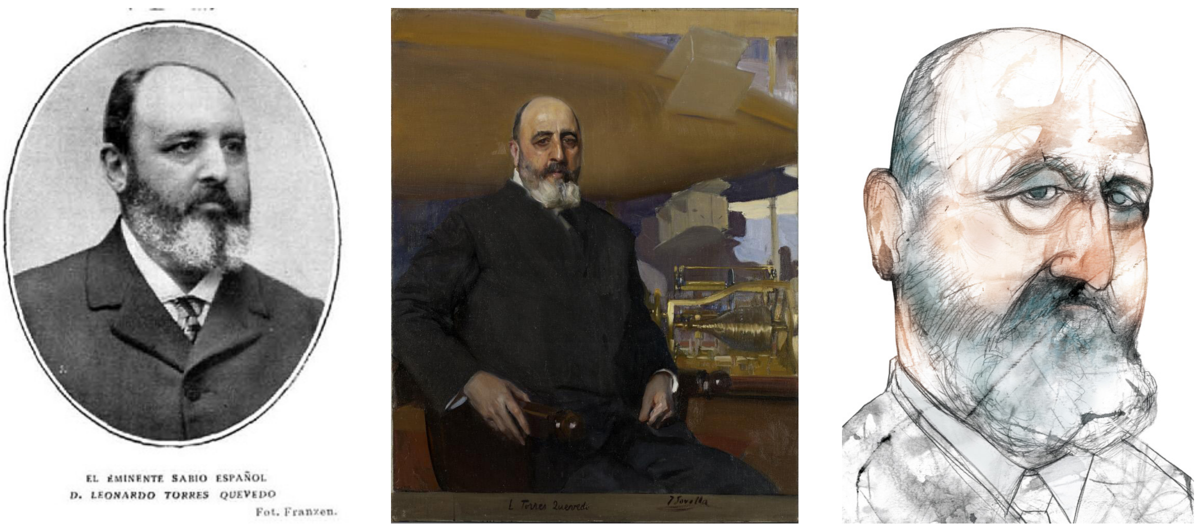


Figura 7.3. Aero-Car en 1926.

¿Quién fue el diseñador del “Aero Car” en las Cataratas del Niágara?

El autor fue Leonardo Torres Quevedo (1852 – 1936), ingeniero civil y matemático español de finales del siglo XIX y principios del XX. Torres fue pionero en el desarrollo del radiocontrol y las máquinas de cálculo automatizado, así como en los principios de operación del control remoto inalámbrico. También fue un diseñador innovador de dirigibles aerostáticos y teleféricos, como el Whirlpool Aero Car ubicado en las Cataratas del Niágara. Fue autor de un gran número de patentes en todo el mundo.

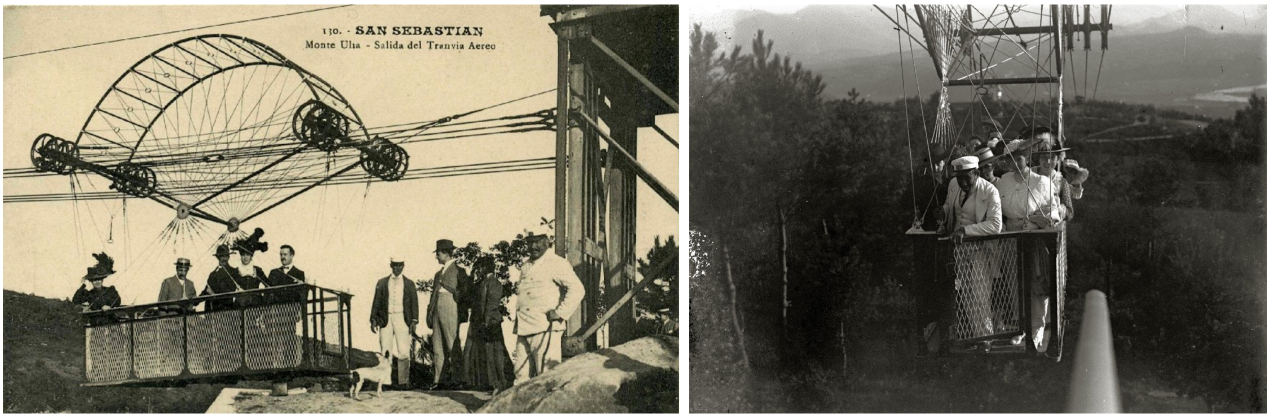


(a) (b) (c)

Figura 7.4. Leonardo Torres Quevedo. (a) Fotografía por C. Franzen, 1916 (b) Retrato por J. Sorolla, 1917; (c) Retrato por E. Merle, FECYT, 2011.

Recibió numerosos honores en reconocimiento a sus servicios tanto a la ciencia como a la sociedad. Fue presidente de la Real Academia de Ciencias Exactas, Físicas y Naturales de Madrid en 1910. En 1920 ingresó en la Real Academia Española y en la Academia Francesa de Ciencias. Fue nombrado Doctor Honoris Causa de la Sorbona de París en 1922.

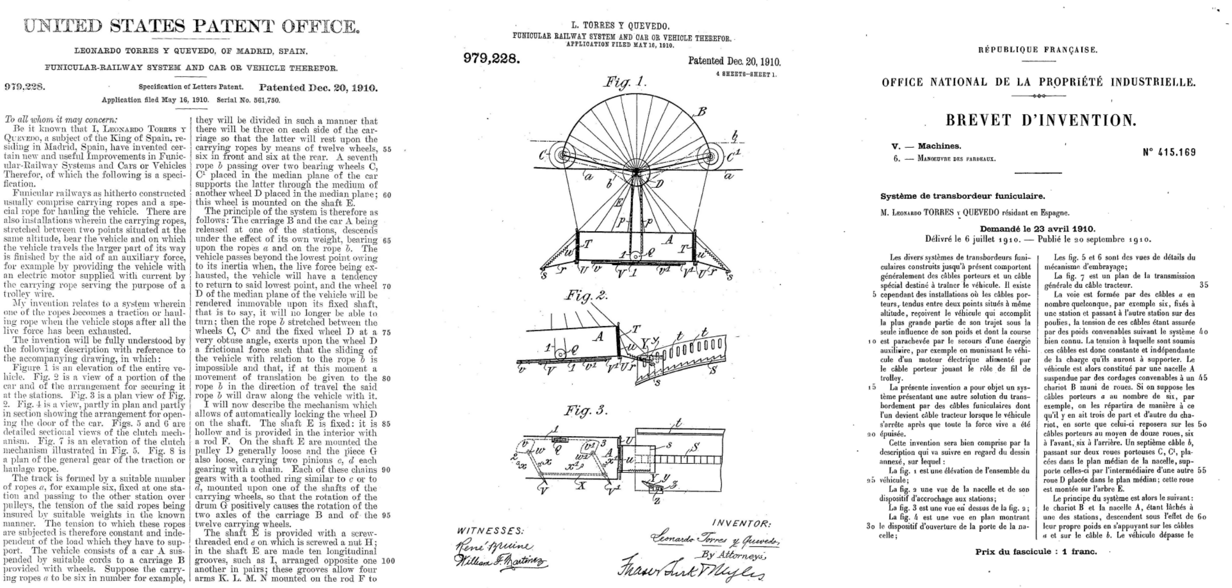
La experimentación de Torres en el área de teleféricos comenzó ya en 1887. En 1907, Torres construyó el primer teleférico adecuado para el transporte público de personas, en el monte Ulía en San Sebastián en España. El problema de la seguridad se resolvió mediante un ingenioso sistema de múltiples cables de soporte. El diseño resultante fue muy fuerte y resistió perfectamente la ruptura de uno de los cables de soporte.



(a) (b)

Figura 7.5. Transbordador del Monte Ulía, San Sebastián. (a)1907; (b) 1916.

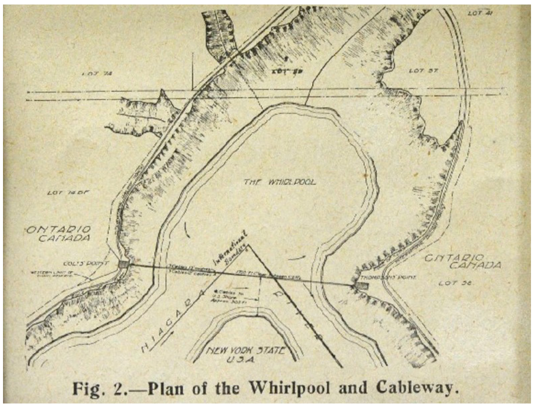
Diseñado y patentado por el ingeniero español, el Whirlpool Aero Car ha estado volando por el desfiladero del Niágara desde 1916. Diseñó la atracción siguiendo los principios de la instalación similar de San Sebastián.



(a) (b) (c)

Figura 7.6. Patentes del teleférico de Torres Quevedo, 1910. (a) Patente US979228A (b) Patente US979228A, esquema; (c) Patente FR415169A.

Aunque viaja entre dos puntos de la costa canadiense, este antiguo teleférico lo llevará a través de la frontera internacional entre Canadá y los Estados Unidos un total de cuatro veces debido a la forma del codo que hace el río. El teleférico tendría capacidad para hasta 40 pasajeros a la vez y estaría suspendido a 76 metros sobre el agua por una serie de cables de acero. La tensión de las líneas de cable debía ser mantenida por un contrapeso de 10 toneladas alojado en su terminal de Thompson Point. El carro está propulsado por un motor eléctrico de 37 kW y viaja aproximadamente a 7 km/h.



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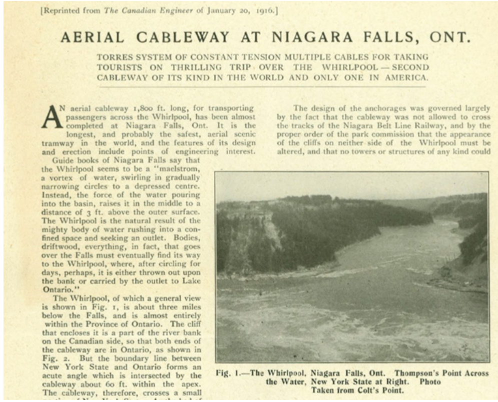


[Reprinted from *The Canadian Engineer* of January 20, 1916.]

AERIAL CABLEWAY AT NIAGARA FALLS, ONT.

TORRES SYSTEM OF CONSTANT TENSION MULTIPLE CABLES FOR TAKING TOURISTS ON THRILLING TRIP OVER THE WHIRLPOOL — SECOND CABLEWAY OF ITS KIND IN THE WORLD AND ONLY ONE IN AMERICA.

AN aerial cableway 1,800 ft. long, for transporting passengers across the Whirlpool, has been almost completed at Niagara Falls, Ont. It is the longest, and probably the safest, aerial scenic tramway in the world, and the features of its design and erection include points of engineering interest.

Guide books of Niagara Falls say that the Whirlpool seems to be a "maelstrom, a vortex of water, swirling in gradually narrowing circles to a depressed centre. Instead, the force of the water pouring into the basin, raises it in the middle to a distance of 3 ft. above the outer surface. The Whirlpool is the natural result of the mighty body of water rushing into a confined space and seeking an outlet. Bodies, driftwood, everything, in fact, that goes over the Falls must eventually find its way to the Whirlpool, where, after circling for days, perhaps, it is either thrown out upon the bank or carried by the outlet to Lake Ontario."

The Whirlpool, of which a general view is shown in Fig. 1, is about three miles below the Falls, and is almost entirely within the Province of Ontario. The cliff that encloses it is a part of the river bank on the Canadian side, so that both ends of the cableway are in Ontario, as shown in Fig. 2. But the boundary line between New York State and Ontario forms an acute angle which is intersected by the cableway about 60 ft. within the apex. The cableway, therefore, crosses a small

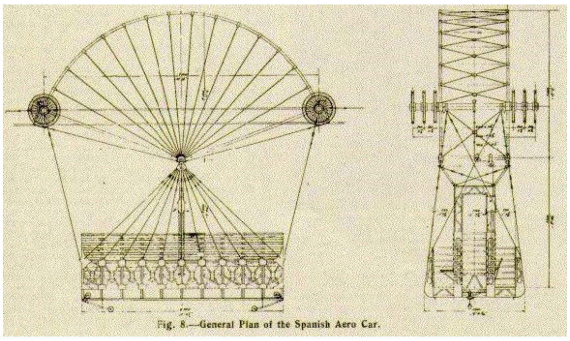
The design of the anchorages was governed largely by the fact that the cableway was not allowed to cross the tracks of the Niagara Belt Line Railway, and by the proper order of the park commission that the appearance of the cliffs on neither side of the Whirlpool must be altered, and that no towers or structures of any kind could

Fig. 1.—The Whirlpool, Niagara Falls, Ont. Thompson's Point Across the Water, New York State at Right. Photo Taken from Colt's Point.

(b)

Figura 7.7. (a) plano del trayecto del Aero-Car entre Canadá y Estados Unidos; (b) Noticia del Aero-Car en *The Canadian Engineer*, 1916.

La construcción comenzó en 1915 y comenzó a operar el 8 de agosto de 1916. Los primeros pasajeros fueron dignatarios españoles, y el carro estaba adornado con las banderas de cuatro naciones, Canadá, España, Estados Unidos y Francia. En 1984, la atracción se sometió a mejoras sustanciales para modernizar sus componentes mecánicos. Sin embargo, el carro no fue cambiado con el interés de preservar su integridad histórica. Durante más de 100 años, sin accidentes dignos de mención, el histórico Whirlpool Aero Car ha ofrecido a los pasajeros vistas espectaculares del remolino y de los rápidos de aguas bravas del río Niágara.

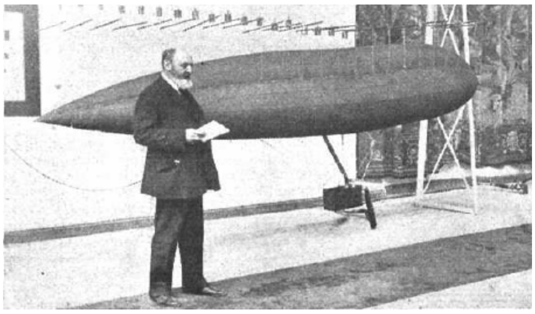


(a)

(b)

Figura 7.8. (a) plano del Aero-Car por Torres Quevedo; (b) Inauguración del Aero-Car.

Otros trabajos de Torres Quevedo se refieren al diseño y construcción de dirigibles aerostáticos. Desde 1902 desarrolló un nuevo tipo de dirigible con un marco interno de cables flexibles que darían rigidez a la aeronave a través de la presión interior. En 1905 construyó el primer dirigible español para el Ejército y, desde 1911, comenzó la colaboración entre Torres y la compañía francesa Astra. Los dirigibles Astra-Torres fueron ampliamente utilizados durante la Primera Guerra Mundial, principalmente para la protección naval y la inspección.



(a)

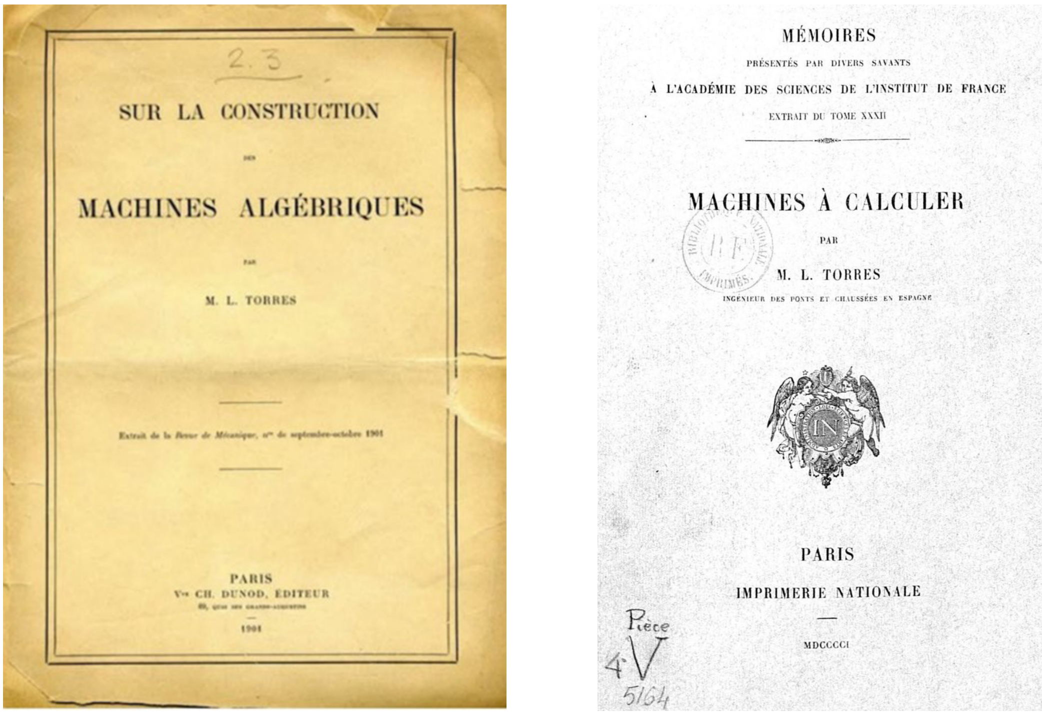
(b)

Figura 7.9. (a) Torres Quevedo y su dirigible; (b) Dirigible Astra-Torres, 1911.

Torres también fue pionero en el campo del control remoto. En 1903, presentó el Telekino en la Academia de Ciencias de Francia. El Telekino consistía en un robot que ejecutaba comandos transmitidos por ondas electromagnéticas. Fue patentado en Francia, España, Gran Bretaña y los Estados Unidos. En 2007, el prestigioso Instituto de Ingenieros Eléctricos y Electrónicos dedicó una placa conmemorativa en Ingeniería Eléctrica y Computación al Telekino.

Figura 7.10. Placa conmemorativa de la IEEE.

Finalmente, de todos los trabajos realizados por Torres Quevedo a lo largo de su vida, su fama más universal se deba probablemente a su trabajo en "automática". Hizo importantes contribuciones a las máquinas algebraicas, las predecesoras de las computadoras analógicas, y las máquinas aritméticas, las predecesoras de las computadoras digitales modernas.



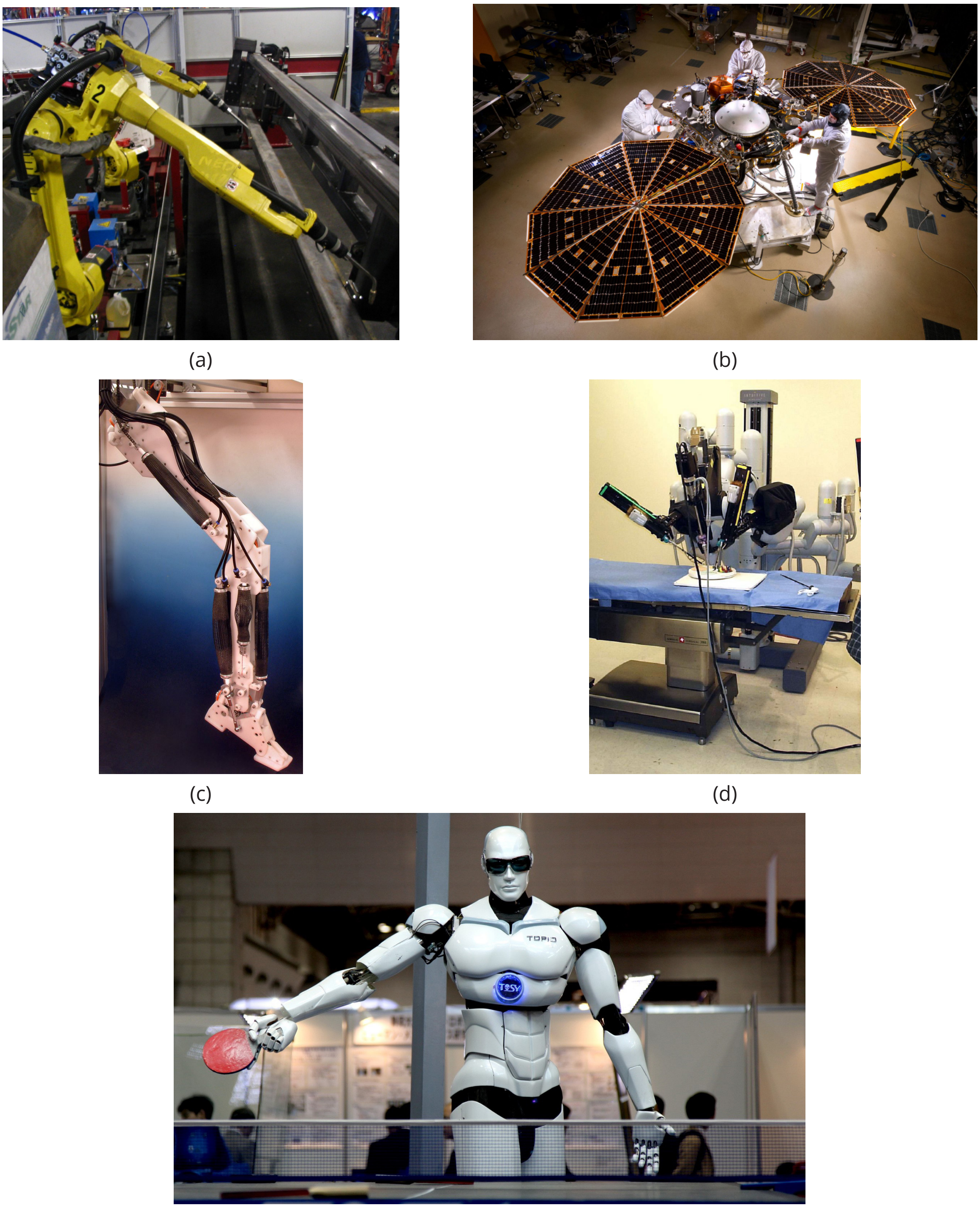
(a) (b)

Figura 7.11. Publicaciones de Torres Quevedo (a) Machines Algébriques, 1901; (b) Machines à calculer, 1901.

En 1900 presentó en la Academia de Ciencias de Francia un informe con una solución teórica general y completa para estas máquinas. También construyó algunos dispositivos electromecánicos capaces de hacer cálculos matemáticos.

8. ¿Quién es considerado el "padre de la robótica"?

La robótica es una rama interdisciplinar de la informática y la ingeniería. Implica el diseño, construcción, operación y uso de robots que pueden ayudar y asistir a los seres humanos. Los robots se pueden utilizar en muchas situaciones y para muchos propósitos: procesos de fabricación, exploración espacial, prótesis humanas o cirugía asistida por robot. Y algunos de ellos se asemejan a los humanos en su apariencia.



(a) (b) (c) (d) (e)

Figura 8.1. (a) robot de soldadura; (b) robot explorador espacial; (c) prótesis robótica; (d) cirugía asistida por robot; (e) robot humanoide.

En Europa, desde la Edad Media, hay muchos ejemplos de autómatas, los predecesores de los robots. Incluyen varios relojes astronómicos mecánicos con figuras de autómatas, que comenzaron a aparecer en el siglo 14. Uno de los más famosos es el reloj astronómico de Praga, adjunto al Antiguo Ayuntamiento de Praga, la capital de la República Checa. El reloj se instaló por primera vez en 1410, lo que lo convierte en el tercer reloj astronómico más antiguo del mundo y el reloj más antiguo aún en funcionamiento. Otro se encuentra en la Catedral de Santa María en Burgos, España. Se llama Papamoscas, un autómata articulado que abre la boca para dar las campanadas de las horas.

(a)

(b)

(c)

Figura 8.2. (a) Reloj astronómico de Praga, República Checa; (b) Reloj Glockenspiel en Graz, Austria; (c) Reloj Papamoscas, Catedral de Burgos, España.

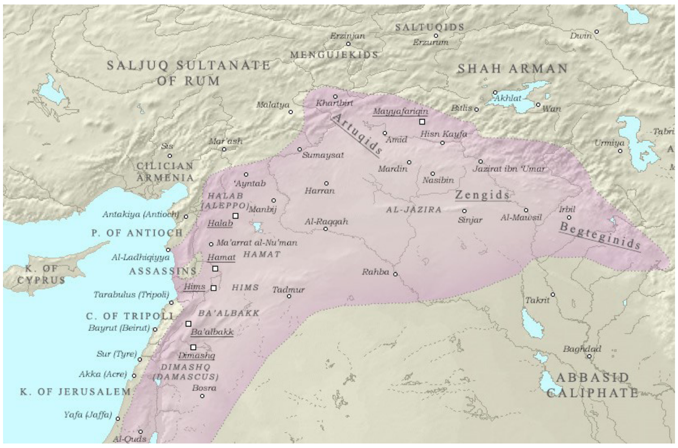
Pero ¿fueron estos autómatas, predecesores de los robots modernos, los primeros de la historia?

La idea de los autómatas se origina en las mitologías de muchas culturas de todo el mundo. Ingenieros e inventores de civilizaciones antiguas, incluyendo China, Grecia, India, Persia y Egipto, intentaron construir máquinas autónomas, algunas parecidas a animales y humanos. La mayoría de ellos fueron concebidos como ilusiones o juguetes para el entretenimiento de reyes y emperadores.

En el siglo XIII, los ingenieros árabes produjeron autómatas que manipulaban el medio natural para la mayor comodidad humana. Además de preservar, difundir y construir sus invenciones sobre el trabajo de los griegos, su mayor contribución fue el concepto de aplicación práctica.

Uno de estos ingenieros árabes es considerado hoy en día el "padre de la robótica".

Ismail Al Jazari (1136 - 1206) era un árabe ilustrado: erudito, inventor, ingeniero mecánico, artesano, artista y matemático. Nació en el área de la Alta Mesopotamia y trabajó como ingeniero jefe de la dinastía Artúquida, un reino regional, para la que diseñó más de cien ingeniosos dispositivos. Pasó casi 25 años en Diyarbakir, a orillas del río Tigris.



(a)

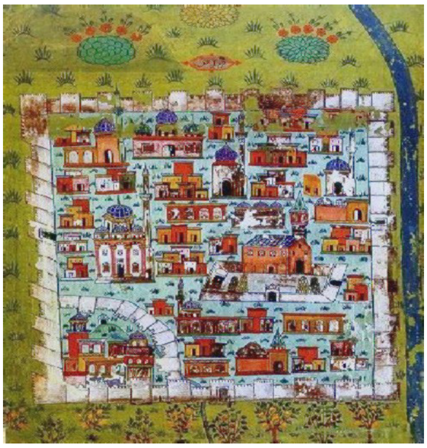

(b)

Figura 8.3. (a) Mapa del reino regional Artúquida dentro del sultanato Ayyúbida, hacia 1193; (b) Mapa de Diyarbakir, siglo XVI.

En 1206 dio al mundo un catálogo de sus incomparables máquinas, conocido hoy como El Libro del Conocimiento de los Dispositivos Mecánicos Ingeniosos. Al-Jazari menciona las mejoras que hace al trabajo de sus predecesores, y describe una serie de dispositivos, técnicas y componentes que son innovaciones originales que no aparecen en los trabajos anteriores. Solo describe dispositivos que ha construido él mismo. El estilo del libro se asemeja al de un libro moderno de "hágalo usted mismo".

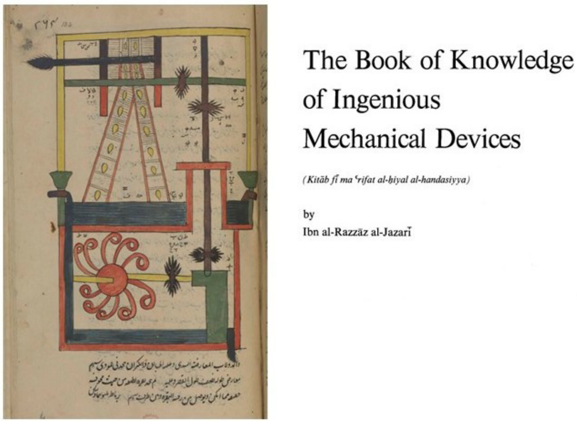


Figura 8.4. The Book of Knowledge of Ingenious Mechanical Devices.

Su diseño de un barco con cuatro músicos -un arpista, un flautista y dos percusionistas- destinado a tocar canciones es considerado por muchos como el primer robot programable de la historia. Tiene una caja de ritmos programable con levas que chocan con pequeñas palancas que operaban la percusión. Se podía hacer que el percusionista tocara diferentes ritmos y diferentes patrones de tambor si se movían las levas adecuadamente.


(a)


(b)


(c)

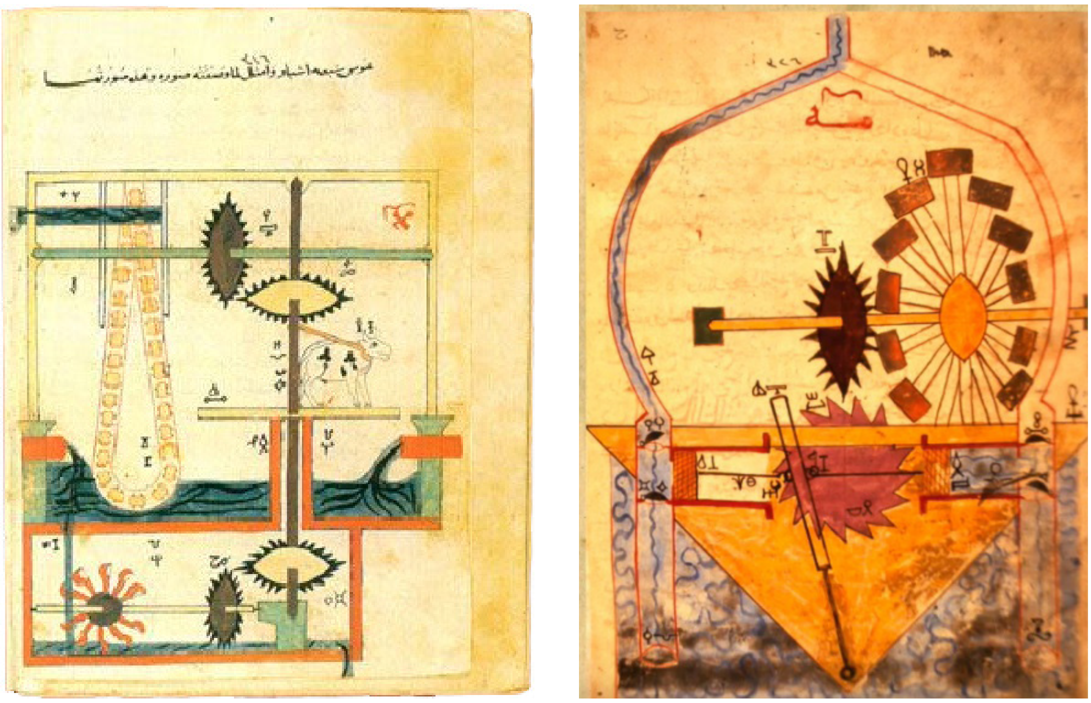
Figura 8.5. Autómatas de Al Jazari. (a) Autómata musical; (b) Autómata musical con mecanismo; (c) Mecanismo de levas.

Otros autómatas eran el reloj de agua de los percusionistas, un autómata de lavado de manos con mecanismo de descarga y una fuente de un pavo real con sirvientes automatizados.

(a) (b) (c)

Figura 8.6. Autómatas de Al Jazari. (a) Reloj de agua de los percusionistas; (b) Autómata del lavado de manos; (c) Fuente del pavo real.

Al-Jazari inventó cinco máquinas para elevar el agua, así como molinos de agua y ruedas hidráulicas con levas en su eje utilizadas para operar los autómatas. Fue en estas máquinas de elevación de agua en las que introdujo sus ideas más importantes y los componentes de los nuevos mecanismos.



(a) (b)

Figura 8.7. Autómatas de Al Jazari. (a) Saqiya (Cadena de ollas); (b) Bomba de aspiración de doble acción con válvulas y movimiento alternativo del pistón.

Otros inventos fueron una diversidad de relojes: el reloj de velas, el reloj de elefante y el reloj del castillo.

(a) (b) (c)

Figura 8.8. Autómatas de Al Jazari. (a) Reloj de velas; (b) Reloj del elefante; (c) Reloj del castillo.

Además de sus logros como inventor e ingeniero, Al-Jazari también fue un artista. En El libro del conocimiento de los dispositivos mecánicos ingeniosos, dio instrucciones de sus inventos y los ilustró utilizando pinturas en miniatura, un estilo medieval de arte islámico.

Es recordado principalmente por su libro, pero sus inventos jugarían un papel clave en la vida civil durante muchos años. La mayoría de sus innovaciones estaban siglos por delante de los logros de la ciencia europea. Muchos autores sobre historia de la tecnología mencionan que, dos siglos más tarde, el inventor renacentista italiano Leonardo da Vinci pudo haber sido influenciado por los autómatas clásicos de Al Jazari al diseñar sus propios autómatas.

Figura 8.9. Modelo del robot de Leonardo da Vinci con funcionamiento interno. Posiblemente construido por Leonardo da Vinci alrededor de 1495.

Las máquinas automáticas fabricadas por Al Jazari formaron las piedras angulares de las ciencias mecánicas y cibernéticas de hoy. Al Jazari ha fundado los hitos de la tecnología actual mediante un uso extraordinario de la ciencia y la tecnología acorde con las condiciones de su época, sentando las bases de la ciencia de control automático de hoy en día.

9. ¿Quién fue el inventor de la olla a presión?

Probablemente tengamos en nuestra cocina una olla a presión. Es un recipiente hermético que aumenta la velocidad de cocción de algunos alimentos, reduciendo el tiempo necesario para su preparación y reduciendo considerablemente su consumo de energía. La cocción a presión es el proceso de cocinar alimentos con vapor y agua a alta presión, o en un líquido de cocción a base de agua. Por lo general, la olla a presión tarda varios minutos en alcanzar las condiciones de cocción deseadas. En algunos modelos, el peso del regulador de presión comienza a levitar por encima de su boquilla, permitiendo que el exceso de vapor escape.

(a) (b)

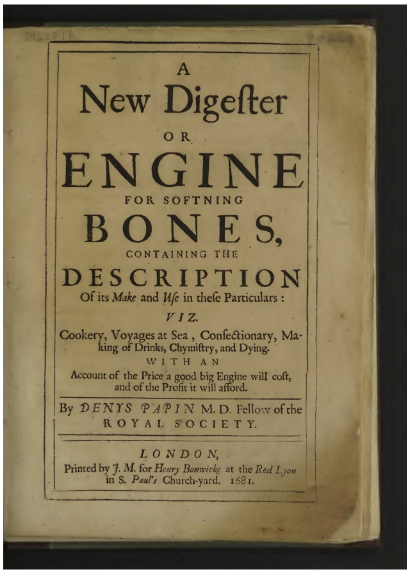
Figura 9.1. Olla a presión. (a) componentes: recipiente, tapa y válvula; (b) conjunto.

¿Quién fue el inventor de la olla a presión?

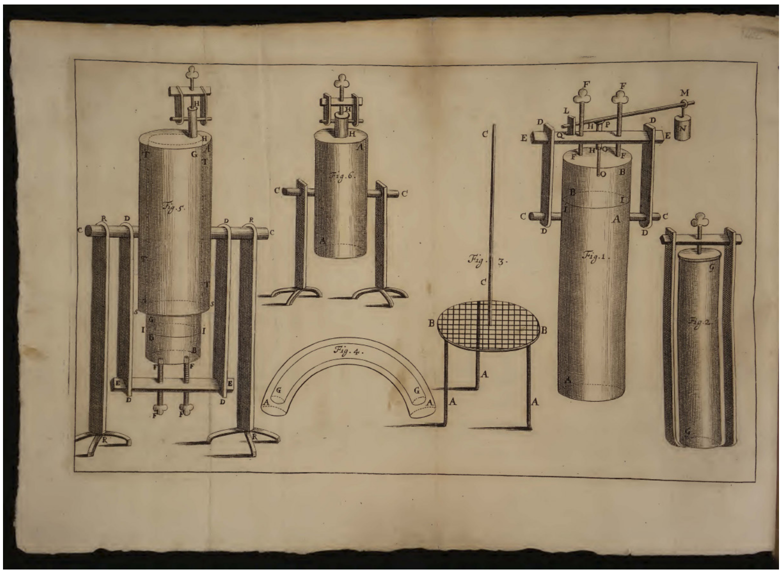
El inventor de la olla a presión fue Denis Papin (1647 - 1713), un físico, matemático, ingeniero e inventor francés. En 1669 obtiene un diploma en medicina por la Universidad de Angers, pero nunca ejerce esta profesión, sino que se dedica al estudio de la física y las máquinas. Residió en Francia, Inglaterra y Alemania, siendo un destacado científico e inventor de su época.

Figura 9.1. Denis Papin, 1689.

En 1680 Papin presentó su invención del digestor de vapor a la Royal Society de Londres como un estudio científico. Más tarde fue elegido miembro de la Sociedad. En 1681 apareció en Londres una primera memoria, para relatar la primera serie de experimentos realizados con esta máquina, titulada *A New Digester or Machine for Softening Bones* (Un nuevo digestor o máquina para ablandar huesos), que contiene la descripción de su marca y uso en estos detalles. Funciona expulsando aire del recipiente y atrapando el vapor producido a partir del líquido hirviendo.


A
New Digeſter
OR
ENGINE
FOR SOFTNING
BONES,
CONTAINING THE
DESCRIPTION
Of its *Make* and *Uſe* in theſe Particulars:
VIZ.
Cookery, Voyages at Sea, Confectionary, Making of Drinks, Chymiſtry, and Dying.
WITH AN
Account of the Price a good big Engine will coſt, and of the Profit it will afford.
By *DENYS PAPIN* M.D. Fellow of the ROYAL SOCIETY.
LONDON,
Printed by *J. M.* for *Henry Bonwicke* at the *Red Lyon* in *S. Paul's* Church-yard. 1681.

(a)



(b)

Figura 9.3. (a) Portada de la edición inglesa de 1681, *Steam Digester*; (b) dibujos del *Steam Digester*.

A presión estándar, el punto de ebullición del agua es de 100°C. Con cualquier alimento que contenga o se cocine con agua, una vez que la temperatura alcanza el punto de ebullición, cualquier exceso de calor hace que parte del agua se convierta en vapor de manera eficiente, manteniendo la temperatura del alimento a 100°C.

En una olla a presión hermética, cuando el agua hierve, el vapor queda atrapado en la olla, que aumenta la presión. Sin embargo, el punto de ebullición del agua aumenta con la presión. En una olla a presión hermética, el volumen y la cantidad de vapor son fijos, por lo que la temperatura se puede controlar directamente ajustando la presión, con una válvula de liberación de presión. Por ejemplo, si la presión alcanza los 2 bar o 200 kPa, el agua habrá alcanzado una temperatura de aproximadamente 120°C, que cocina los alimentos mucho más rápido.

Presiones y temperaturas en la olla a presión

Presión total	Presión manométrica relativa a la atmósfera	Temperatura	Tiempo de cocción aproximado respecto la ebullición
1.0 bar	**0.0 bar**	**100ºC (212ºF)**	**100%**
1.1 bar	0.1 bar	103ºC (217ºF)	80%
1.2 bar	0.2 bar	105ºC (221ºF)	70%
1.3 bar	0.3 bar	107ºC (225ºF)	61%
1.4 bar	0.4 bar	110ºC (230ºF)	50%
1.5 bar	0.5 bar	112ºC (234ºF)	43%
1.6 bar	0.6 bar	114ºC (237ºF)	38%
1.7 bar	0.7 bar	116ºC (241ºF)	33%
1.8 bar	0.8 bar	117ºC (243ºF)	31%
1.9 bar	0.9 bar	119ºC (246ºF)	27%
2.0 bar	**1.0 bar**	**121ºC (250ºF)**	**23%**

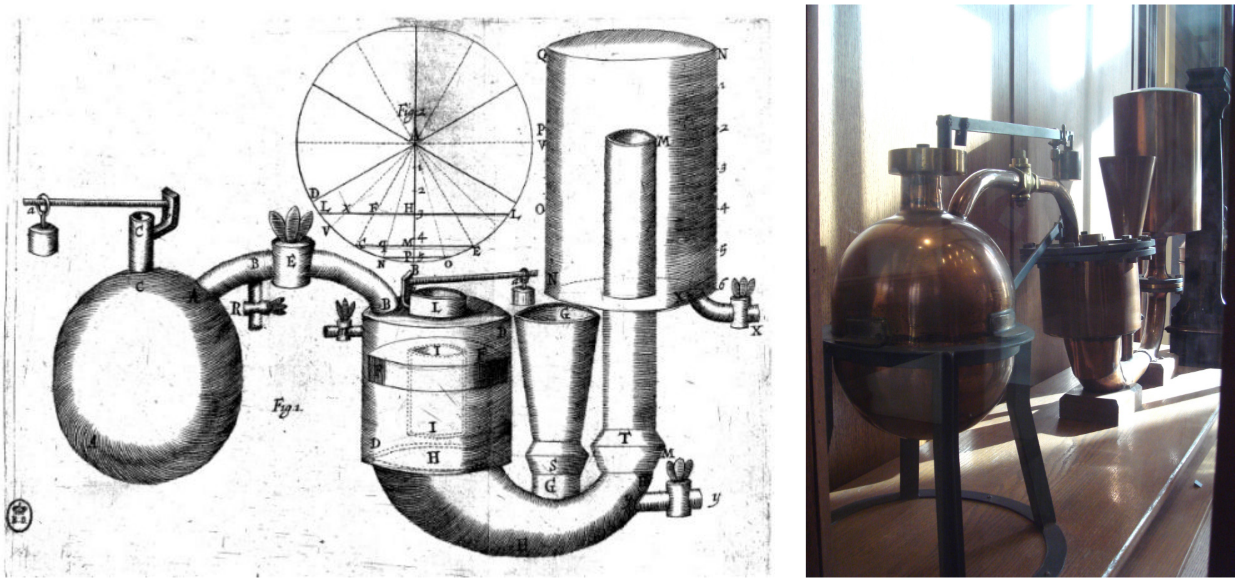
Figura 9.4. Evolución de la temperatura de ebullición del agua con la presión.

Incluso aunque, en esa época, no había posibilidad de convertir este invento en un producto de uso general por el pueblo, su diseño fue la base de las primeras ollas a presión que, a principio del siglo XX, comenzaron a forma parte del menaje habitual en nuestras cocinas.

(a) (b) (c)

Figura 9.5. (a) Olla a presión, finales del siglo XVIII; (b) Olla a presión, hacia 1864; (c) Super Cocotte, 1973.

A lo largo de su carrera, Papin inventó muchos otros dispositivos: una máquina para elevación de agua, una máquina para incendios, el primer sistema pistón-cilindro a vapor, un modelo de submarino a vapor, y una máquina de vapor para bombeo de agua. Esta máquina es contemporánea de las primeras máquinas de vapor británicas operativas de principios del siglo XVIII.



(a) (b)

Figura 9.6. Máquina de vapor de Papin. (a) esquema, hacia 1705; (b) reconstrucción.

A lo largo de su carrera Denis Papin colaboró con otros grandes científicos de su época, como Christiaan Huygens, Gottfried Leibniz y Robert Boyle.

10. Más pesado que el aire: primer vuelo pionero en Europa.

Muchas historias de la antigüedad involucran el deseo de volar, como la leyenda griega de Ícaro y Dédalo, y el Vimana en las antiguas epopeyas indias. Algunos de los primeros intentos registrados con planeadores fueron los del poeta andalusí y árabe del siglo IX Abbas Ibn Firnas y el monje inglés del siglo XI Eilmer de Malmesbury. Leonardo da Vinci investigó el diseño de las alas de las aves y diseñó un avión propulsado por el hombre.

Figura 10.1. (a) Ícaro y Dédalo, Musée des Beaux-Arts et de la Dentelle d'Alençon; (b) El carro celestial Vimana, ilustración del Ramayana; (c) Estatua Ibn Firnas en el aeropuerto de Bagdad; (d) Monje Eilmer, Malmesbury Abbey; (e) Leonardo da Vinci, máquina voladora.

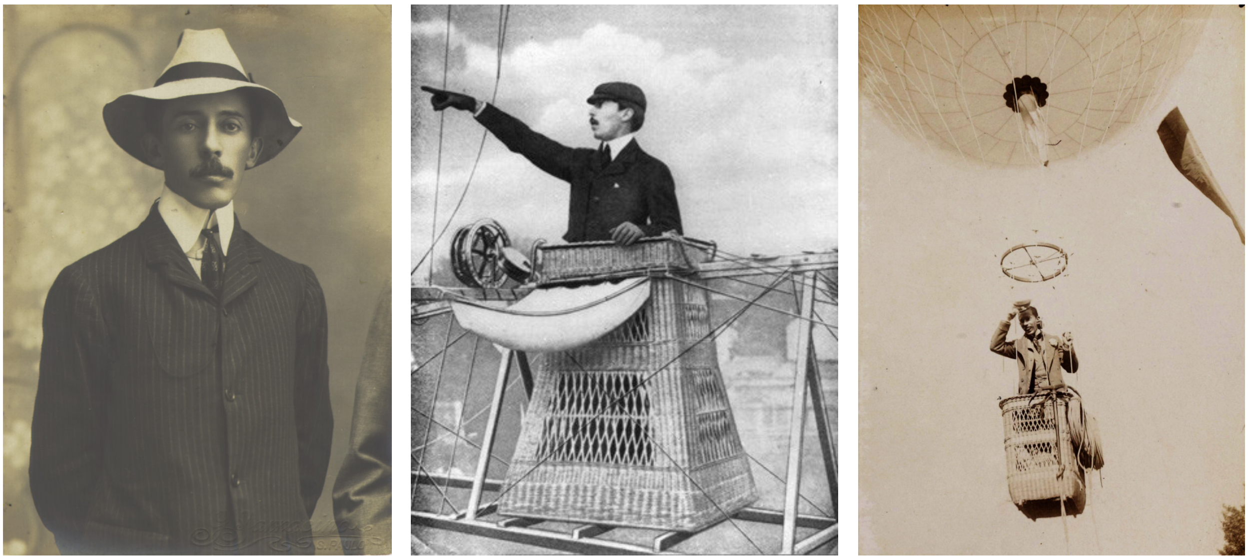
Desde entonces, muchos pioneros de la aviación contribuyeron al desarrollo de aviones prácticos. Los aviones modernos son una máquina voladora de ala fija con sistemas separados para la elevación, la propulsión y el control.

Los hermanos Wright, Orville y Wilbur Wright, fueron pioneros de la aviación estadounidense a los que generalmente se les atribuye la invención, construcción y vuelo del primer avión exitoso del mundo. El invento revolucionario de los hermanos fue la creación de un sistema de control de tres ejes, que permitía al piloto dirigir la aeronave de manera efectiva y mantener su equilibrio. El primer vuelo de Orville Wright, de 37 metros en 12 segundos, realizó el primer vuelo tripulado controlado y propulsado más pesado que el aire en Kitty Hawk, Carolina del Norte, el 17 de diciembre de 1903. En sus primeros vuelos, los hermanos Wright utilizaron unos railes de guía y una catapulta para hacerlo despegar.

Figura 10.2. Primer vuelo de los hermanos Wright en Kitty Hawk, Carolina del Norte, el 17 de diciembre de 1903.

En 1906, el brasileño Alberto Santos-Dumont (1873-1932) realizó lo que se afirmó que fue el primer vuelo de un avión, despegando sin la ayuda de un sistema de lanzamiento externo. Estableció el primer récord mundial reconocido por el Aéro-Club de France y por la Fédération Aéronautique Internationale al volar 220 metros en menos de 22 segundos.

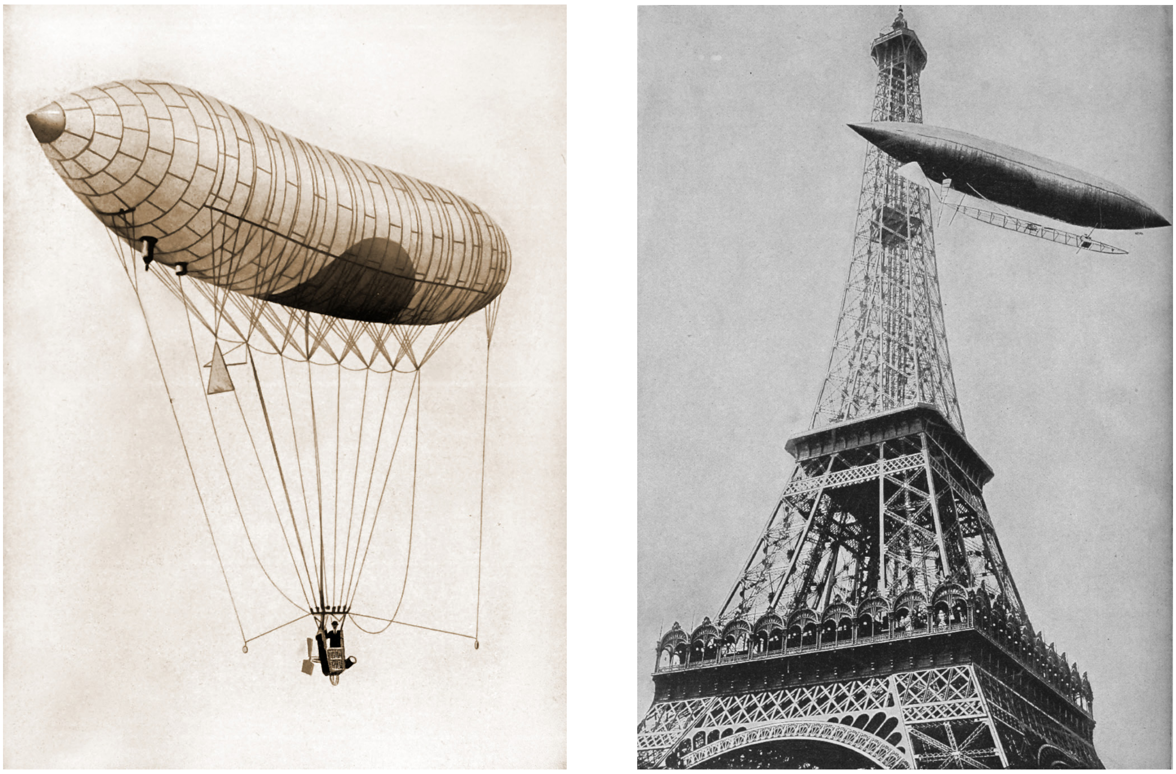
Alberto Santos-Dumont fue un aeronauta, deportista e inventor brasileño. Aunque nunca se graduó, siguió algunos cursos de ingeniería y desarrolló un admirable talento práctico y mecánico y, desde entonces, de genio inventivo. A muy temprana edad, destacó como montañero y automovilista. A los 24 años, Santos-Dumont se fue a Francia, donde pasó la mayor parte de su vida adulta. Allí se convirtió en aeronauta profesional.



(a) (b) (c)

Figura 10.3. Alberto Santos Dumont (a) Retrato, 1903; (b) A bordo de un globo aerostático; (c) Despegue el 4 de julio de 1898 en Brasil.

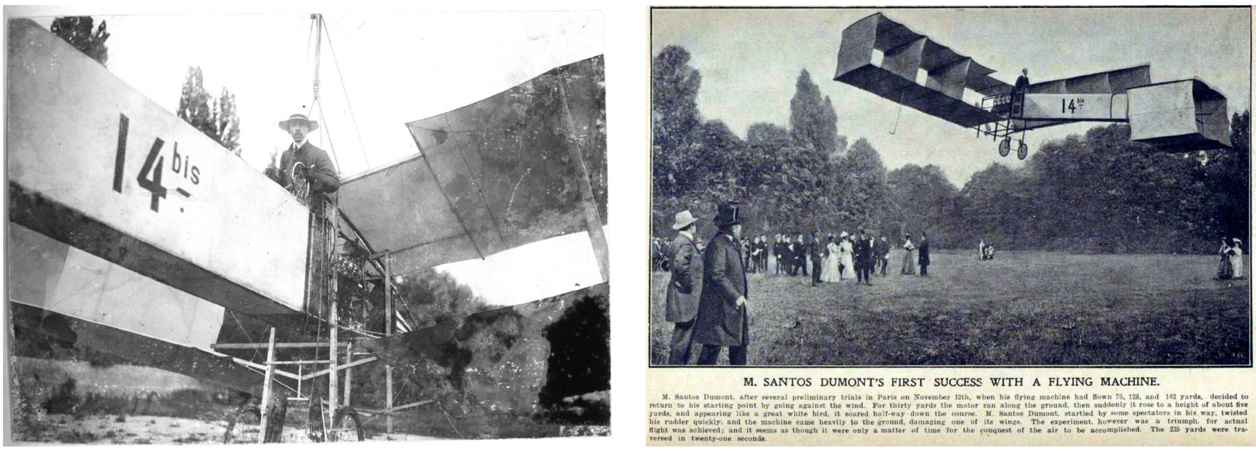
Desde 1898 hasta 1903, construyó hasta 13 dirigibles, más ligeros que el aire, propulsados por motores de combustión interna. Voló alrededor de la Torre Eiffel en sus dirigibles varias veces, como parte de competiciones de dirigibles.



(a) (b)

Figura 10.4. (a) Dirigible Santos-Dumont Nº1, 1898; (b) Vuelo de Santos-Dumont alrededor de la Torre Eiffel.

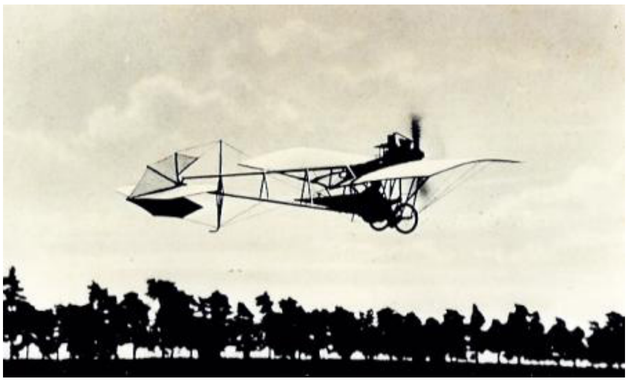
En 1904, se fundaron varios premios de aviación en Francia, para estimular el desarrollo de aviones más pesados que el aire. El despegue, el control y el aterrizaje eran las grandes preocupaciones. La Fédération Aéronautique Internationale, creada en 1905, se encargó de registrar las demostraciones oficiales. Después de desarrollar varios prototipos, Santos-Dumont presentó el avión 14-bis, un biplano con dos superficies octogonales insertadas como alerones que mejoraban el control, y el timón en la parte delantera, como la configuración de los hermanos Wright. El 12 de noviembre de 1906, fue capaz de volar 220 metros, durante 21 segundos a una velocidad media de 37,4 km/h.



(a) (b)

Figura 10.5. (a) Santos-Dumont en el 14-bis; (b) Noticia del vuelo del 14-bis.

Santos-Dumont continuó desarrollando aviones, como el *Demoiselle*. Este avión fue diseñado para competiciones deportivas, capaz de alcanzar hasta 2 kilómetros y alcanzar los 96 km/h. Más tarde, se utilizó para el entrenamiento de pilotos durante la Primera Guerra Mundial.



(a)

(b)

Figura 10.6. (a) Santos-Dumont en el *Demoiselle*; (b) Placa de Alberto Santos-Dumont en Avenue des Champs-Élysées, París.

El 19 de octubre de 1906, Santos-Dumont ganó una competición de vuelo sobre París con su dirigible número 6. El premio le fue entregado en una cena en el célebre restaurante Maxim's. Allí coincidió con el joyero Louis Cartier. El joyero se enteró que el piloto no podía consultar su reloj de bolsillo durante el vuelo porque necesitaba ambas manos para pilotar el avión. Cartier diseñó y regaló a Santos-Dumont un nuevo reloj de oro, cuadrado y plano, sujeto a la muñeca gracias a una correa y una hebilla. Acababa de crear el primer reloj de pulsera para hombre. Santos-Dumont lo usó como cronómetro en sus siguientes vuelos. Este reloj, denominado Cartier-Santos, se sigue fabricando en la actualidad.

(a)

(b)

Figura 10.7. (a) Santos-Dumont, 1916; (b) Reloj Cartier-Santos.

11. ¿Quién construyó el puente de Brooklyn?

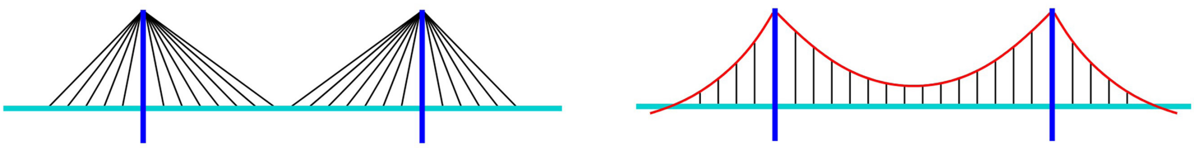
El puente de Brooklyn es un icono de la ciudad de Nueva York.

El puente cruza el East River entre los distritos de Manhattan y Brooklyn. Inaugurado el 24 de mayo de 1883, el puente de Brooklyn fue el primer cruce permanente del East River. También era el puente colgante más largo del mundo en el momento de su inauguración, con un vano principal de 486 m y un tablero a 38 metros por encima de la pleamar media. El puente se llamaba originalmente Puente de Nueva York y Brooklyn o Puente del East River, pero fue rebautizado oficialmente como Puente de Brooklyn en 1915.

(a) (b)

Figura 11.1. (a), (b) Puente de Brooklyn en New York, entre Manhattan y Brooklyn.

El puente de Brooklyn es un emblema de la ingeniería del siglo XIX por lo innovador que fue en aquel entonces el uso del acero como material constructivo a gran escala. Utiliza un diseño híbrido de puente atirantado/colgante, con cables de suspensión verticales y diagonales. Fue el primer puente suspendido mediante cables de acero. Sus torres de piedra son neogóticas, con característicos arcos apuntados.



(a) (b)

Figura 11.2. (a) Un puente atirantado tiene una o más torres, desde las cuales los cables soportan el tablero del puente; (b) Un puente colgante tiene un tablero que cuelga debajo de los cables de suspensión entre las torres, con cables de suspensión verticales.

En origen el puente estaba diseñado para albergar en los extremos dos calzadas de doble vía para carruajes y caballería, dos vías de tranvía en el centro y una plataforma peatonal elevada. Actualmente consta de seis carriles para automóviles, tres en cada sentido.

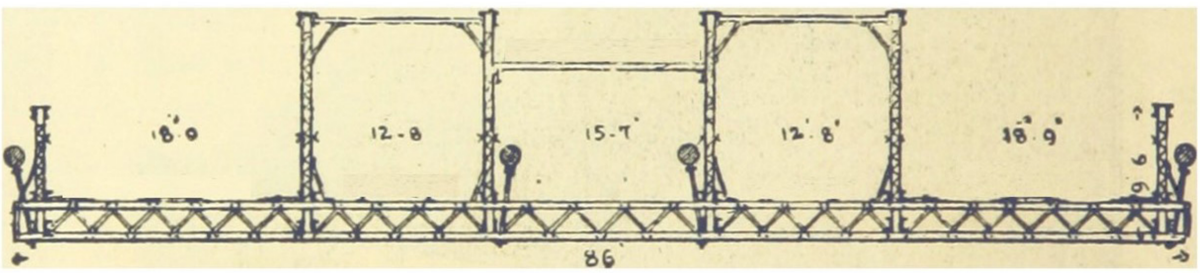
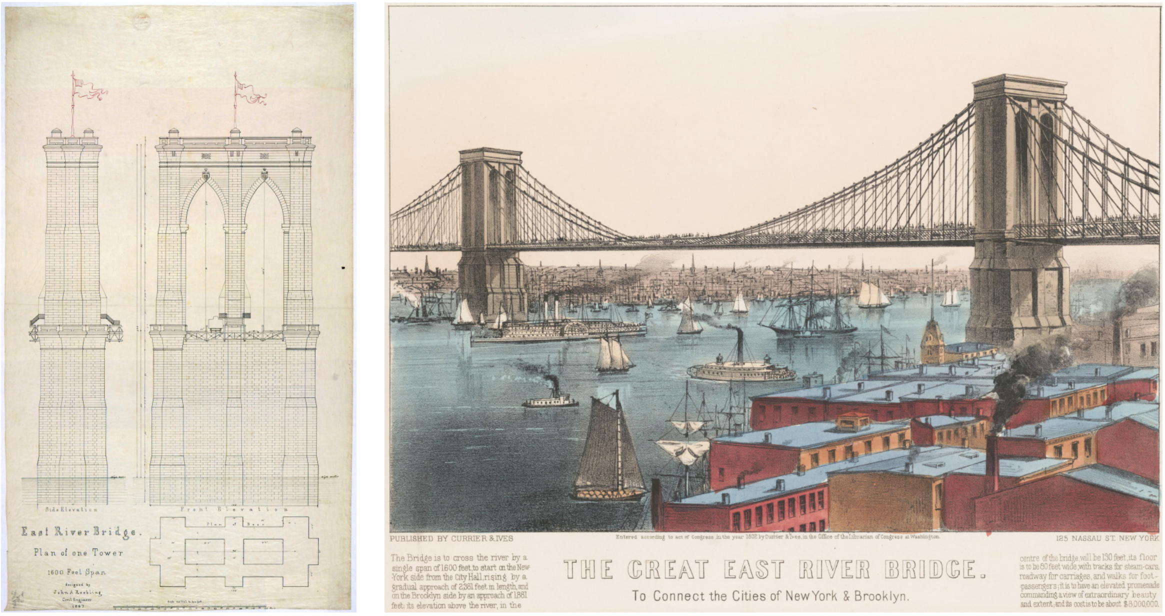


Figura 11.3. Diseño inicial del Puente de Brooklyn.

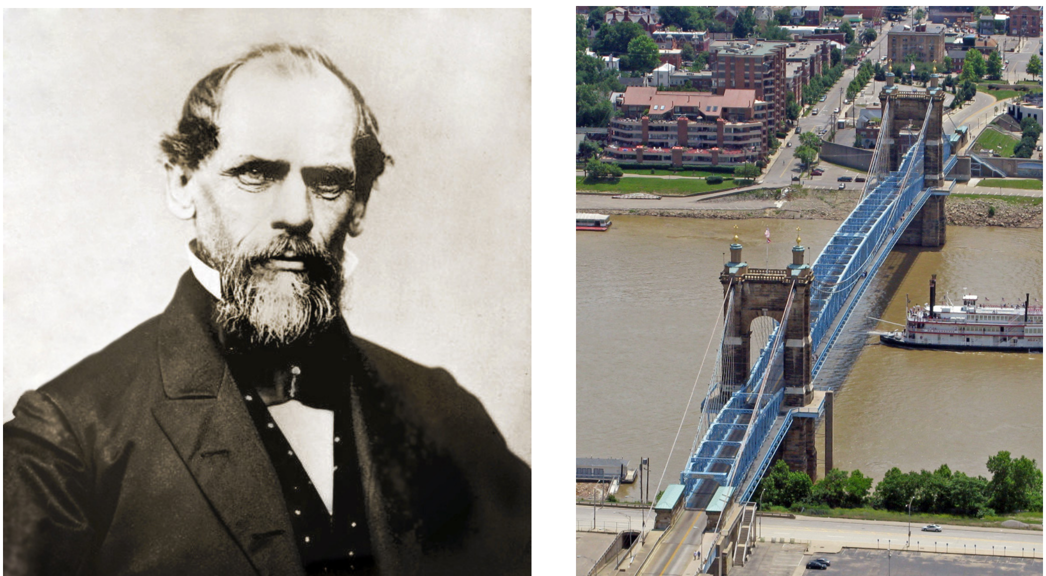
Las primeras propuestas para conectar Manhattan y Brooklyn mediante un puente se hicieron a principios del siglo XIX. En ese momento, el único viaje posible entre las dos ciudades era en unas pocas líneas de ferry. En febrero de 1867, el Senado del Estado de Nueva York aprobó un proyecto de ley que permitía la construcción de un puente colgante desde Brooklyn hasta Manhattan. En abril de 1867, se permitió a las ciudades de Nueva York y Brooklyn suscribir 5 millones de dólares en capital social, que financiaría la construcción del puente por parte de la New York and Brooklyn Bridge Company. El puente fue construido entre 1870 y 1883.



(a) (b)

Figura 11.4. (a) Plano de la torre del puente de Brooklyn, 1867; (b) Imagen esperada del puente.

El ingeniero jefe designado en 1867 para construir el puente de Brooklyn fue John Roebling (1806–1869), un ingeniero civil estadounidense nacido en Alemania. Era un ingeniero experimentado en puentes colgantes de cable de acero, como los de Pittsburgh, Niágara o Cincinnati. Desgraciadamente, falleció en 1869, justo antes de iniciar las obras.

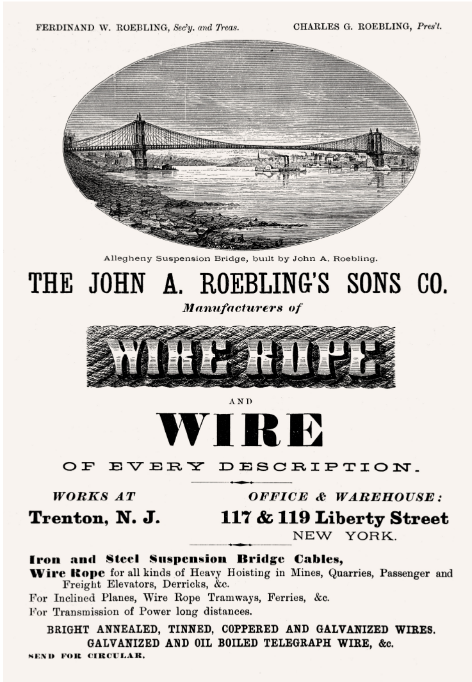


(a) (b)

Figura 11.5. (a) John Roebling, 1867; (b) Puente colgante de John Roebling en Cincinnati.

Washington Roebling (1837–1926), el hijo de John Roebling, de 32 años, fue contratado para ocupar el puesto de su padre. Adquirió estudios superiores en ingeniería en el Rensselaer Polytechnic Institute en Troy, Nueva York, y trabajó con su padre en varios puentes colgantes. En 1868, Washington se convirtió en ingeniero asistente en el puente de Brooklyn y fue nombrado ingeniero jefe después de la muerte de su padre a mediados de 1869.

(a)



(b)

Figura 11.6. (a) Washington Roebling, 1854; (b) Anuncio de Roebling's & Sons, 1879.

Pero, muy pronto al comienzo de las obras, en 1870, sufrió una enfermedad pulmonar por descompresión contraída mientras trabajaba en los cajones presurizados de los pilares del puente, en las profundidades del río. Le afectó tanto que quedó postrado en cama. A causa de ello, su esposa, Emily Warren Roebling, se puso al frente de la ingeniería.

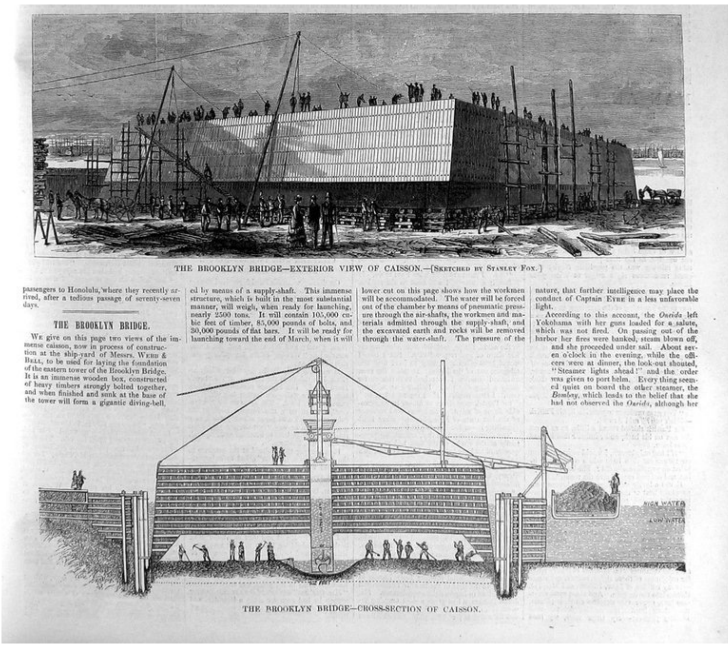


Figura 11.7. Cajones presurizados de los pilares del Puente de Brooklyn.

Emily Warren Roebling (1843–1903) es conocida por su contribución a la finalización del Puente de Brooklyn durante un período de más de 10 años. Había estudiado matemáticas y ciencias, y empezó a seguir las instrucciones que su marido decía de lo que quedaba por hacer en el puente. También comenzó sus propios estudios sobre cuestiones técnicas, aprendiendo sobre resistencia de los materiales, el análisis de tensiones, la construcción de cables y el cálculo de curvas de catenaria. Se hizo cargo de gran parte de las funciones de ingeniero jefe, incluida la supervisión diaria y la gestión de proyectos.

(a) (b)

Figura 11.8. (a) Emily Roebling, 1896; (b) Puente de Brooklyn en construcción.

Durante la década posterior a que Washington fuera confinado a su lecho de enfermo, Emily Roebling se dedicó a la finalización del puente de Brooklyn. Emily y su esposo planearon conjuntamente la continuación de la construcción del puente. Trató con políticos, ingenieros competidores y todos aquellos asociados con el trabajo en el puente, hasta el punto en que la gente creía que ella estaba detrás del diseño del puente. Emily Roebling fue la primera en cruzar el puente en un carruaje en la ceremonia de apertura en 1883.

Los excelentes trabajos de Emily Warren Roebling como ingeniera fueron reconocidos por la Sociedad Americana de Ingenieros Civiles. Una placa, colocada en el puente en 1951 por el Club de Ingenieros de Brooklyn, conmemora su contribución para completar la construcción del puente.

Figura 11.9. Placa conmemorativa, 1951.

Tras terminar su trabajo en el puente de Brooklyn, Roebling pasó a apoyar varias tareas civiles organizadas por mujeres. También escribió varios ensayos, abogó por mayores derechos de las mujeres y criticó las prácticas discriminatorias dirigidas a las mujeres. Continuó su educación y recibió el grado en derecho por la Universidad de Nueva York en 1899, a la edad de 56 años.

Case Study *English edition*

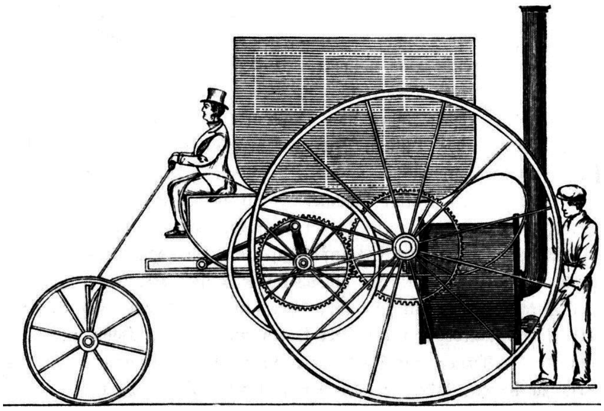
CASE STUDY

English edition

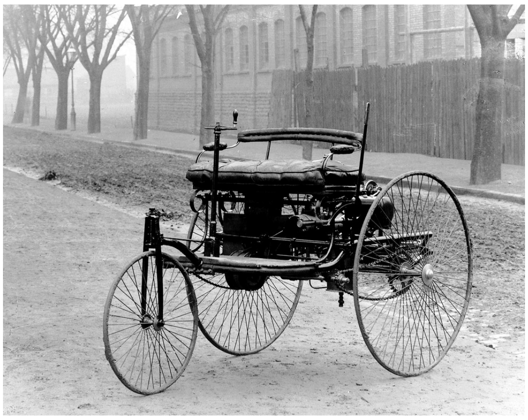
https://www.merlot.org/merlot/viewSite.htm?id=9164183

1. Who defined the "horsepower" as the unit of power?

In the early years of the automobile, we can imagine horses pulling the steam automobile of Richard Trevithick in 1801, that hardly could go up a slope, or the gas-engine car patented by Karl Benz in 1886. The first motor vehicles kept the structure of horse carriages in which the horse was substituted by an engine. The "horsepower" was a suitable, meaningful unit.



(a)



(b)

(c)

Figure 1.1. (a) Richard Trevithick's steam car in 1801; (b) Karl Benz's gas car in 1886; (c) horse-drawn carriages.

Who defined the "horsepower" as the unit of power? The answer is that the definition was stated by an engineer. The Scottish engineer James Watt (1736 – 1819) started his professional career as instrument maker, after he worked as civil engineer and, finally, he founded the Boulton & Watt company producing steam engines. He improved the efficiency of the machine and was the owner of several patents.

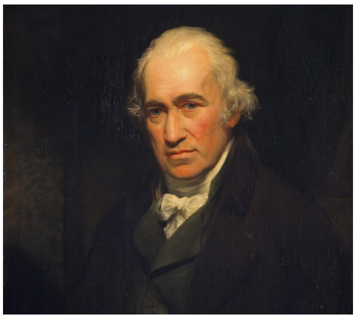
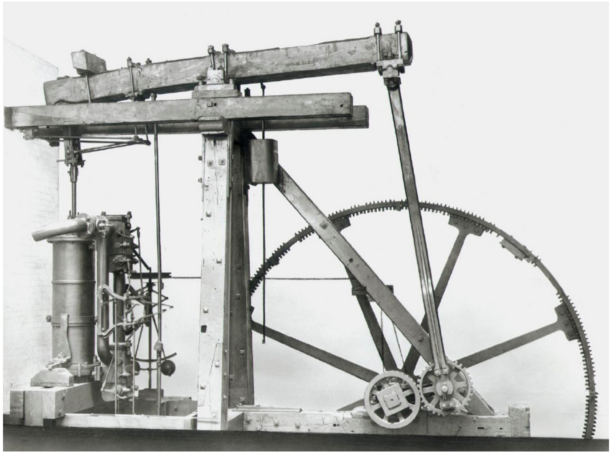
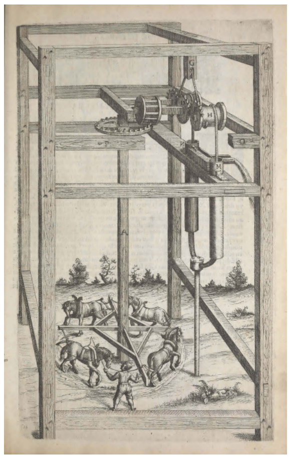


Figure 1.2. Portrait of James Watt.

Watt defined the engine and its qualities in a commercial and clever form. Since the steam engine had to compete, at that time, with the horse like source of energy in the mining industry, he decided to use the horse as unit of measure.



(a)



(b)

Figure 1.3. (a) Boulton&Watt steam engine, 1788. (b) Hydraulic pump for a mine, by Salomon de Caus in 1615.

Was there a better form to present the steam engine qualities that indicating the number of horses that it could substitute? The only question missing was to find the numerical equivalence to achieve it.

Watt supposed that a standard 'horse' could pull 180 pounds and determined that a horse could turn a mill wheel 144 times in an hour (or 2.4 times a minute). The wheel was 12 feet in radius; therefore, the horse travelled 2.4 × 2π × 12 feet in one minute. Power is calculated as the product of force by distance divided by time.

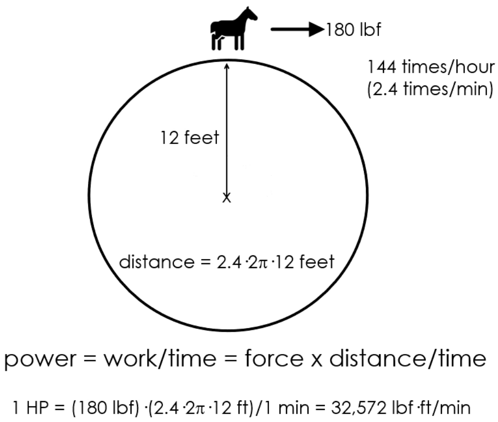


Figure 1.4. Definition of "horsepower" (HP) by James Watt.

1 HP (Watt) = force x distance/time = (180 lbf) x (2,4 x 2π x 12 ft) / 1 min = 32,572 ft·lbf/min)

The result was rounded to 33.000 lbf·ft/min. The formal definition of the "horsepower" was published in 1809 by James Watt.

The idea not only was brilliant but the resultant unit, the "horsepower", was deeply meaningful for his fellow citizens. Watt not only improved the steam engine as a technical alternative for the mining industry but comes to easy the understanding for the general people.

The systems of measurement that were born close to people experience are deeply meaningful, because by means of the measure they establish a dialogue between the man and the nature. The significance of the traditional measures, such as the "horsepower", constitutes one of his more outstanding virtues.

2. Did James Watt define the “watt” unit for power with his own name?

We are used to have at home many household appliances, which help us to make our life easier. Let’s turn round these devices and we will find a technical label. In all of them we can read a line with the symbol W, and we use to name this “watt”. It tells us something about the power of the device. Which is the origin of that name?

(a) (b)

Figure 2.1. (a) coffee maker and (b) toaster, with their technical labels.

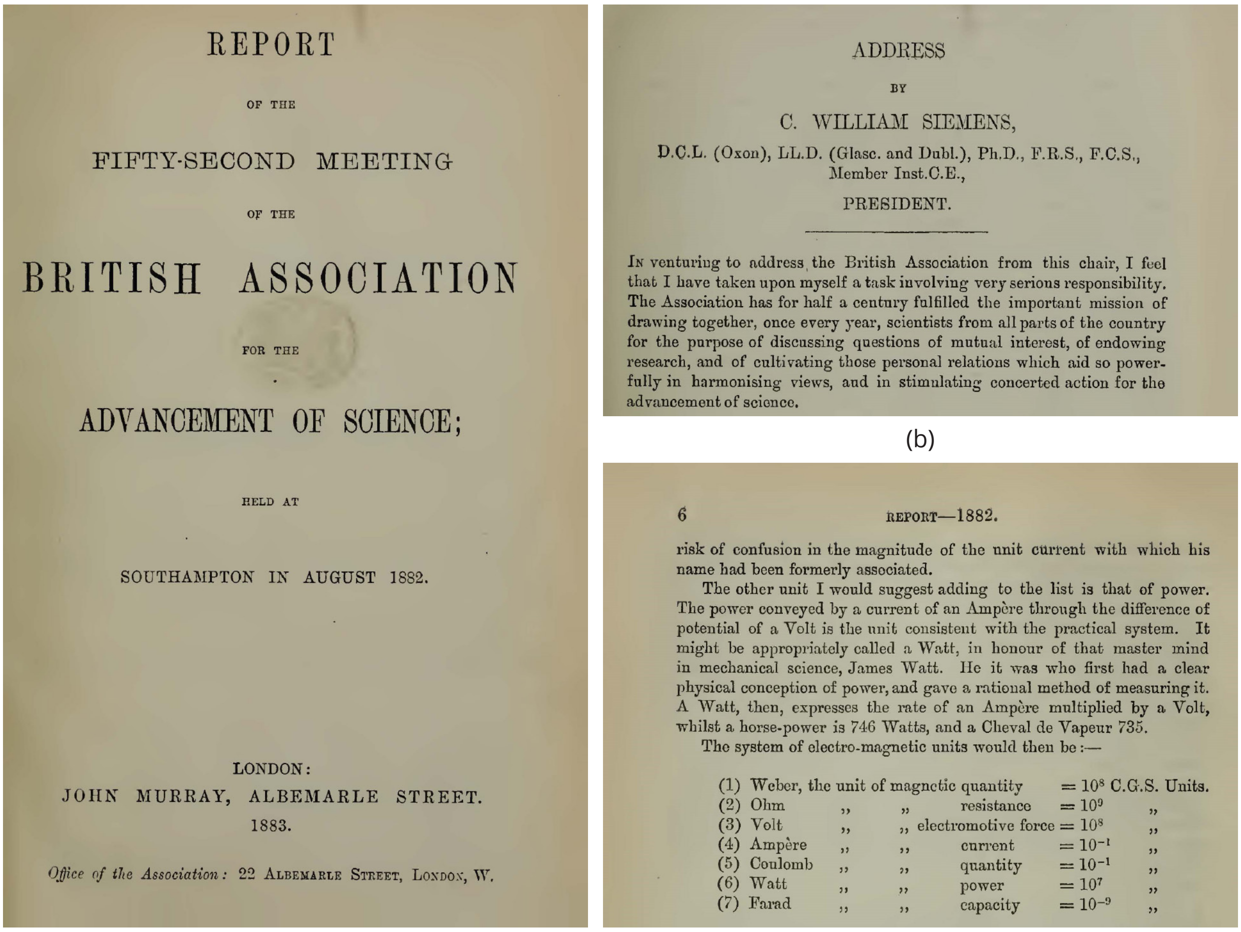
As he is very famous worldwide, many people could associate this name to the Scottish engineer James Watt. But did James Watt define the “watt” unit for power with his own name?

James Watt defined the “horsepower” but not the unit of power of the International System of Units, the “watt” (W). The “watt” as unit of power was proposed and defined by the German electrical engineer Carl Wilhelm Siemens.

Sir Carl Wilhelm Siemens (1823 – 1883) was a German-British engineer and businessman. He is also known as Charles William Siemens as he became a naturalised British citizen. He was a brilliant businessman and entrepreneur and, at the same time, a talented science researcher. He worked in various industrial activities and got international recognition as scientist.

Figure 2.2. The German-British engineer Carl Wilhelm Siemens.

During the 19th century the use of dynamos to generate electricity and those of electrical engines to transform the electrical power in mechanics became generalized. The need of a unit of power related with the electrical magnitudes (volt, ampere, ohm) was increasing along the years. In 1882 Carl Wilhelm Siemens, president of the British Association for the Advancement of Science, proposed the adoption of the "watt" unit in his report to the Association as he was his President. The proposed unit of power in the CGS system was named "watt" in honour of the engineer James Watt.



REPORT

OF THE

FIFTY-SECOND MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

HELD AT

SOUTHAMPTON IN AUGUST 1882.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1883.

Office of the Association: 22 ALBEMARLE STREET, LONDON, W.

(a)

ADDRESS

BY

C. WILLIAM SIEMENS,

D.C.L. (Oxon), LL.D. (Glasc. and Dubl.), Ph.D., F.R.S., F.C.S., Member Inst.C.E.,

PRESIDENT.

IN venturing to address the British Association from this chair, I feel that I have taken upon myself a task involving very serious responsibility. The Association has for half a century fulfilled the important mission of drawing together, once every year, scientists from all parts of the country for the purpose of discussing questions of mutual interest, of endowing research, and of cultivating those personal relations which aid so powerfully in harmonising views, and in stimulating concerted action for the advancement of science.

(b)

6 REPORT—1882.

risk of confusion in the magnitude of the unit current with which his name had been formerly associated.

The other unit I would suggest adding to the list is that of power. The power conveyed by a current of an Ampère through the difference of potential of a Volt is the unit consistent with the practical system. It might be appropriately called a Watt, in honour of that master mind in mechanical science, James Watt. He it was who first had a clear physical conception of power, and gave a rational method of measuring it. A Watt, then, expresses the rate of an Ampère multiplied by a Volt, whilst a horse-power is 746 Watts, and a Cheval de Vapeur 735.

The system of electro-magnetic units would then be:—

(1) Weber, the unit of magnetic quantity				$= 10^8$	C.G.S. Units.
(2) Ohm	,,	,,	resistance	$= 10^9$	,,
(3) Volt	,,	,,	electromotive force	$= 10^8$	,,
(4) Ampère	,,	,,	current	$= 10^{-1}$	,,
(5) Coulomb	,,	,,	quantity	$= 10^{-1}$	,,
(6) Watt	,,	,,	power	$= 10^7$	,,
(7) Farad	,,	,,	capacity	$= 10^{-9}$	,,

(c)

Figure 2.3. (a) August 1882 issue of the British Association for the Advancement of Science. (b) communication from the president of the association, C. William Siemens, to the associates, (c) proposal by C. William Siemens for, among others, the "watt" power unit in honour of James Watt.

The "watt" was defined as follows:

$$1\ watt = 1\ ampere \times 1\ volt$$

The international recognition of this unit was attained before the end of the 19th century.

In the same report of 1882, Siemens had proposed the joule (J) as unit of energy and work, which was definitively adopted by the British Association in 1888. From 1908 until 1948, the definition of "watt" was still related to the electrical units. From 1948, the definition of "watt" is based in the joule of energy:

$$1\ watt = 1\ joule/second$$

There are many scientific units named after people, of which most were given their names a relatively long time ago. Much of the personal naming occurred in 1860-70s for CGS system and 1870-1880s for SI. The most frequent case is that the unit is given its name by someone else to honour the discoverer or because nobody could come up with a better name. By convention, the name of the unit is properly written in all-lowercase, but its abbreviation is capitalized.

3. Some temperatures are measured in degrees Rankine. Who was Mr. Rankine?

In some US engineering textbooks dealing with temperature concepts, we find the mention of a temperature measured in a so-called Rankine scale. Very often, the relations between this temperature scale and those of Celsius (°C), Fahrenheit (°F) and Kelvin (K) are described by the respective conversion factors:

$$K = (5/9)R = (5/9)(^{o}F + 459.67) = {}^{o}C + 273.15$$

As with the other well-known temperature scales, it seems that this scale was named after a certain Mr. Rankine.

The Rankine scale was named after the Scottish engineer William John Macquorn Rankine (1820 - 1872). William Rankine worked as mechanical and civil engineer. Apart his career as professional engineer, from 1855 he was Professor of Civil Engineering and Mechanics at Glasgow University. He was one of the great contributors to the science of Thermodynamics. Many of his studies were focused on the Efficiency of Heat Engines and the Science of Energetics.

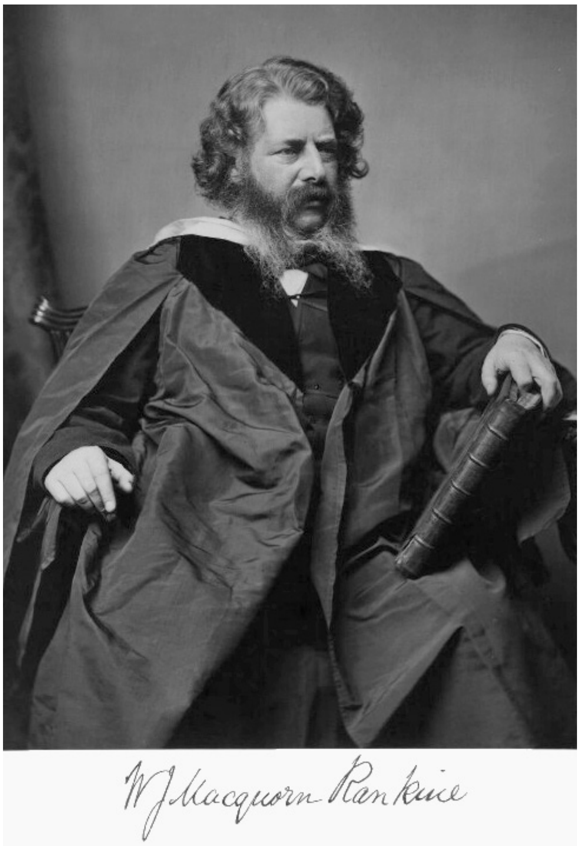
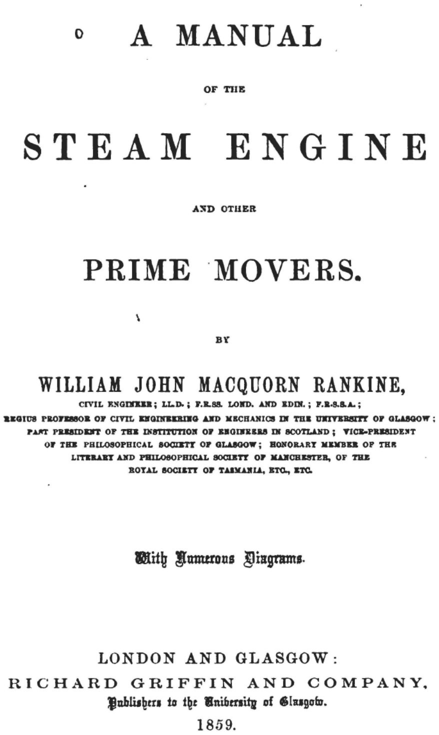


Figure 3.1. The Scottish engineer William John Macquorn Rankine.

He wrote several engineering treatises, being the one on the steam engine and other prime movers a reference manual for many years in the 19th century. He got international recognition and became member of prestigious institutions as the Royal Society of Edinburgh and the Royal Society of London.

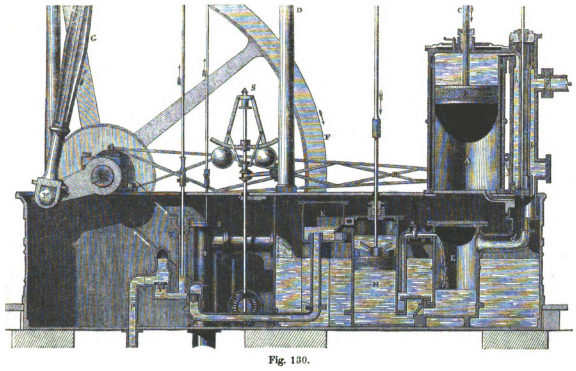
William Rankine published in 1859 his Manual of the Steam Engine and other Prime Movers. In the Part III, Rankine describes first the furnaces and boilers which supply heat from burning fuel and, second, the engine by which the heated fluid perform work by driving mechanism. Previously, he discussed those laws of the relations amongst the phenomena of heat and mechanical energy, which constitute the principles of Thermodynamics, upon which the work and efficiency of heat engines depend.


A MANUAL
OF THE
STEAM ENGINE
AND OTHER
PRIME MOVERS.
BY
WILLIAM JOHN MACQUORN RANKINE,
CIVIL ENGINEER; LL.D.; F.R.SS. LOND. AND EDIN.; F.R.S.S.A.;
REGIUS PROFESSOR OF CIVIL ENGINEERING AND MECHANICS IN THE UNIVERSITY OF GLASGOW;
PAST PRESIDENT OF THE INSTITUTION OF ENGINEERS IN SCOTLAND; VICE-PRESIDENT
OF THE PHILOSOPHICAL SOCIETY OF GLASGOW; HONORARY MEMBER OF THE
LITERARY AND PHILOSOPHICAL SOCIETY OF MANCHESTER, OF THE
ROYAL SOCIETY OF TASMANIA, ETC., ETC.

With Numerous Diagrams.

LONDON AND GLASGOW:
RICHARD GRIFFIN AND COMPANY,
Publishers to the University of Glasgow.
1859.

(a)



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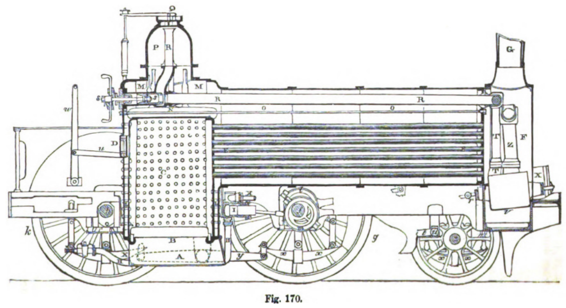


(c)

Figure 3.2. (a) Cover of the book *Steam Engine and Other Prime Movers* (1859). (b) longitudinal section of a double-acting rotary steam engine, by W. Rankine. (c) longitudinal section of a six-wheeled steam locomotive, by W. Rankine.

When presenting the temperature concepts and ideas, Rankine introduces the definition of the Absolute Temperature scales in relation to the ordinary scales. Thus, in relation with the Fahrenheit scale, he proposes the respective Absolute Temperature where the absolute zero corresponds to -461.2°F. This absolute temperature scale will be named afterwards as Rankine Scale.

With regards to the data available by 1859, Rankine calculations for the Absolute Zero of the Celsius scale led to the value of -274, very close to the -273.15 of today calculations. This scale corresponds to the present Kelvin scale, proposed in 1848 by William Thomson (Lord Kelvin). Rankine calculations for the Absolute Zero of the Fahrenheit's scale led to the value of -461.2. Today value is -459.67.

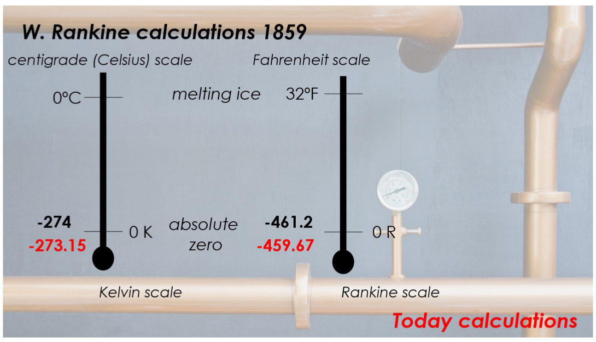


Figure 3.3. Comparison of Celsius, Fahrenheit, Kelvin, and Rankine temperature scales.

Nevertheless, the Rankine scale is very scarcely used. It seems that during the second half of the 20th century, people in the United States were creating programs and using equations that needed an absolute temperature, and they used Rankine before Kelvin became dominate for scientific calculations. The reason people still sometimes use it in the aerospace industry is that there are a lot of programs that were developed using Rankine, so, to be compatible with those old programs, it's often simpler to just use Rankine in the new programs too.

4. Does the SI unit for the electrical conductance, "siemens", has some relation with the Siemens AG© company?

In the International System of units, there is a set of derived units. Amongst them, we can find the one named "siemens", which symbol is the capital letter S, corresponding to the property electrical conductance.

SI derived units with special names and symbols[3]: 15

Name	Symbol	Quantity	In SI base units	In other SI units
radian[N 1]	rad	plane angle	m/m	1
steradian[N 1]	sr	solid angle	m^2/m^2	1
hertz	Hz	frequency	s^{-1}	
newton	N	force, weight	$kg \cdot m \cdot s^{-2}$	
pascal	Pa	pressure, stress	$kg \cdot m^{-1} \cdot s^{-2}$	N/m^2
joule	J	energy, work, heat	$kg \cdot m^2 \cdot s^{-2}$	$N \cdot m = Pa \cdot m^3$
watt	W	power, radiant flux	$kg \cdot m^2 \cdot s^{-3}$	J/s
coulomb	C	electric charge	$s \cdot A$	
volt	V	electrical potential difference (voltage), emf	$kg \cdot m^2 \cdot s^{-3} \cdot A^{-1}$	W/A = J/C
farad	F	capacitance	$kg^{-1} \cdot m^{-2} \cdot s^4 \cdot A^2$	$C/V = C^2/J$
ohm	Ω	resistance, impedance, reactance	$kg \cdot m^2 \cdot s^{-3} \cdot A^{-2}$	$V/A = J \cdot s/C^2$
siemens	S	electrical conductance	$kg^{-1} \cdot m^{-2} \cdot s^3 \cdot A^2$	Ω^{-1}
weber	Wb	magnetic flux	$kg \cdot m^2 \cdot s^{-2} \cdot A^{-1}$	$V \cdot s$
tesla	T	magnetic flux density	$kg \cdot s^{-2} \cdot A^{-1}$	Wb/m^2
henry	H	inductance	$kg \cdot m^2 \cdot s^{-2} \cdot A^{-2}$	Wb/A
degree Celsius	°C	temperature relative to 273.15 K	K	
lumen	lm	luminous flux	$cd \cdot sr$	$cd \cdot sr$
lux	lx	illuminance	$cd \cdot sr \cdot m^{-2}$	lm/m^2
becquerel	Bq	activity referred to a radionuclide (decays per unit time)	s^{-1}	
gray	Gy	absorbed dose (of ionising radiation)	$m^2 \cdot s^{-2}$	J/kg
sievert	Sv	equivalent dose (of ionising radiation)	$m^2 \cdot s^{-2}$	J/kg
katal	kat	catalytic activity	$mol \cdot s^{-1}$	

Notes

1. ^ a b The radian and steradian are defined as dimensionless derived units.

Figure 4.1. Derived units derived from the International System.

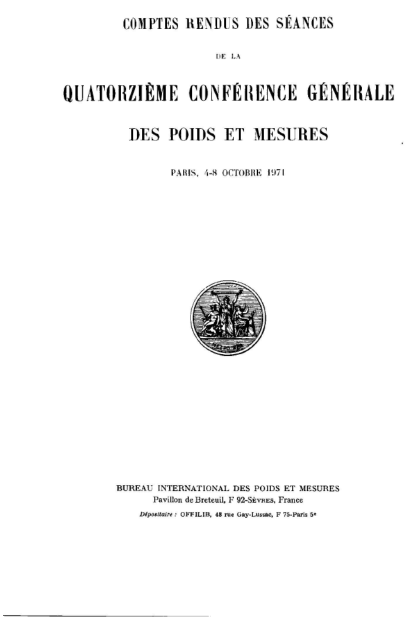
Besides, we can find worldwide the name Siemens associated to, for instance, household appliances, electrical motors, trains, or industrial automation systems.

(a) (b) (c)

Figure 4.2. Products of the company Siemens AG© (a) electric motors; (b) industrial automation systems; (c) trains.

Does the International System unit for the electrical conductance, "siemens", has some relation with the Siemens AG© company?

The 14th General Conference on Weights and Measures approved the addition of the "siemens" as a derived unit in 1971.



COMPTES RENDUS DES SÉANCES
DE LA
QUATORZIÈME CONFÉRENCE GÉNÉRALE
DES POIDS ET MESURES
PARIS, 4-8 OCTOBRE 1971

BUREAU INTERNATIONAL DES POIDS ET MESURES
Pavillon de Breteuil, F 92-Sèvres, France
Dépositaire : OFFILIB, 48 rue Gay-Lussac, F 75-Paris 5e

(a)

Tableau 4. Les 22 unités SI ayant un nom spécial et un symbole particulier

Grandeur dérivée	Nom spécial de l'unité	Expression de l'unité en unités de base (a)	Expression de l'unité en d'autres unités SI
angle plan	radian (b)	rad = m/m	
angle solide	stéradian (c)	$sr = m^2/m^2$	
fréquence	hertz (d)	$Hz = s^{-1}$	
force	newton	$N = kg\ m\ s^{-2}$	
pression, contrainte	pascal	$Pa = kg\ m^{-1}\ s^{-2}$	
énergie, travail, quantité de chaleur	joule	$J = kg\ m^2\ s^{-2}$	N m
puissance, flux énergétique	watt	$W = kg\ m^2\ s^{-3}$	J/s
charge électrique	coulomb	C = A s	
différence de potentiel électrique (e)	volt	$V = kg\ m^2\ s^{-3}\ A^{-1}$	W/A
capacité électrique	farad	$F = kg^{-1}\ m^{-2}\ s^4\ A^2$	C/V
résistance électrique	ohm	$\Omega = kg\ m^2\ s^{-3}\ A^{-2}$	V/A
conductance électrique	siemens	$S = kg^{-1}\ m^{-2}\ s^3\ A^2$	A/V
flux d'induction magnétique	weber	$Wb = kg\ m^2\ s^{-2}\ A^{-1}$	V s
induction magnétique	tesla	$T = kg\ s^{-2}\ A^{-1}$	Wb/m^2
inductance	henry	$H = kg\ m^2\ s^{-2}\ A^{-2}$	Wb/A
température Celsius	degré Celsius (f)	°C = K	
flux lumineux	lumen	lm = cd sr (g)	cd sr
éclairement lumineux	lux	$lx = cd\ sr\ m^{-2}$	lm/m^2
activité d'un radionucléide (d, h)	becquerel	$Bq = s^{-1}$	
dose absorbée, kerma	gray	$Gy = m^2\ s^{-2}$	J/kg
équivalent de dose	sievert (i)	$Sv = m^2\ s^{-2}$	J/kg
activité catalytique	katal	$kat = mol\ s^{-1}$	

(b)

Figure 4.3. (a) Publication of the 14th General Conference on Weights and Measures, October 4-8, 1971; (b) Table 4, with the units derived from the International System.

The "siemens" (symbol S) is the derived unit of electrical conductance. In equations, conductance is represented by G. A conductor has a conductance of 1 siemens if an electrical potential difference of 1 volt produces 1 ampere current in it. It is the reciprocal of resistance. Hence one "siemens" is equal to the reciprocal of one 1 *ohm* (Ω^{-1}).

$$G = 1/R = I/V$$

Unit: *siemens;* $[S] = [A/V] = [\Omega^{-1}]$, Ω, *ohm*; A, *ampere*; V, *volt*

It can be expressed also in terms of International System base units only. The same word "siemens" is used both for the singular and plural. The unit "siemens" was named after the engineer Ernst Werner von Siemens.

Figure 4.4. Werner von Siemens.

Werner von Siemens (1816 - 1892) was a brilliant German electrical engineer, businessman and talented inventor and scientist.

In 1847 he founded the company Siemens and Halske, the telegraph construction company after the invention of the pointer telegraph. Within a few decades, the company became a leading manufacturer of electrical equipment operating internationally. This company is the present company Siemens AG. In addition, Siemens was intensively devoted to scientific research. He discovered the dynamo-electric principle and thus laid the basis for the use of electrical energy as a source of power. During his lifetime, the pioneering electrical engineer received numerous honours in recognition of his services to both science and society.

By 1971, the unit "siemens" was not entirely new. It was used as the unit of electrical conductance by electrical engineers since 1935, as the International Electrotechnical Commission recommended its use at the plenary meeting in Scheveningen-Brussels. It must be pointed out that Werner von Siemens contributed largely to the technical and scientific studies of electrical resistance during the 19th century.

12. Transmission Circuits for Telephonic Communication (a book), K. S. Johnson. D. Van Nostrand Company, Inc., 1927.
13. Transmission Networks and Wave Filters (a book), T. E. Shea. D. Van Nostrand Company, Inc., 1929.
14. Phase Distortion in Telephone Apparatus, C. E. Lane. Bell System Tech. Jl., v. 9, July 1930, p. 493–521.
15. Harmonic Production in Ferromagnetic Materials, Eugene Peterson. Bell System Tech. Jl., v. 7, Oct. 1928, p. 762–96.

I.E.C. Adopts MKS System of Units

At its plenary meeting of June 1935 at Scheveningen-Bruxelles, the International Electrotechnical Commission unanimously adopted the meter-kilogram-second (mks) or Giorgi system of units, 15 of the 25 constituent countries being represented. In this paper the principal historical antecedents of this action by the I.E.C. are outlined, and its principal import to electrical engineering is indicated. Since the preparation of this paper there have been further important developments in connection with the adoption of this system; reports of these developments, as translated from the original French texts, are given in appendixes I and II.

By ARTHUR E. KENNELLY
HONORARY MEMBER A.I.E.E.
Harvard University, Cambridge, Mass.

As is well known, the International Electrotechnical Commission is an international organization maintained by 25 countries. It was called into existence under the leadership of R. E. Crompton, in response to a recommendation of the International Electrical Congress of St. Louis (Mo.) in 1904. It was organized in 1906 with its secretariat in London, and C. LeMaistre has been its general secretary since that time. It comprises 24 advisory committees, each dealing with a particular electrotechnical subject, and it has held plenary meetings in London, Paris, Brussels, The Hague, Berlin, Cologne, Turin, Zurich, Bellagio-Rome, Geneva, Denmark, Scandinavia, and New York. It has accomplished much international electrotechnical work during its 29 years of activity.

At its plenary meeting, in June 1935, at Scheveningen-Bruxelles, the I.E.C. unanimously adopted the Giorgi System of meter-kilogram-second (mks) units, 15 countries being represented by the delegates present. Every electrical engineer should make himself acquainted with the significance of this decision. In effect, it replaces the 3 systems at present in use (namely, the absolute electromagnetic cgs system, the absolute electrostatic cgs system, and the practical series) by one practical system.

The fundamental units are so chosen that the present practical series or system becomes at once an absolute system. This brings about a great simplification in the teaching of units and in practical calculations.

For the present, the question of rationalization has been left for future consideration. As the permeability and permittivity of space are no longer unity, it would be an easy matter to fix their values so as to rationalize all calculations; that is to say, to arrange matters so that the multiplier 4π comes into those formulas only where it would be expected to enter.

Not since the International Congress of Electricians, at Paris[7] in 1881, has there been made a decision of similar international significance. It is the purpose of this paper to outline the principal historical antecedents of this I.E.C. action, to indicate its main import to electrical engineering, and to suggest a few of the implications it may involve. The account here given is, however, necessarily subsidiary to the official minutes of the meeting, which should be consulted by interested readers.

History of CGS and Practical Units

As early as 1848, resistance boxes had been produced in Germany, calibrated to correspond to the linear resistance of particular sizes of telegraph wire. Gauss and Weber, about 1850, showed how to make certain electric and magnetic measurements in absolute measure, adopting for this purpose the millimeter-milligram-second system (mms). In 1860, Werner Siemens introduced his mercury unit of resistance; i. e., a glass tube of one square millimeter cross sectional area and one meter long, filled with pure mercury, at zero degrees centigrade.

The British Association for the Advancement of Science (commonly abbreviated to B.A.), at its meeting in Manchester, of 1861, established a committee to report upon "standards of electrical resistance." This B.A. committee became famous for its pioneer work. It made annual reports[1] until 1867. It recommended the adoption of an absolute fundamental system of scientific units, and after trying the foot-grain-second system (fgs) advocated the meter-gram-second system (mgs). It computed theoretically, and worked out practically, approximate electric standards, especially that of electrical resistance, for which Latimer Clark suggested the name *ohm*. Because the mgs absolute electromag-

A paper recommended for publication by the A.I.E.E. committee on electrophysics, and scheduled for discussion at the A.I.E.E. winter convention, New York, N. Y., Jan. 28–31, 1936. Manuscript submitted Sept. 30, 1935; released for publication Nov. 1, 1935.
Scheduled for republication by the Institution of Electrical Engineers, London.
7. For all numbered references see list at end of paper.

(a)

Table I—Incomplete List of MKS Units and of Corresponding CGS Units

No.	Quantity	Symbol	MKS Unit	CGS Unit	CGS Units in One MKS Unit
Mechanical					
1	Length	L	meter	centimeter	10^2
2	Mass	M	kilogram	gram	10^3
3	Time	T	second	second	1
4	Area	S	square meter	square centimeter	10^4
5	Volume	V	cubic meter (stere)	cubic centimeter	10^6
6	Frequency	f	hertz (cycle per second)	cycle per second	1
7	Density	d	kilogram per meter	gram per cubic centimeter	10^{-3}
8	Specific gravity		numeric	numeric	1
9	Velocity	v	meter per second	centimeter per second	10^2
10	Slowness		second per meter	second per centimeter	10^{-2}
11	Acceleration	a	meter per second per second	centimeter per second per second	10^2
12	Force	F	— (joule per meter)	dyne	10^5
13	Pressure	p	— (joule per cubic meter)	dyne per square centimeter, barye	10
14	Angle	α, β	radian	radian	1
15	Angular velocity	ω	radian per second	radian per second	1
16	Torque	τ	— (joule per radian)	dyne ⊥ centimeter	10^7
17	Moment of inertia	J	kilogram-square meter	gram-square centimeter	10^7
Energetics					
18	Work or energy	W	joule	erg	10^7
19	Angular work, $\tau\alpha$	W	joule	erg	10^7
20	Volume energy	w	joule per cubic meter	erg per cubic centimeter	10
21	Active power	P	watt	erg per second	10^7
22	Reactive power	jQ	var	erg per second	10^7
23	Vector power, $P \pm jQ$		watt ∠	erg per second	10^7
Thermal					
24	Quantity of heat	Q	kilogram-calorie	gram-calorie	10^3
25	Temperature	θ	degree centigrade or Kelvin	degree centigrade or Kelvin	1
Luminous					
26	Intensity	I	candle	candle	1
27	Luminous flux	ψ	lumen	lumen	1
28	Illumination	E	lux	phot	10^{-4}
29	Brightness	b	candle per square meter	stilb	10^{-4}
30	Focal power		diopter		10^{-2}
Electrical					
31	Electromotive force	E	volt		10^8
32	Potential gradient	ε	volt per meter		10^6
33	Resistance	R	ohm		10^9
34	Resistivity	ρ	ohm-meter		10^{11}
35	Conductance	G	siemens, mho		10^{-9}
36	Conductivity	γ	siemens per meter, mho per meter		10^{-11}
37	Reactance	jX	ohm		10^9
38	Impedance, $R \pm jX$	Z	ohm ∠		10^9
39	Quantity	Q	coulomb		10^{-1}
40	Displacement	Q	coulomb		10^{-1}
41	Current	I	ampere		10^{-1}
42	Current density	i	ampere per square meter		10^{-5}
43	Capacitance	C	farad		10^{-9}
44	Specific inductive capacity	ϵ/ϵ_0	numeric	numeric	1
Magnetic					
45	Magnetic flux	Φ	weber	maxwell	10^8
46	Flux density	B	weber per square meter	gauss	10^4
47	Inductance	L	henry		10^9
48	Relative permeability	μ/μ_0	numeric	numeric	1

(b)

Figure 4.5. (a) Publication of the agreements of the International Electrotechnical Commission of 1935; (b) Table I, with MKS units (Kenelly, 1935).

As the electrical conductance is the reciprocal of electrical resistance, (Ω^{-1}), the first name proposed for this unit was "mho", before it was named "siemens" in 1971. As the reciprocal of one ohm, "mho" is the word ohm spelled backwards, at the suggestion of Sir William Thomson (Lord Kelvin) in 1883. Thomson helpfully added that the proper pronunciation of "mho" could be obtained by taking a phonograph and turn it backwards. Its symbol is an inverted capital Greek letter omega.

THOMSON ON ELECTRICAL UNITS OF MEASUREMENT. 149

3 May, 1883.

JAMES BRUNLEES, F.R.S.E, President, in the Chair.

Electrical Units of Measurement.

By Sir William Thomson, F.R.S., M. Inst. C.E.

In physical science a first essential step in the direction of learning any subject, is to find principles of numerical reckoning, and methods for practicably measuring, some quality connected with it.

(a)

in series. For the reciprocal of an ohm in the measurement of resisting power—for the unit reckoning of conductivity which will agree with the ohm—it is suggested to take a phonograph and turn it backwards, and see what it will make of the word "ohm." I admire the suggestion, and I wish some one would take the responsibility of adopting it; we should then have *mho* boxes of coils at once in general use. With respect to electric light,

(b)

Figure 4.6. (a) Thomson's (Lord Kelvin) proposal on electric units, 1883; (b) Proposed name of the electrical conductance unit

5. Who gave the Eiffel Tower its name?

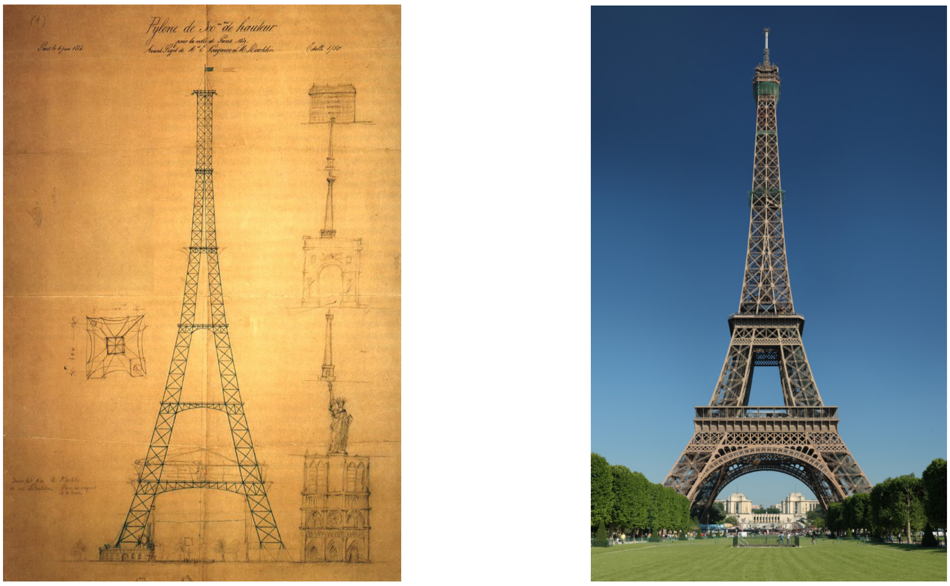
Probably you have heard about the Eiffel Tower, the famous tower in Paris, France. It is an iron lattice tower, and it was the centrepiece of the 1889 World' Fair. The tower is 330 metres tall, about the same height as an 81-storey building. It was the tallest man-made structure in the world till 1930. The Tower was named part of UNESCO World Heritage Site in 1991.

(a) (b)

Figure 5.1. (a) Poster of the Universal Fair of Paris, 1889; (b) Comparison of heights of well-known buildings in the publication La Ilustración Artística, 1889, 367, pp.3.

The tower design is attributed to Maurice Koechlin and Émile Nouguier, two engineers, and Stephen Sauvestre, an architect. It was conceived as "a great pylon, consisting of four lattice girders standing apart at the base and coming together at the top, joined together by metal trusses at regular intervals", in words of Koechlin. Note the sketched stack of buildings, with Notre Dame at the bottom, indicating the scale of the proposed tower.

The patent was filed in 1884. The tower was constructed from 1887 to 1889.



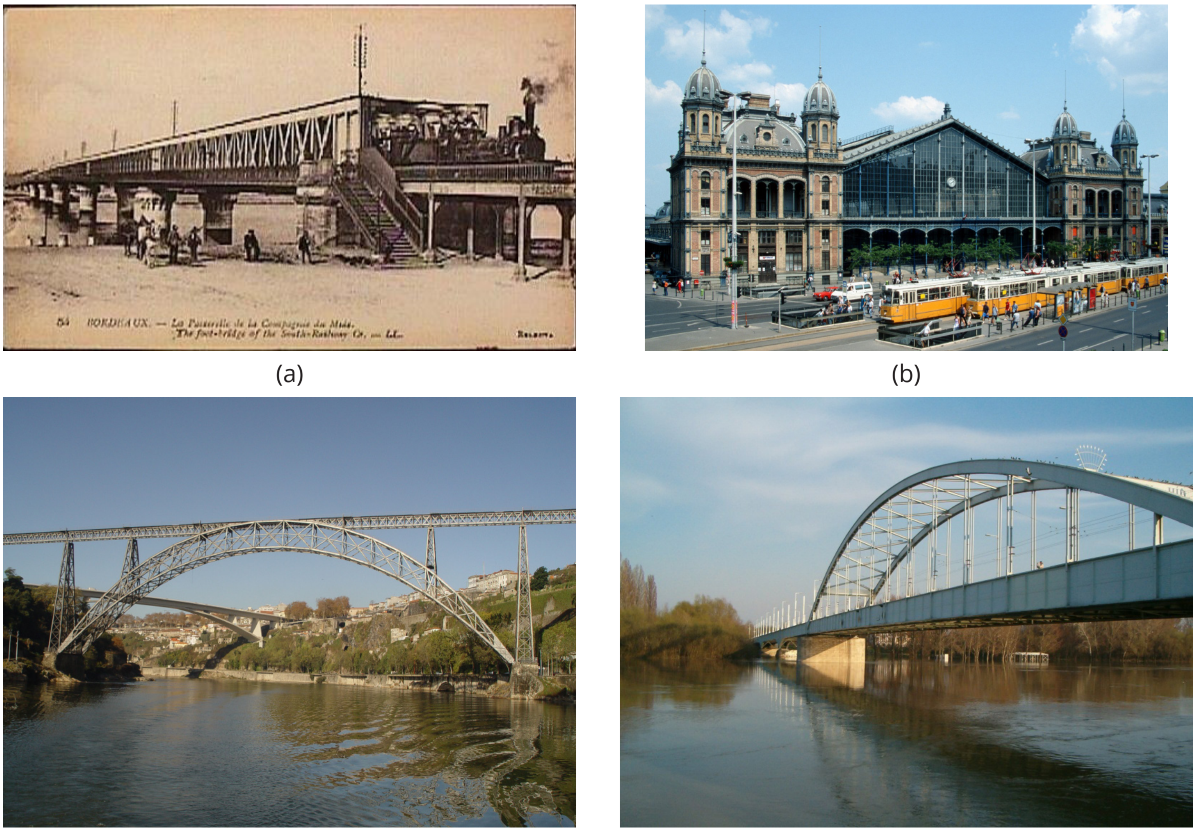
(a) (b)

Figure 5.2. (a) Sketch by Maurice Koechlin and Émile Nouguier and comparison of the stacking of well-known buildings; (b) Eiffel Tower, UNESCO World Heritage Site in 1991.

The designers were working for the Compagnie des Établissements Eiffel, the company of the engineer Gustave Eiffel.

Figure 5.3. Gustave Eiffel, 1890.

Graduate of the École Centrale des Arts et Manufactures in Paris, he made his name as engineer with various bridges for the French railway network. In 1868 he was co-founder of the Eiffel and Company firm and began to undertake work in other countries of Europe and abroad.



(a) (b)

(c) (d)

Figure 5.4. (a) Bordeaux Bridge, France, 1861; (b) Railway station, Budapest, 1877; (c) Maria Pia Bridge in Porto, Portugal, 1877; (d) Belvárosi Bridge in Szeged, Hungary, 1881.

In 1881, Eiffel devised a structure consisting of a four-legged pylon to support the copper sheeting which made up the body of the Statue of Liberty in New York. The entire statue was erected at the Eiffel works in Paris before being dismantled and shipped to the United States.


(a)

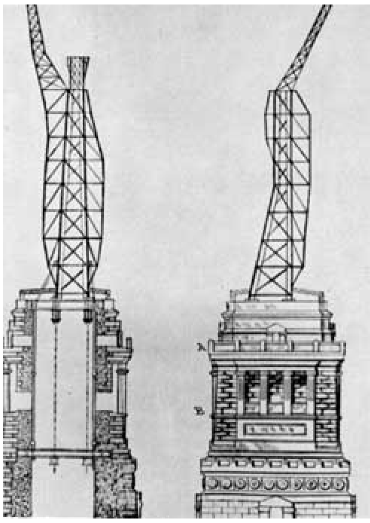
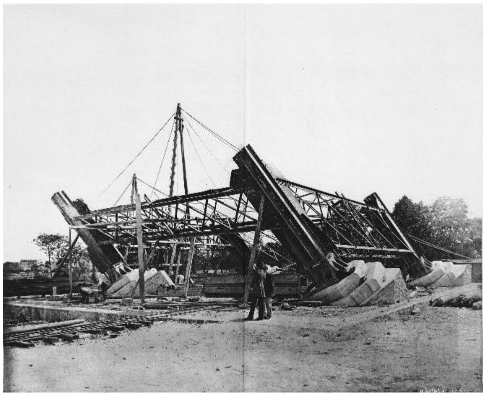

(b)

Figure 5.5. (a) Statue of Liberty, New York; (b) Internal structure of the Statue of Liberty.

The Eiffel Tower is the most famous work of Gustave Eiffel. The patent 164 364 was filed on September 18, 1884. The tower was constructed from 1887 to 1889. The main structural work was completed at the end of March 1889, and, on 31 March, Eiffel celebrated by leading a group of government officials and representatives of the press to the top of the tower. Since the lifts were not yet in operation, the ascent was made by foot, and took over an hour.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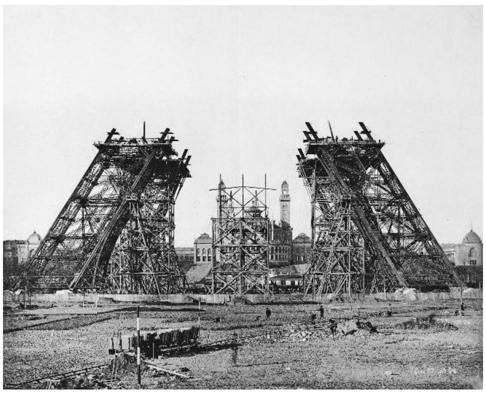

(b)


(c)

(d)

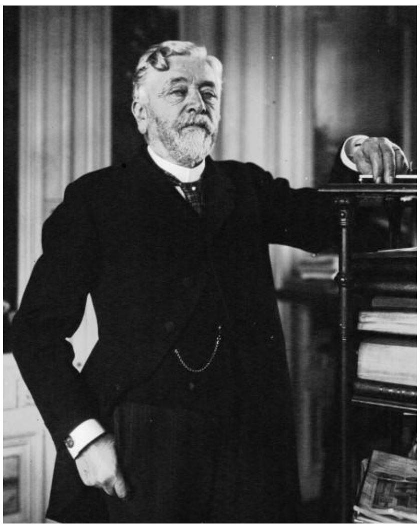
(e)

(f)

(g)

Figure 5.6. Construcción de la Torre Eiffel (a) 1 July 1887; (b) 2 December 1887; (c) 3 March 1888; (d) 4 May 1888; (e) 5 August 1888; (f) 6 December 1888; (g) 7 March 1889.

In 1893 Eiffel resigned from the direction of the Compagnie des Établissements Eiffel and his name disappeared from the name of the company. He then started a career as researcher on aerodynamics and his contribution in this field is probably of equal importance to his work as engineer, though much less known. At that time, he is more than 70 years old. A new career of scientist begins for him, which will last twenty years.

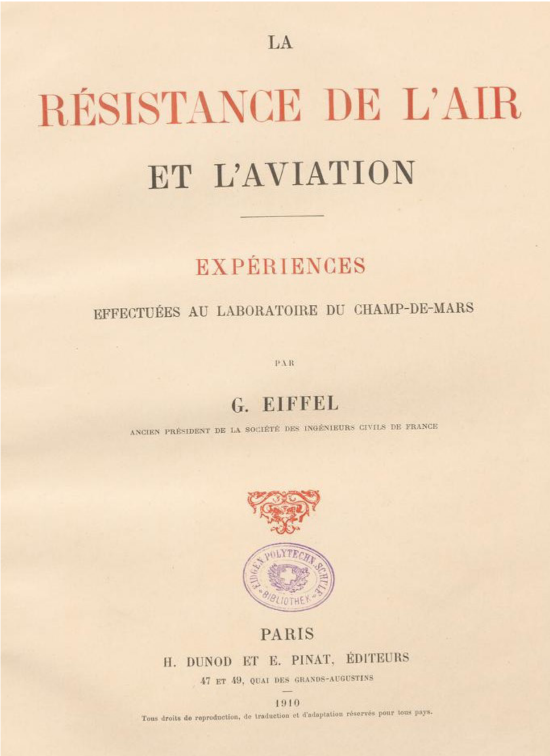


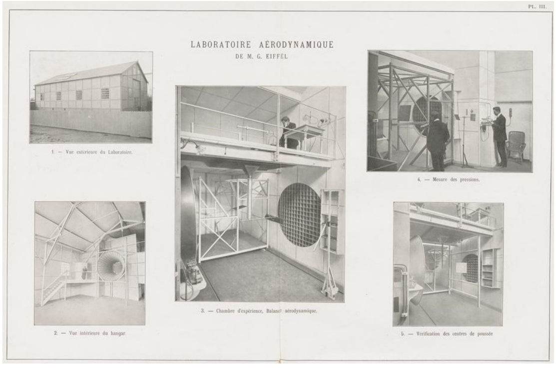
(a)

(b)

Figure 5.7. (a) Gustave Eiffel, 1910; (b) Eiffel with a model airplane.

In 1909, Eiffel built his first wind tunnel at the foot of the Eiffel Tower in the Champ de Mars. This facility was operational till 1911 to study aerodynamics. In the beginning of 1912, he installs in the district of Auteuil a new wind tunnel with increased performance. Being successful with his first set of tests, Eiffel's wind tunnel was then available for the pioneers in their conquest of air: Farman, Bleriot, Voisin, Bréguet.





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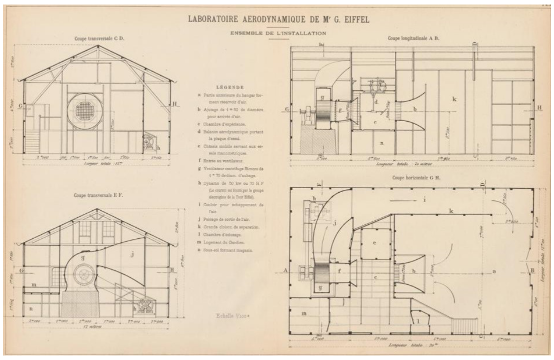


(a) (c)

Figure 5.8. (a) Cover of Eiffel's book on aerodynamics, 1910; (b) Photographs of Eiffel's laboratory; (c) Plans of Eiffel's laboratory

One of the main innovations of Eiffel was the addition of a diffuser to the wind tunnel. It was the subject of a patent dated 28 November 1911. This invention was rich in consequences, as it allowed Eiffel to drastically reduce the electric power required for such a facility. From that date all wind tunnels have been equipped with a diffuser.

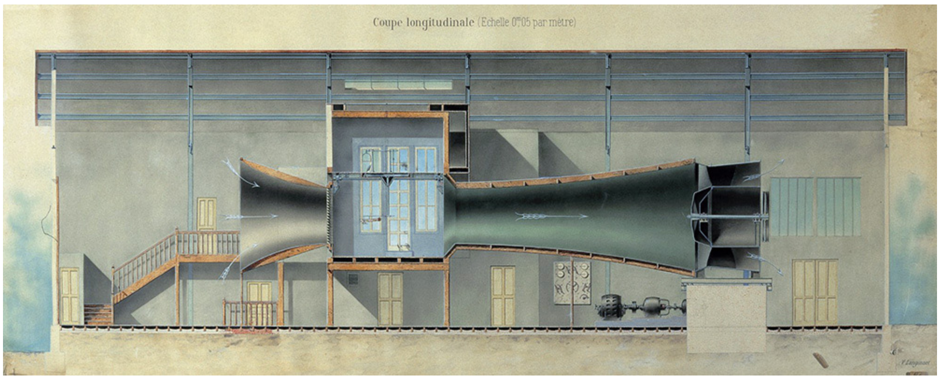


Figure 5.9. Eiffel wind tunnel.

His studies on airplanes performance were published in several books and journals. In 1917 he even filed a patent for a high-speed fighter plane.

Eiffel contribution to this emerging science of aerodynamics was recognized in the USA, where he received the gold medal of Langley in 1913, which had only been awarded to Wilbur and Orville Wright before.

6. Who gave its name to the Nobel Prizes?

Nobel Prizes, which are known worldwide, are five separate prizes awarded to those who have conferred the greatest benefit to mankind. Nobel prizes are awarded in the fields of Physics, Chemistry, Physiology or Medicine, Literature, and Peace since 1901. The Prize in Economic Sciences was added in 1969. Nobel prizes are widely regarded as the most prestigious awards available in their respective fields.

Between 1901 and 2017 the Nobel Prizes were awarded 585 times to 923 people and organizations. The Nobel Prize was not awarded between 1940 and 1942 due to the outbreak of World War II. Each laureate receives a gold medal, a diploma, and a monetary award.

(a) (b)

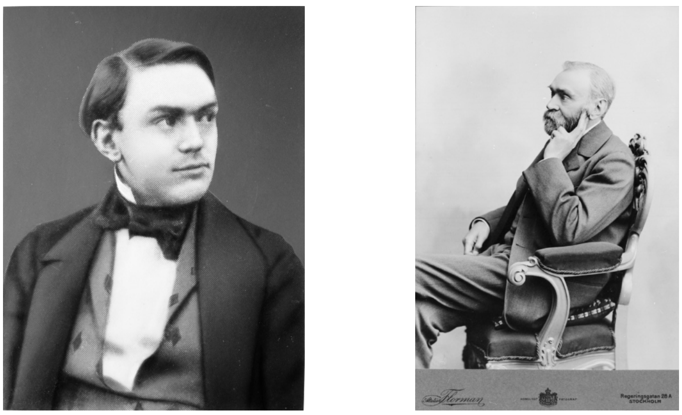
Figure 6.1. (a) Nobel Prize Medal; (b) Nobel Prize Diploma.

Among the Laureates, there are some curiosities.

Six laureates have received more than one prize. The International Committee of the Red Cross has received the Nobel Peace Prize three times, more than any other. United Nations High Commissioner for Refugees (UNHCR) has been awarded the Nobel Peace Prize twice. In Physics, it was awarded to John Bardeen twice. The same in Chemistry to Frederick Sanger. Two laureates have been awarded twice but not in the same field: Marie Curie (Physics and Chemistry) and Linus Pauling (Chemistry and Peace). Among the 892 Nobel laureates, 48 have been women (till 2021). Six Nobel laureates were not permitted to accept the Nobel Prize by their governments: four Germans (1936-1939), one Chinese (2010) and one Russian (1958). Two Nobel laureates, Jean-Paul Sartre (Literature, 1964) and Lê Đức Thọ (Peace, 1973), declined the award.

Who gave its name to the Nobel Prizes?

Nobel Prizes were named by its creator, Alfred Bernhard Nobel. (1833 - 1896). Nobel was a Swedish chemist, engineer, inventor, businessman, and philanthropist. He was born in Stockholm, where he lived his early childhood. In 1842 he moved with his family to Saint Petersburg, where the family had a business of manufacturing machine tools and explosives. Alfred Nobel's interest in technology and engineering was inherited from his father.

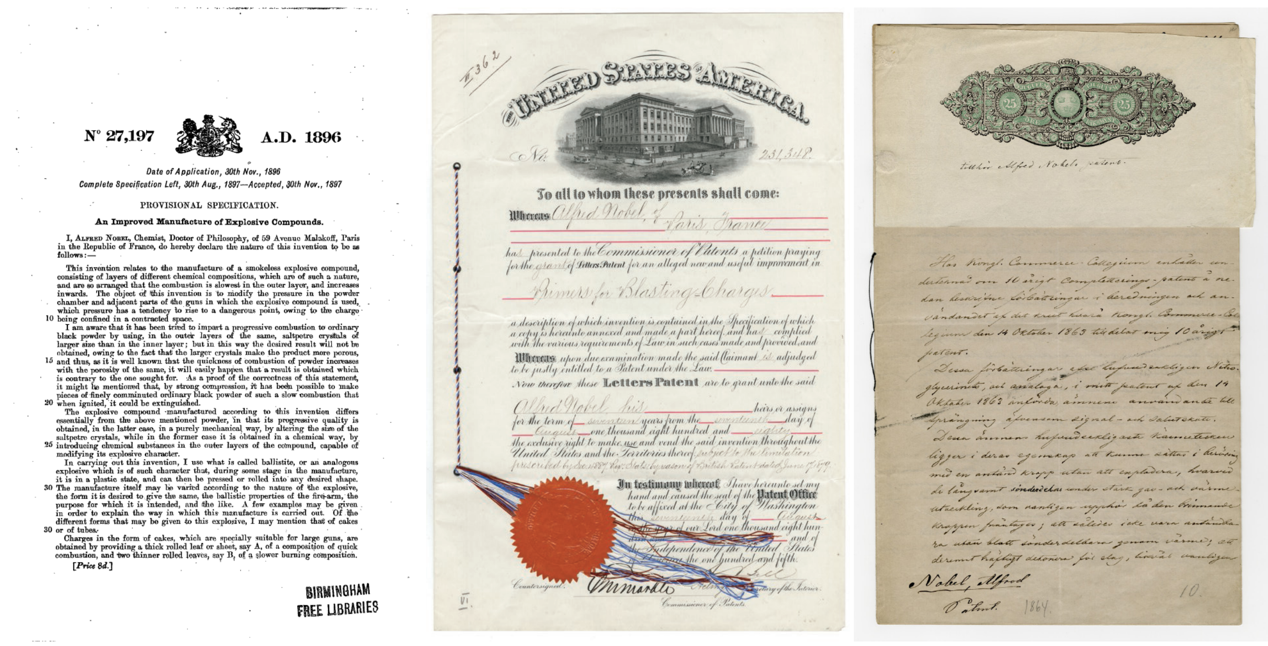


(a) (b)

Figure 6.2. (a) Alfred Nobel, young (b) Alfred Nobel, adult.

Nobel became an excellent inventor and engineer. He filed his first patent for a gas meter in 1857. During his life, Nobel was issued 355 patents internationally.

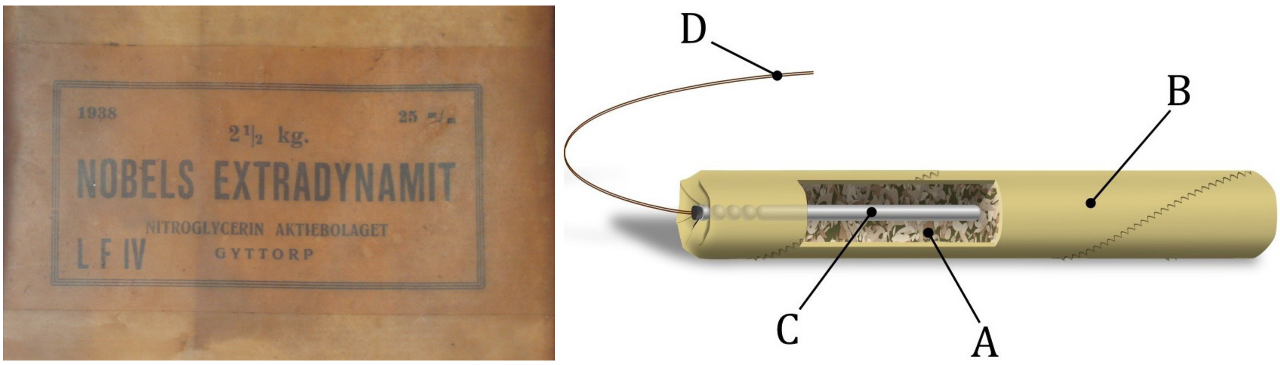
Back to Sweden in 1859, Nobel devoted himself to the study of explosives and invented a detonator in 1863 and the dynamite in 1867, a substance easier and safer to handle than the more unstable nitro-glycerine. Dynamite was patented in the US and the UK and was used extensively in mining and the building of transport networks internationally.



(a) (b) (d)

Figure 6.3. Alfred Nobel Explosives Patents (a) Great Britain (b) United States of America; (c) Sweden.

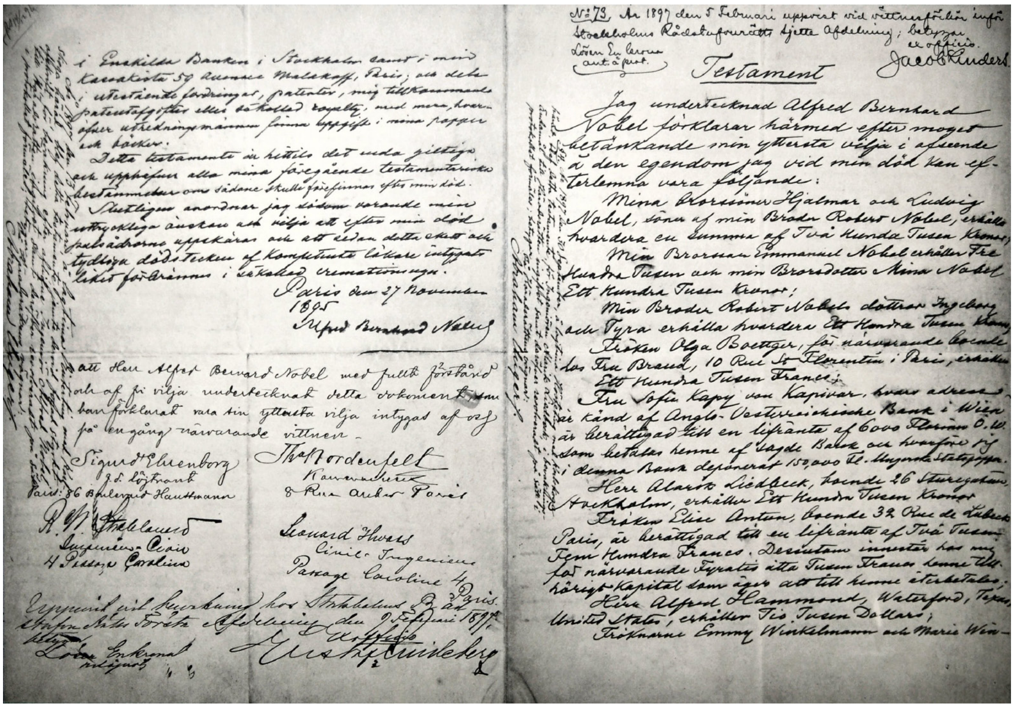
To improve the image of his business from the earlier controversies associated with dangerous explosives and the war, Nobel had also considered naming the highly powerful substance “Nobel’s Safety Powder”, but settled with Dynamite instead, referring to the Greek word for “power” (δύναμις). At the end of his life, his business had established more than 90 armaments factories, despite his apparently pacifist character.



(a) (b)

Figure 6.4. (a) Nobel dynamite box (b) Dynamite cartridge: [A] Diatomaceous earth (or any other type of absorbent material) soaked in nitro-glycerine, [B] Protective coating surrounding the explosive material, [C] Detonator, [D] Wire connected to the detonator.

Nobel decided to posthumously donate most of his wealth to find the Nobel Prize as his better legacy. In 1895 he signed his last will and testament and set aside the bulk of his estate to establish the Nobel Prizes, to be awarded annually without distinction of nationality.


Testament

Jag undertecknad Alfred Bernhard Nobel förklarar härmed efter moget betänkande min yttersta vilja i afseende å den egendom jag vid min död kan efterlemna vara följande:

Paris den 27 November 1895

Alfred Bernhard Nobel

Figure 6.5. Last will of Alfred Nobel, 1895.

Nobel was elected a member of the Royal Swedish Academy of Sciences in 1884, the same institution that would later select laureates for two of the Nobel Prizes, and he received an honorary doctorate from Uppsala University in 1893. The chemical element Nobelium, with the symbol No and atomic number 102, was named in honour of Alfred Nobel. Like all elements with atomic number over 100, nobelium can only be produced in particle accelerators.

Nobel was also a poet and a playwright with a taste for the melodramatic, though most of his writings remained unpublished. Nobel wrote the playwright Nemesis in the last year of his life and the script was given a limited publication following his death in 1896. After one century, the first, and so far the only production was at the Strindberg's Intima theatre in Stockholm in 2005.

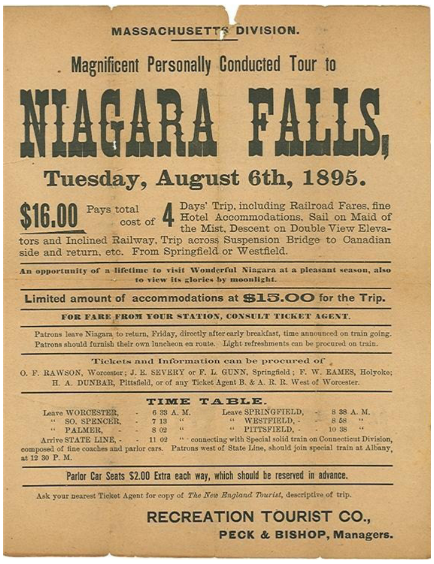
(a) (b)

Figura 6.6. (a) Intima Strindberg's Theatre in Stockholm; (b) Alfred Nobel's private library at Björkborn Manor, Karlskoga, Sweden.

Alfred Nobel's huge interest in literature and writing is reflected in his book collections. After his death he left a private library of over 1500 volumes, mostly fiction in the original language, works by the great writers of the 19th century, but also the classics and works by philosophers, theologians, historians, and other scientists.

7. Who was the designer of the "Aero Car" in Niagara Falls?

Niagara Falls are some of the largest, most beautiful, and most famous waterfalls in the world. It consists of a group of three waterfalls at the southern end of Niagara Gorge, spanning the border between the province of Ontario in Canada and the state of New York in the United States. The Falls are formed by the Niagara River, which drains Lake Erie into Lake Ontario. Niagara Falls is famed for its beauty and is a valuable source of hydroelectric power. Balancing recreational, commercial, and industrial uses has been a challenge for the stewards of the falls since the 19th century.



(a)


(b)

Figure 7.1. (a) Advertisement of Niagara Falls, 1895; (b) Panoramic view of Niagara Falls.

One of the main touristic attractions of Niagara Falls is the Whirlpool Aero Car, an unforgettable ride over the vibrant waters of the Niagara River. Witness spectacular views of the swirling Niagara Whirlpool and the river's rapids.


(a)


(b)

Figure 7.2. (a) Panoramic view of the Aero-Car; (b) Aero-Car truck.

In 1913, Niagara Parks was approached by a group of Spanish businessmen interested in building a new cable car that would take visitors across the Niagara Whirlpool. It would provide an entirely new perspective of the gorge with unobstructed views of the natural phenomenon below.

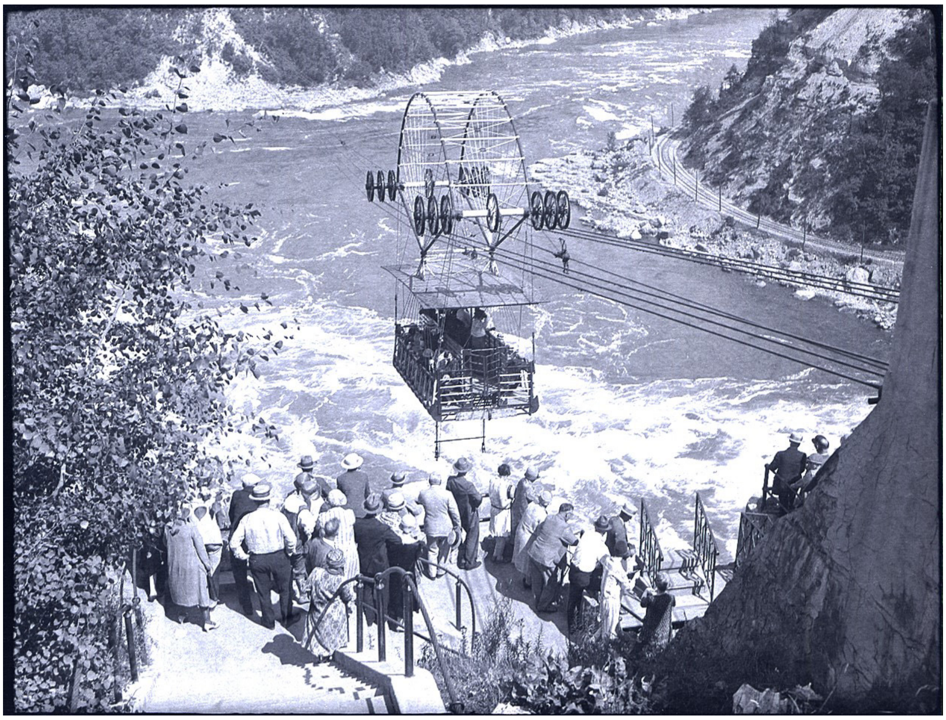
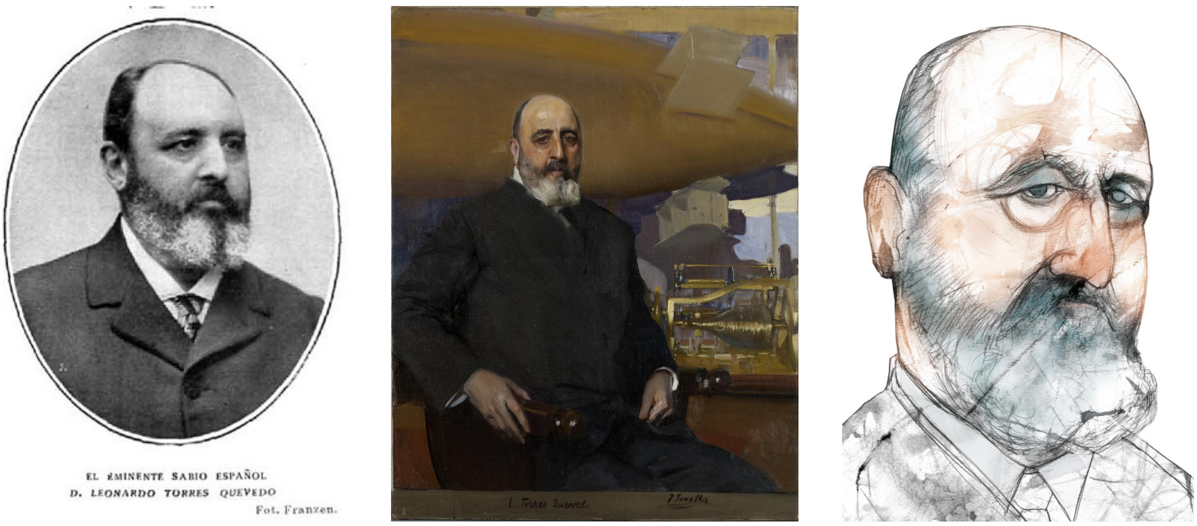


Figure 7.3. Aero-Car in 1926.

Who was the designer of the "Aero Car" in Niagara Falls?

The author was Leonardo Torres Quevedo (1852 – 1936), a Spanish civil engineer and mathematician of the late nineteenth and early twentieth centuries. Torres was a pioneer in the development of the radio control and automated calculation machines, as well as wireless remote-control operation principles. He was also an innovative designer of aerostatic airships and cableways, as the Whirlpool Aero Car located in Niagara Falls. He was the author of a great number of patents worldwide.

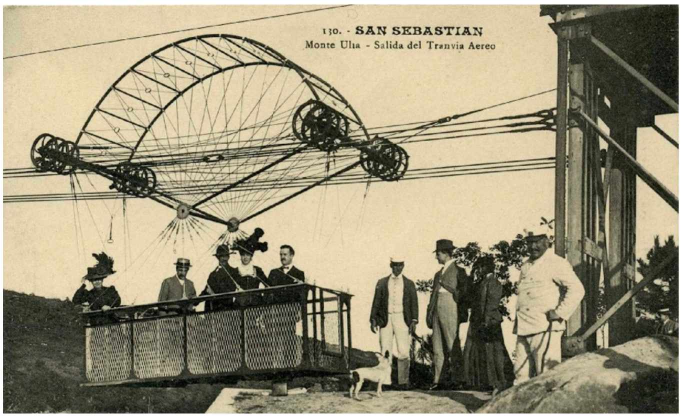


(a) (b) (c)

Figure 7.4. Leonardo Torres Quevedo. (a) Photograph by C. Franzen, 1916 (b) Portrait by J. Sorolla, 1917; (c) Portrait by r E. Merle, FECYT, 2011.

He received numerous honours in recognition of his services to both science and society. He was President of the Royal Academy of Exact, Physical and Natural Sciences in Madrid in 1910. In 1920, he entered the Royal Spanish Academy and the French Academy of Science. He was named Doctor Honoris Causa of the Sorbonne in Paris in 1922.

Torres's experimentation in cableways and cable cars began as early as in 1887. In 1907, Torres constructed the first cableway suitable for the public transportation of people, in the mount Ulía in San Sebastián in Spain. The problem of safety was solved by means of an ingenious system of multiple support cables. The resulting design was very strong and perfectly resisted the rupture of one of the support cables.



(a)

(b)

Figure 7.5. Cableway of Monte Ulía, San Sebastián. (a)1907; (b) 1916.

Designed and patented by the Spanish engineer, the Whirlpool Aero Car has been soaring the Niagara Gorge since 1916. He designed the attraction, following the principles of the similar installation at San Sebastián.

UNITED STATES PATENT OFFICE.

LEONARDO TORRES Y QUEVEDO, OF MADRID, SPAIN.

FUNICULAR-RAILWAY SYSTEM AND CAR OR VEHICLE THEREFOR.

979,228. Specification of Letters Patent. Patented Dec. 20, 1910.

Application filed May 16, 1910. Serial No. 561,750.

To all whom it may concern:

Be it known that I, Leonardo Torres y Quevedo, a subject of the King of Spain, residing in Madrid, Spain, have invented certain new and useful Improvements in Funicular-Railway Systems and Cars or Vehicles Therefor, of which the following is a specification.

Funicular railways as hitherto constructed usually comprise carrying ropes and a special rope for hauling the vehicle. There are also installations wherein the carrying ropes, stretched between two points situated at the same altitude, bear the vehicle and on which the vehicle travels the larger part of its way is finished by the aid of an auxiliary force, for example by providing the vehicle with an electric motor supplied with current by the carrying rope serving the purpose of a trolley wire.

My invention relates to a system wherein one of the ropes becomes a traction or hauling rope when the vehicle stops after all the live force has been exhausted.

The invention will be fully understood by the following description with reference to the accompanying drawing, in which:

Figure 1 is an elevation of the entire vehicle. Fig. 2 is a view of a portion of the car and of the arrangement for securing it at the stations. Fig. 3 is a plan view of Fig. 2. Fig. 4 is a view, partly in plan and partly in section showing the arrangement for opening the door of the car. Figs. 5 and 6 are detailed sectional views of the clutch mechanism. Fig. 7 is an elevation of the clutch mechanism illustrated in Fig. 5. Fig. 8 is a plan of the general gear of the traction or haulage rope.

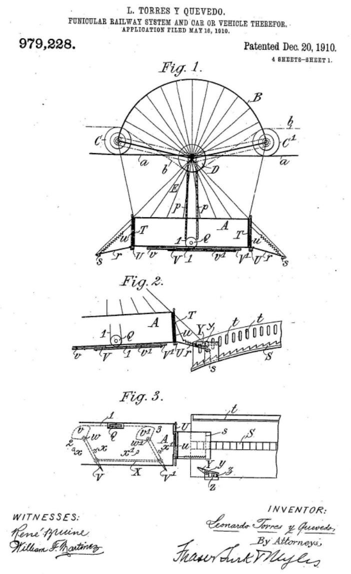
The track is formed by a suitable number of ropes *a*, for example six, fixed at one station and passing to the other station over pulleys, the tension of the said ropes being insured by suitable weights in the known manner. The tension to which these ropes are subjected is therefore constant and independent of the load which they have to support. The vehicle consists of a car A suspended by suitable cords to a carriage B provided with wheels. Suppose the carrying ropes *a* to be six in number for example, they will be divided in such a manner that there will be three on each side of the carriage so that the latter will rest upon the carrying ropes by means of twelve wheels, six in front and six at the rear. A seventh rope *b* passing over two bearing wheels C, C^1 placed in the median plane of the car supports the latter through the medium of another wheel D placed in the median plane; this wheel is mounted on the shaft E.

The principle of the system is therefore as follows: The carriage B and the car A being released at one of the stations, descends under the effect of its own weight, bearing upon the ropes *a* and on the rope *b*. The vehicle passes beyond the lowest point owing to its inertia when, the live force being exhausted, the vehicle will have a tendency to return to said lowest point, and the wheel D of the median plane of the vehicle will be rendered immovable upon its fixed shaft, that is to say, it will no longer be able to turn; then the rope *b* stretched between the wheels C, C^1 and the fixed wheel D at a very obtuse angle, exerts upon the wheel D a frictional force such that the sliding of the vehicle with relation to the rope *b* is impossible and that, if at this moment a movement of translation be given to the rope *b* in the direction of travel the said rope *b* will draw along the vehicle with it.

I will now describe the mechanism which allows of automatically locking the wheel D on the shaft. The shaft E is fixed: it is hollow and is provided in the interior with a rod F. On the shaft E are mounted the pulley D generally loose and the piece G also loose, carrying two pinions *c*, *d* each gearing with a chain. Each of these chains gears with a toothed ring similar to *c* or to *d*, mounted upon one of the shafts of the carrying wheels, so that the rotation of the drum G positively causes the rotation of the two axles of the carriage B and of the twelve carrying wheels.

The shaft E is provided with a screw-threaded end *e* on which is screwed a nut H; in the shaft E are made ten longitudinal grooves, such as I, arranged opposite one another in pairs; these grooves allow four arms K. L. M. N mounted on the rod F to

(a)



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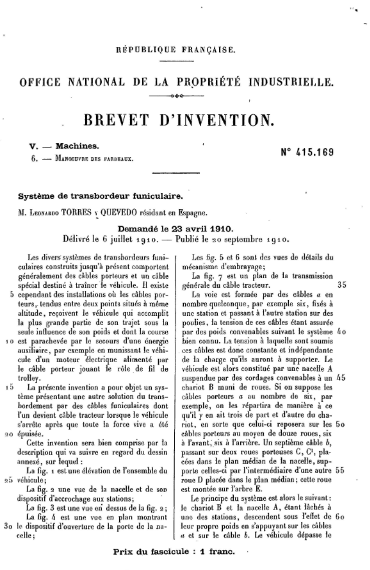


RÉPUBLIQUE FRANÇAISE.

OFFICE NATIONAL DE LA PROPRIÉTÉ INDUSTRIELLE.

BREVET D'INVENTION.

V. — Machines.
6. — Manoeuvre des fardeaux.

N° 415.169

Système de transbordeur funiculaire.

M. Leonardo TORRES y QUEVEDO résidant en Espagne.

Demandé le 23 avril 1910.
Délivré le 6 juillet 1910. — Publié le 20 septembre 1910.

Les divers systèmes de transbordeurs funiculaires construits jusqu'à présent comportent généralement des câbles porteurs et un câble spécial destiné à traîner le véhicule. Il existe cependant des installations où les câbles porteurs, tendus entre deux points situés à même altitude, reçoivent le véhicule qui accomplit la plus grande partie de son trajet sous la seule influence de son poids et dont la course est parachevée par le secours d'une énergie auxiliaire, par exemple en munissant le véhicule d'un moteur électrique alimenté par le câble porteur jouant le rôle de fil de trolley.

La présente invention a pour objet un système présentant une autre solution du transbordement par des câbles funiculaires dont l'un devient câble tracteur lorsque le véhicule s'arrête après que toute la force vive a été épuisée.

Cette invention sera bien comprise par la description qui va suivre en regard du dessin annexé, sur lequel :

La fig. 1 est une élévation de l'ensemble du véhicule;

La fig. 2 une vue de la nacelle et de son dispositif d'accrochage aux stations;

La fig. 3 est une vue en dessus de la fig. 2;

La fig. 4 est une vue en plan montrant le dispositif d'ouverture de la porte de la nacelle;

Les fig. 5 et 6 sont des vues de détails du mécanisme d'embrayage;

La fig. 7 est un plan de la transmission générale du câble tracteur.

La voie est formée par des câbles *a* en nombre quelconque, par exemple six, fixés à une station et passant à l'autre station sur des poulies, la tension de ces câbles étant assurée par des poids convenables suivant le système bien connu. La tension à laquelle sont soumis ces câbles est donc constante et indépendante de la charge qu'ils auront à supporter. Le véhicule est alors constitué par une nacelle A suspendue par des cordages convenables à un chariot B muni de roues. Si on suppose les câbles porteurs *a* au nombre de six, par exemple, on les répartira de manière à ce qu'il y en ait trois de part et d'autre du chariot, en sorte que celui-ci reposera sur les câbles porteurs au moyen de douze roues, six à l'avant, six à l'arrière. Un septième câble *b*, passant sur deux roues porteuses C, C^1, placées dans le plan médian de la nacelle, supporte celles-ci par l'intermédiaire d'une autre roue D placée dans le plan médian; cette roue est montée sur l'arbre E.

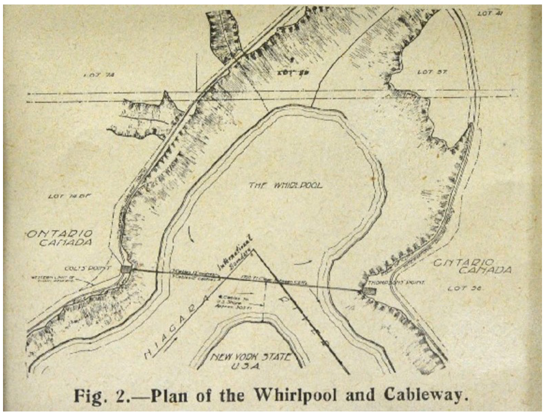
Le principe du système est alors le suivant : le chariot B et la nacelle A, étant lâchés à une des stations, descendent sous l'effet de leur propre poids en s'appuyant sur les câbles *a* et sur le câble *b*. Le véhicule dépasse le

Prix du fascicule : 1 franc.

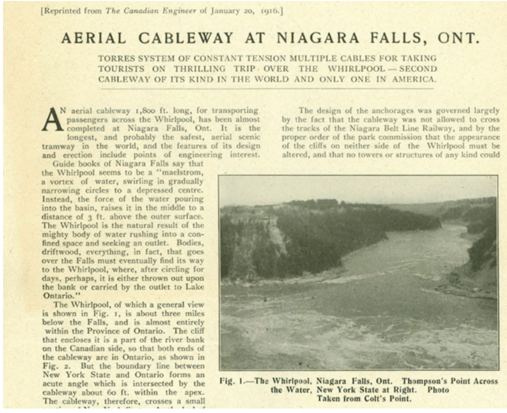
(c)

Figure 7.6. Patents of the cableway of Torres Quevedo, 1910. (a) Patent US979228A (b) Patent US979228A, sketch; (c) Patent FR415169A.

Although it travels between two points on the Canadian shore, this antique cable car will take you across the international border between Canada and the United States a total of four times due to the way the river elbows. The car would hold up to 40 passengers at a time and be suspended 76 meters above the water by a series of steel cables. Tension of the cable lines was to be maintained by a 10 tons counterweight housed at its Thompson Point terminus. The car is powered by an electric motor of 37 kW and travels at approximately 7 km/h.



(a)



[Reprinted from *The Canadian Engineer* of January 20, 1916.]

AERIAL CABLEWAY AT NIAGARA FALLS, ONT.

TORRES SYSTEM OF CONSTANT TENSION MULTIPLE CABLES FOR TAKING TOURISTS ON THRILLING TRIP OVER THE WHIRLPOOL — SECOND CABLEWAY OF ITS KIND IN THE WORLD AND ONLY ONE IN AMERICA.

An aerial cableway 1,800 ft. long, for transporting passengers across the Whirlpool, has been almost completed at Niagara Falls, Ont. It is the longest, and probably the safest, aerial scenic tramway in the world, and the features of its design and erection include points of engineering interest.

Guide books of Niagara Falls say that the Whirlpool seems to be a "maelstrom, a vortex of water, swirling in gradually narrowing circles to a depressed centre. Instead, the force of the water pouring into the basin, raises it in the middle to a distance of 3 ft. above the outer surface. The Whirlpool is the natural result of the mighty body of water rushing into a confined space and seeking an outlet. Bodies, driftwood, everything, in fact, that goes over the Falls must eventually find its way to the Whirlpool, where, after circling for days, perhaps, it is either thrown out upon the bank or carried by the outlet to Lake Ontario."

The Whirlpool, of which a general view is shown in Fig. 1, is about three miles below the Falls, and is almost entirely within the Province of Ontario. The cliff that encloses it is a part of the river bank on the Canadian side, so that both ends of the cableway are in Ontario, as shown in Fig. 2. But the boundary line between New York State and Ontario forms an acute angle which is intersected by the cableway about 60 ft. within the apex. The cableway, therefore, crosses a small

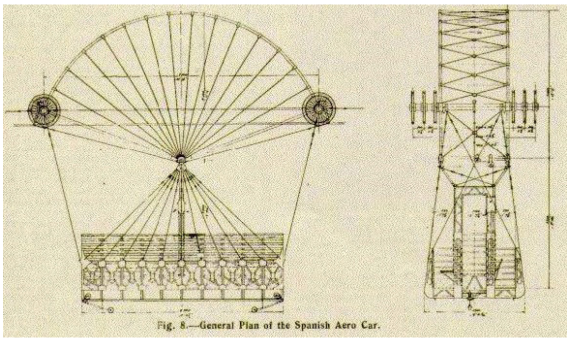
The design of the anchorages was governed largely by the fact that the cableway was not allowed to cross the tracks of the Niagara Belt Line Railway, and by the proper order of the park commission that the appearance of the cliffs on neither side of the Whirlpool must be altered, and that no towers or structures of any kind could

Fig. 1.—The Whirlpool, Niagara Falls, Ont. Thompson's Point Across the Water, New York State at Right. Photo Taken from Colt's Point.

(b)

Figure 7.7. (a) map of the Aero-Car's route between Canada and the United States; (b) Aero-Car news in *The Canadian Engineer*, 1916.

Construction began in 1915 and started operations on August 8, 1916. The first passengers included Spanish dignitaries, and the car was adorned with the flags of four nations, Canada, Spain, the United States and France. In 1984, the attraction underwent substantial upgrades to modernize its mechanical components. The carriage was not changed however, in the interest of preserving its historical integrity. For over 100 years, with no accidents worthy of mention, the historic Whirlpool Aero Car has offered riders spectacular views of the swirling Niagara Whirlpool and the whitewater rapids of the Niagara River.

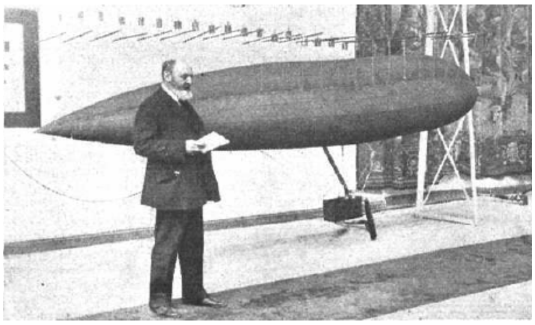


(a)

(b)

Figure 7.8. (a) Drawing of the Aero-Car by Torres Quevedo; (b) Inauguration of the Aero-Car.

Other works of Torres Quevedo concerned the design and construction of aerostatic airships. Since 1902 he developed a new type of dirigible with an internal frame of flexible cables that would give the airship rigidity by way of interior pressure. In 1905 he built the first Spanish dirigible for the Army and, since 1911, collaboration began between Torres and the French company Astra. The Astra-Torres airships were widely used during the First World War, mainly for naval protection and inspection.



(a)

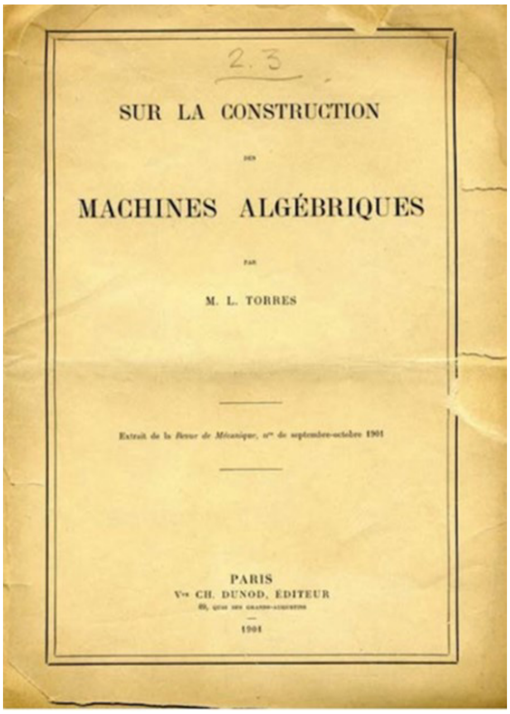
(b)

Figure 7.9. (a) Torres Quevedo and his airship; (b) Airship Astra-Torres, 1911.

Torres was also a pioneer in the field of remote control. In 1903, he presented the Telekino at the French Academy of Sciences. The Telekino consisted of a robot that executed commands transmitted by electromagnetic waves. It was patented in France, Spain, Great Britain, and the United States. In 2007, the prestigious Institute of Electrical and Electronics Engineers dedicated a Milestone in Electrical Engineering and Computing to the Telekino.

Figure 7.10. IEEE commemorative plaque.

Finally, out of all the work carried out by Torres Quevedo throughout his life, his most universal fame is probably due to his work in "automatics". He made important contributions to algebraic machines—the predecessors of analogue computers—and arithmetical machines—the predecessors of modern digital computers.



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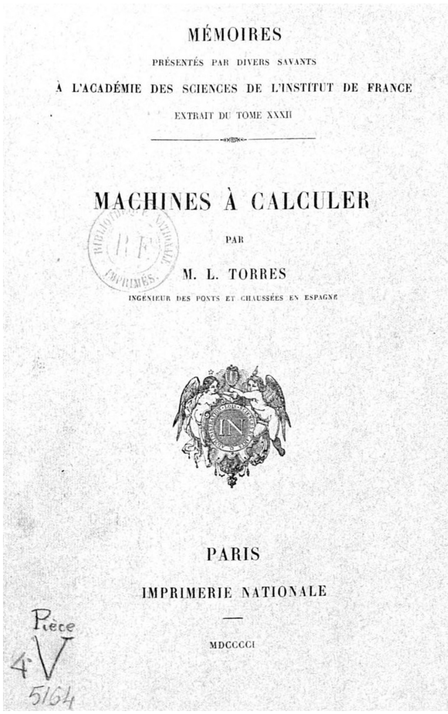


(b)

Figure 7.11. Torres Quevedo's Publications (a) Machines Algébriques, 1901; (b) Machines à calculer, 1901.

In 1900 he presented at the French Academy of Science a report with a general and full theoretical solution for these machines. He also built some electromechanical devices able to make mathematical calculations.

8. Who is considered the "father of robotics"?

Robotics is an interdisciplinary branch of computer science and engineering. It involves the design, construction, operation, and use of robots that can help and assist humans. Robots can be used in many situations for many purposes: manufacturing processes, space exploration, human prosthesis, or robot-assisted surgery. And some of them resemble humans in appearance.

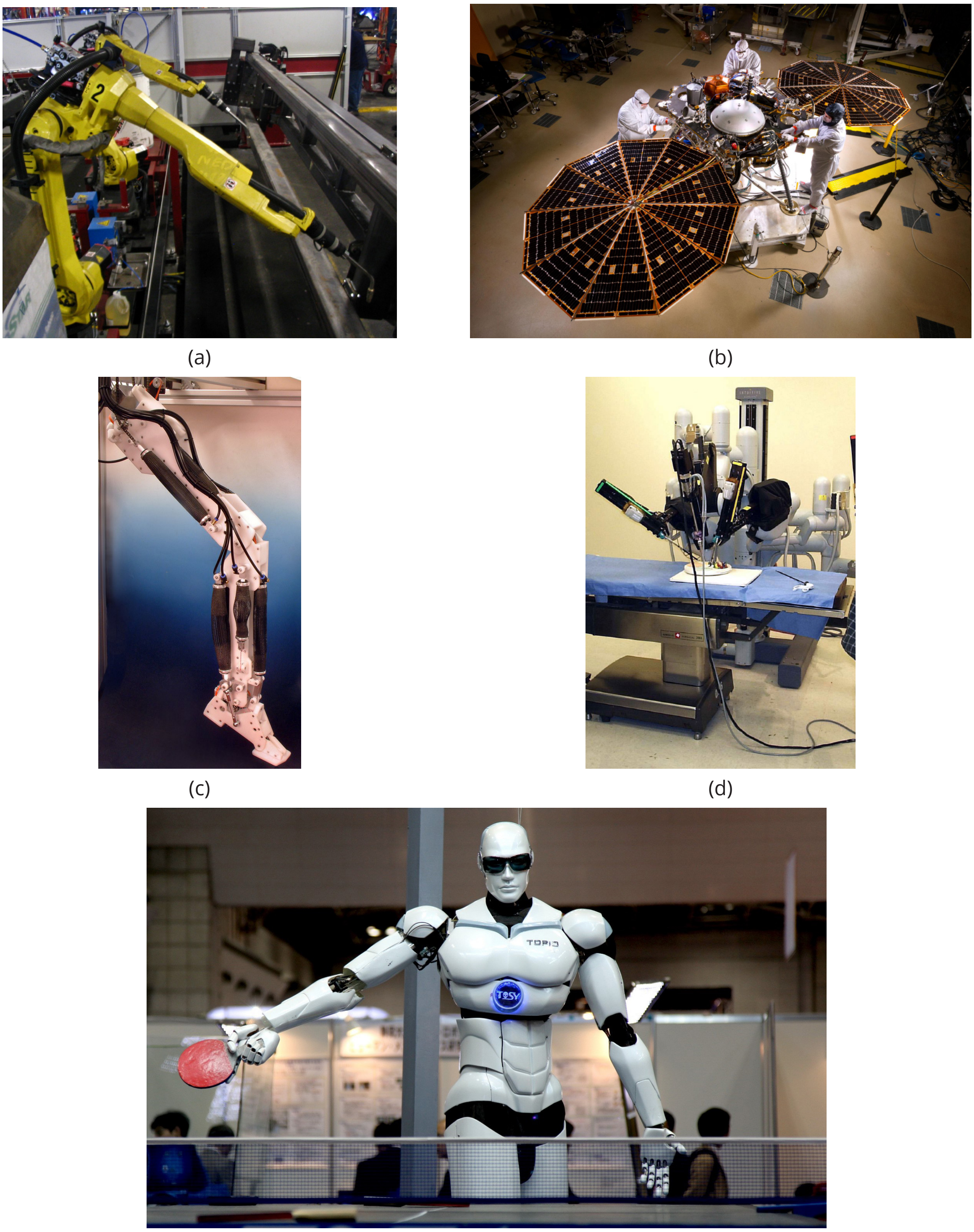


Figure 8.1. (a) welding robot; (b) space exploration robot; (c) robotic prostheses; (d) robotic-assisted surgery; (e) humanoid robot.

In Europe, from the Middle Ages, there are many examples of automata, the predecessors of robots. They include several mechanical astronomical clocks with automata figures that began to appear in the 14th century. One of the most famous is the Prague astronomical clock, attached to the Old Town Hall in Prague, the capital of the Czech Republic. The clock was first installed in 1410, making it the third-oldest astronomical clock in the world and the oldest clock still in operation. Another one is in the Cathedral of Santa María in Burgos, Spain. It is called the Papamoscas, an articulated automaton which opens his mouth to give the chiming of the hours.

(a)

(b)

(c)

Figure 8.2. (a) Prague Astronomical Clock, Czech Republic; (b) Glockenspiel watch in Graz, Austria; (c) Papamoscas Clock, Burgos Cathedral, Spain.

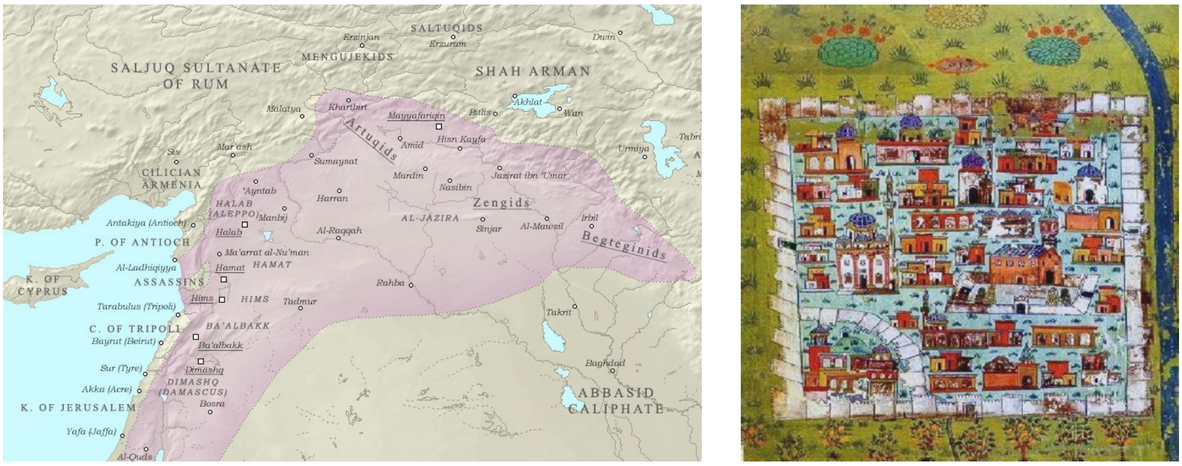
But were this automata, predecessors of modern robots, the first ones in history?

The idea of automata originates in the mythologies of many cultures around the world. Engineers and inventors from ancient civilizations, including China, Greece, India, Persia, and Egypt, attempted to build self-operating machines, some resembling animals and humans. Most of them were conceived as illusions or playthings for the entertainment of kings and emperors.

In the 13th century, Arabic engineers produced automata to manipulate the environment for human comfort. Besides preserving, disseminating, and building on the work of the Greeks, their greatest contribution was the concept of practical application.

One of these Arabic engineers is considered nowadays the “father of robotics”.

Ismail Al Jazari (1136 - 1206) was an Arabic polymath: a scholar, inventor, mechanical engineer, artisan, artist, and mathematician. He was born in Upper Mesopotamia and served as chief engineer of the Artuquids dynasty, a regional kingdom, for whom he designed more than a hundred ingenious devices. He spent nearly 25 years in Diyarbakir, on the banks of the Tigris River.



(a) (b)

Figure 8.3. (a) Map of the Artuquids regional kingdom within the Ayyubid sultanate, circa 1193; (b) Map of Diyarbakir, 16th century.

In 1206 he gave the world a catalogue of his matchless machines, known today as The Book of Knowledge of Ingenious Mechanical Devices. Al-Jazari goes on to describe the improvements he made to the work of his predecessors, and describes several devices, techniques and components that are original innovations which do not appear in the previous works. He only describes devices he has built himself. The book's style resembles that of a modern "do-it-yourself" book.

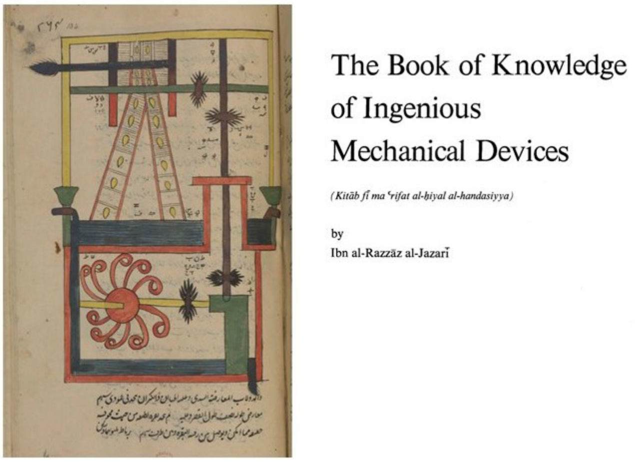


Figure 8.4. The Book of Knowledge of Ingenious Mechanical Devices.

His design of a boat with four musicians -a harpist, a flautist, and two drummers-aimed to play songs is regarded by many to be the first programmable robot in history. It has a programmable drum machine with cams that bump into little levers that operated the percussion. The drummer could be made to play different rhythms and different drum patterns if the cams were moved around.

(a) (b) (c)

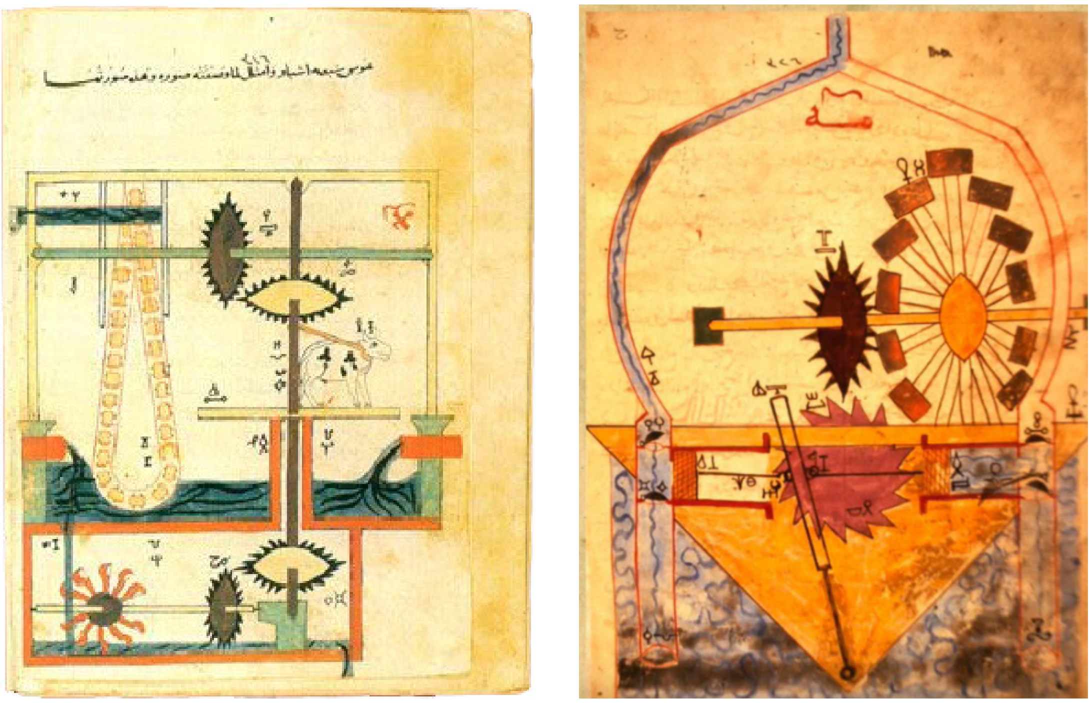
Figure 8.5. Al Jazari Automata. (a) Musical automaton; (b) Musical automaton with mechanism; (c) Cam mechanism.

Other automata were a water-clock of the drummers, a hand washing automaton with flush mechanism, and a peacock fountain with automated servants.

(a) (b) (c)

Figure 8.6. Al Jazari Automata. (a) Percussionists' water clock; (b) Automaton for hand washing; (c) Peacock fountain.

Al-Jazari invented five machines for raising water, as well as watermills and water wheels with cams on their axle used to operate the automata. It was in these water-raising machines that he introduced his most important ideas and components of new mechanisms.



(a) (b)

Figure 8.7. Al Jazari Automata. (a) Saqiya (Chain of pots); (b) Double-acting suction pump with valves and reciprocating piston movement.

Other inventions were a diversity of clocks: the candle clock, the elephant clock, and the castle clock.

(a) (b) (c)

Figure 8.8. Al Jazari Automata. (a) Candle clock; (b) Elephant clock; (c) Castle clock.

Alongside his accomplishments as an inventor and engineer, Al-Jazari was also an artist. In The Book of Knowledge of Ingenious Mechanical Devices, he gave instructions of his inventions and illustrated them using miniature paintings, a medieval style of Islamic art.

He is remembered mainly for this book, but his realized inventions would play a key role in civic life for many years. Most of his innovations were centuries ahead of the achievements of European science. Many authors on history of technology mention that, two centuries later, the Italian Renaissance inventor Leonardo da Vinci may have been influenced by the classic automata of Al Jazari when designing his own automata.

Figure 8.9. Leonardo da Vinci's robot model with internal workings. Possibly built by Leonardo da Vinci around 1495.

Automatic machines made by Al Jazari formed the cornerstones of today's mechanical and cybernetic sciences. Al Jazari has created milestones of today's technology by using science and technology in an extraordinary way according to the conditions of the time, giving the foundations of today's automatic control science.

9. Who was the inventor of the pressure cooker?

We probably have a pressure cooker in our kitchen. It is an airtight container that increases the cooking speed of some foods, reducing the time needed for their preparation and saving energy. Pressure cooking is the process of cooking food under high pressure steam and water or a water-based cooking liquid. It usually takes several minutes for the pressure cooker to reach the desired cooking conditions. In some models, the pressure regulator weight begins levitating above its nozzle, allowing excess steam to escape.

(a) (b)

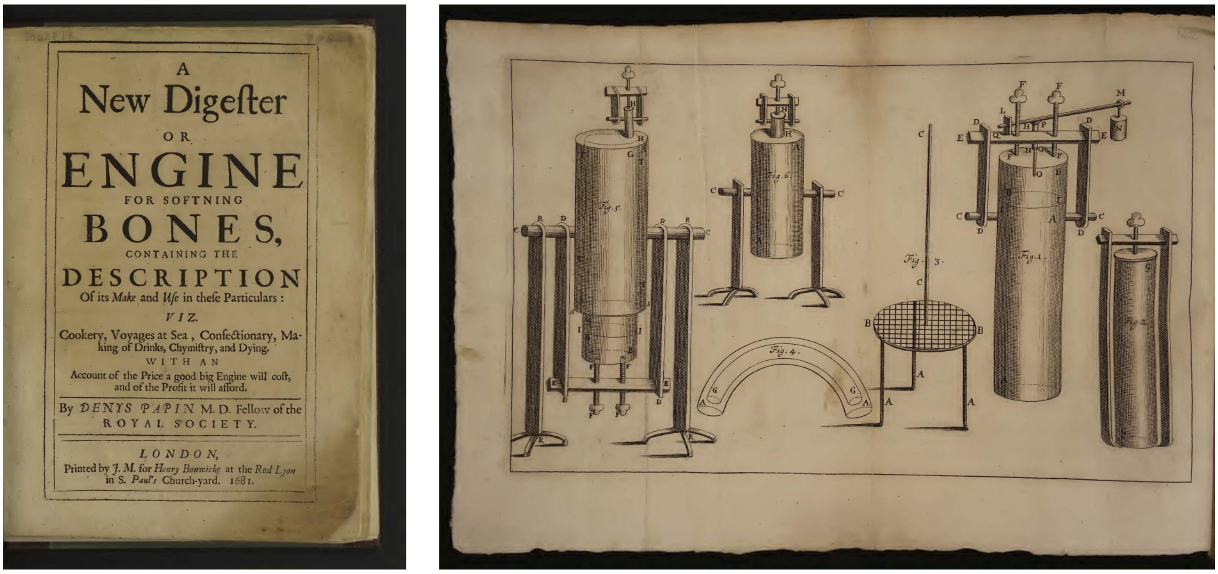
Figure 9.1. Pressure cooker. (a) components: vessel, lid and valve; (b) Set.

Who was the inventor of the pressure cooker?

The inventor of the steam digester was Denis Papin (1647 - 1713), a French physicist, mathematician, engineer, and inventor. In 1669 he obtained a diploma in medicine from the University of Angers, but never practiced this profession. He devoted himself to the study of physics and machines. He lived in France, England, and Germany, being a leading scientist and inventor of his time.

Figure 9.2. Denis Papin, 1689.

In 1680 Papin presented his invention of the Steam Digester to the Royal Society of London as a scientific study. He was later elected as a member of the Society. In 1681 appeared in London a first memoir, to relate the first series of experiments made with this machine, entitled A new Digester or Engine for softening bones, containing the description of its make and use in these particulars. It works by expelling air from the vessel and trapping steam produced from the boiling liquid.



(a) (b)

Figure 9.3. (a) Cover of the English edition of 1681, *Steam Digester*; (b) Drawings of the *Steam Digester*.

At standard pressure the boiling point of water is 100°C. With any food containing or cooked with water, once the temperature reaches the boiling point, any excess heat causes some of the water to vaporize into steam efficiently carrying away heat keeping the food temperature at 100°C.

In a sealed pressure-cooker, as the water boils, the steam is trapped in the cooker which raises the pressure. However, the boiling point of water increases with pressure. In a sealed pressure-cooker the volume and amount of steam is fixed, so the temperature can be controlled by setting the pressure, with a pressure release valve. For example, if the pressure reaches 2 bar or 200 kPa, the water will have reached a temperature of approximately 120°C which cooks the food much faster.

Pressure cooker pressures and temperatures

Total pressure	Gauge pressure relative to atmospheric	Temperature	Approximate cooking time versus boiling
1.0 bar	**0.0 bar**	**100°C (212°F)**	**100%**
1.1 bar	0.1 bar	103°C (217°F)	80%
1.2 bar	0.2 bar	105°C (221°F)	70%
1.3 bar	0.3 bar	107°C (225°F)	61%
1.4 bar	0.4 bar	110°C (230°F)	50%
1.5 bar	0.5 bar	112°C (234°F)	43%
1.6 bar	0.6 bar	114°C (237°F)	38%
1.7 bar	0.7 bar	116°C (241°F)	33%
1.8 bar	0.8 bar	117°C (243°F)	31%
1.9 bar	0.9 bar	119°C (246°F)	27%
2.0 bar	**1.0 bar**	**121°C (250°F)**	**23%**

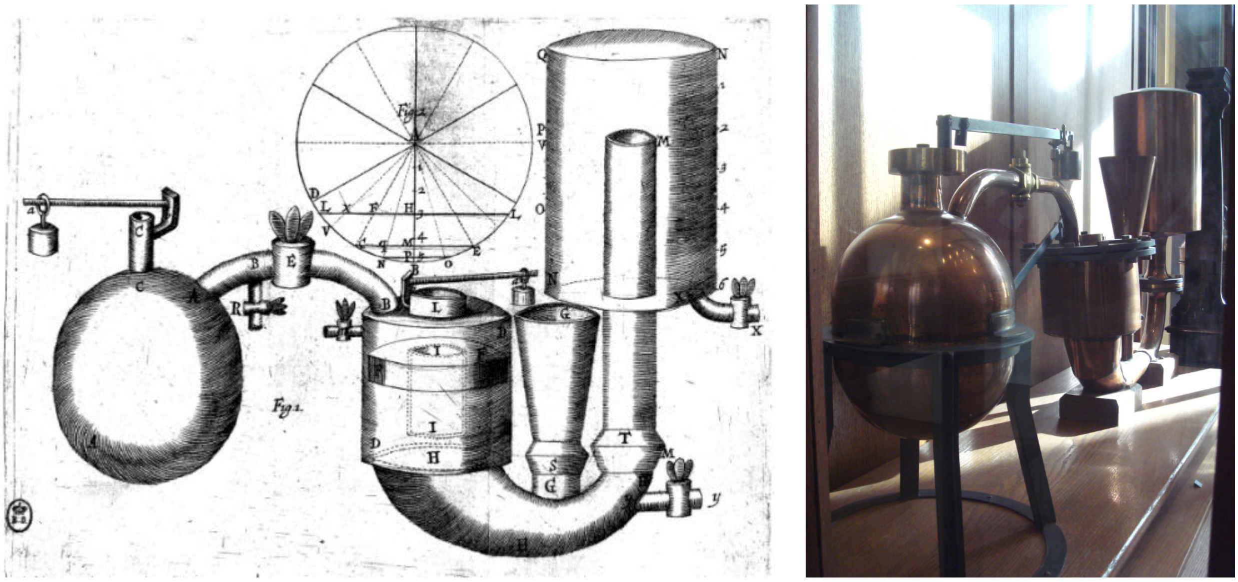
Figure 9.4. Evolution of the boiling temperature of water with pressure.

Even though, at that time, there was no possibility of turning this invention into a product of general use by the people, its design was the basis of the first pressure-cookers that, at the beginning of the twentieth century, began to be part of the usual kitchenware in our kitchens.

(a) (b) (c)

Figure 9.5. (a) Pressure cooker, late eighteenth century; (b) Pressure cooker, circa 1864; (c) Super Cocotte, 1973.

Throughout his career, Papin invented many other devices: a machine for raising water, a fire engine, the first steam piston-cylinder system, a model of a steam submarine, and a steam engine for pumping water. This engine is contemporary with the first operational British steam engines of the early eighteenth century.



(a) (b)

Figure 9.6. Papin steam engine. (a) schema, circa 1705; (b) Reconstruction.

Along his career, Denis Papin collaborated with other great scientists of his time, such as Christiaan Huygens, Gottfried Leibniz, and Robert Boyle.

10. Heavier than air: first pioneer flight in Europe.

Many stories from antiquity involve the desire to fly, such as the Greek legend of Icarus and Daedalus, and the Vimana in ancient Indian epics. Some of the earliest recorded attempts with gliders were those by the 9th-century Andalusian and Arabic-language poet Abbas ibn Firnas and the 11th-century English monk Eilmer of Malmesbury. Leonardo da Vinci researched the wing design of birds and designed a man-powered aircraft.

Figure 10.1. (a) Icarus and Daedalus, Musée des Beaux-Arts et de la Dentelle d'Alençon; (b) The Vimana celestial chariot, illustration of the Ramayana; (c) Ibn Firnas statue at Baghdad airport; (d) Monk Eilmer, Malmesbury Abbey; (e) Leonardo da Vinci, flying machine.

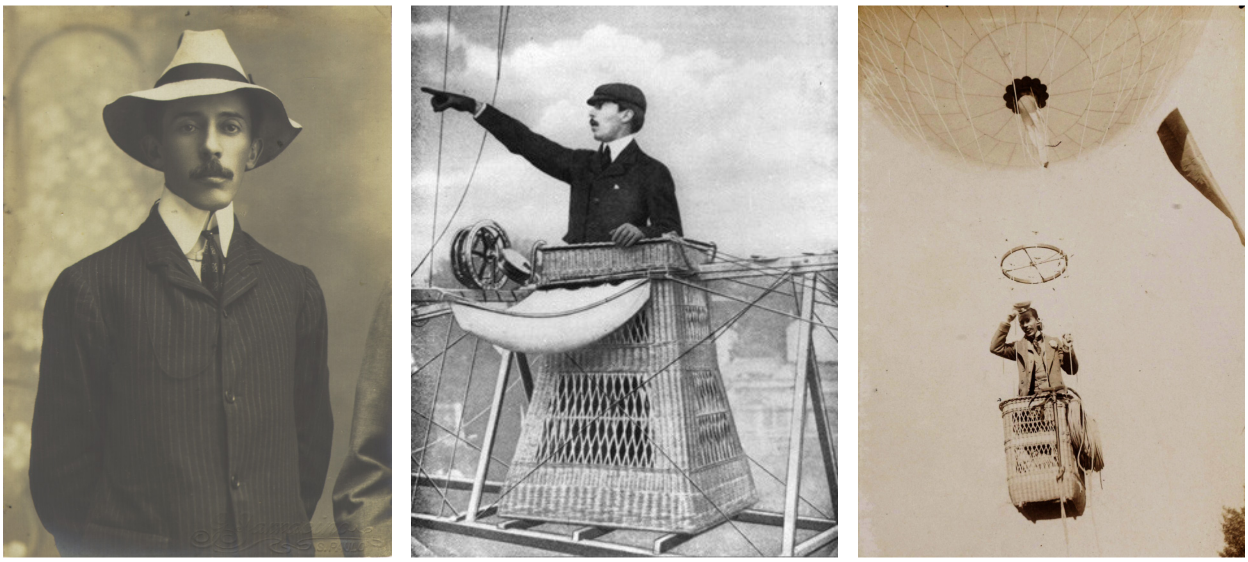
Since then, many pioneers of aviation contributed to the development of practical airplanes. Modern airplanes are a fixed wing flying machine with separate systems for lift, propulsion, and control.

The Wright brothers, Orville and Wilbur Wright, were American aviation pioneers generally credited with inventing, building, and flying the world's first successful airplane. The brothers' breakthrough invention was their creation of a three-axis control system, which enabled the pilot to steer the aircraft effectively and to maintain its equilibrium. The first flight by Orville Wright, of 37 meters in 12 seconds, made the first controlled, powered heavier-than-air manned flight at Kitty Hawk, North Carolina, on 17 December 1903. On their first flights, the Wright brothers used guide rails and a catapult to get it off the ground.

Figure 10.2. The Wright brothers' first flight at Kitty Hawk, North Carolina, on December 17, 1903.

In 1906, the Brazilian Alberto Santos-Dumont (1873 - 1932) made what was claimed to be the first airplane flight, taking off unassisted by an external launch system. He set the first world record recognized by the Aéro-Club de France and by the Fédération Aéronautique Internationale by flying 220 meters in less than 22 seconds.

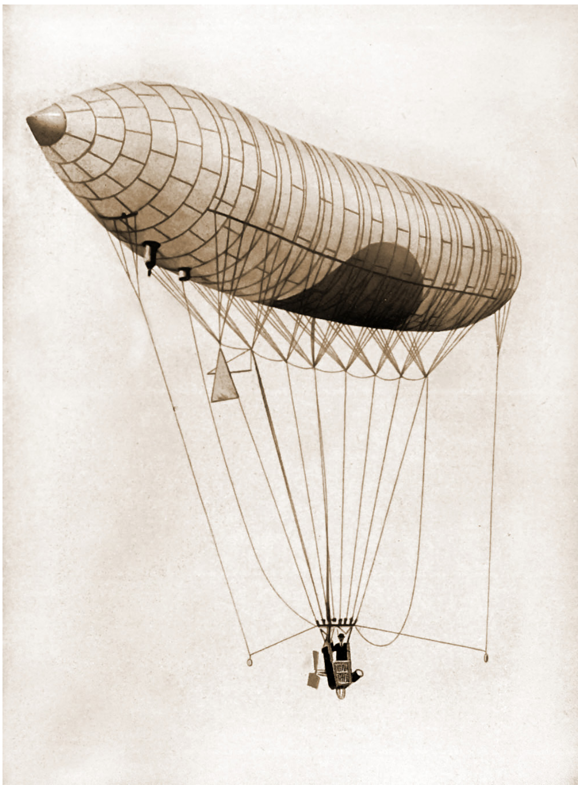
Alberto Santos-Dumont was a Brazilian aeronaut, sportsman and inventor. Though he never graduated, he followed some engineering courses and developed an admirable practical and mechanical talent and, since then, of inventive genius. At a very young age, he stood out as mountaineer and motor sportsman. At 24 years of age, Santos-Dumont left for France, where he spent most of his adult life. There, he became a professional aeronaut.



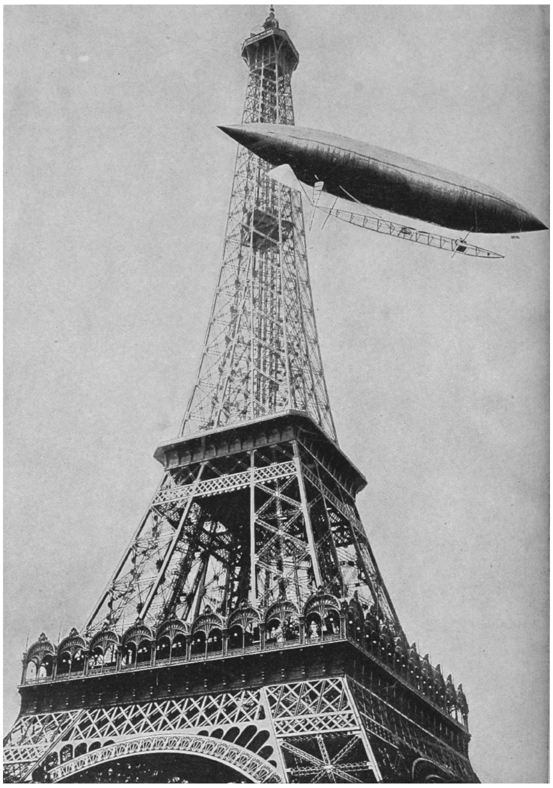
(a) (b) (c)

Figure 10.3. Alberto Santos Dumont (a) Portrait, 1903; (b) On board a hot air balloon; (c) Take-off on 4 July 1898 in Brazil.

Since 1898 till 1903, he built up to 13 airships, lighter-than-air, powered by internal combustion engines. He flew around the Eiffel Tower in his airships several times, as part of airships competitions.



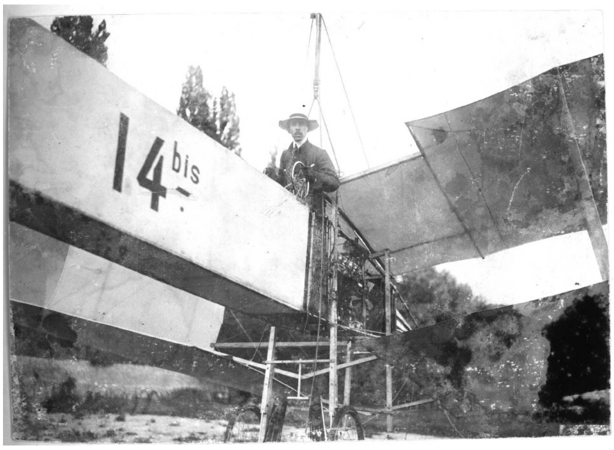
(a)



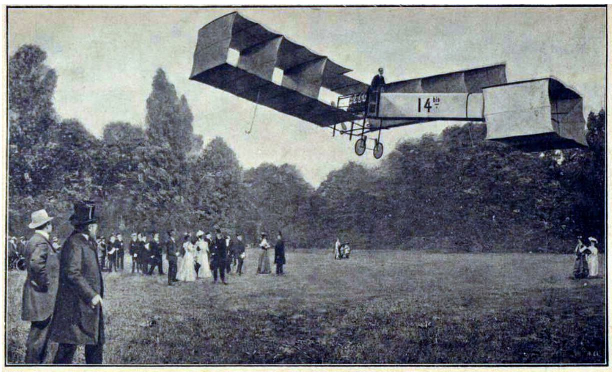
(b)

Figure 10.4. (a) Airship Santos-Dumont Nº1, 1898; (b) Santos-Dumont flight around the Eiffel Tower.

In 1904, several aviation prizes were founded in France, to stimulate the development of heavier-than-air aircrafts. Take-off, control, and landing were the big concerns. The Fédération Aéronautique Internationale, created in 1905, was in charge to record official demonstrations. After developing several prototypes, Santos-Dumont presented the plane 14-bis, a biplane with two octagonal surfaces inserted as ailerons improving control, and the rudder in the front, as the Wright brother's configuration. On 12 November 1906, he was able to fly 220 metres, for 21 seconds at an average speed of 37.4 km/h.



(a)



M. SANTOS DUMONT'S FIRST SUCCESS WITH A FLYING MACHINE.

M. Santos Dumont, after several preliminary trials in Paris on November 12th, when his flying machine had flown 75, 128, and 142 yards, decided to return to his starting point by going against the wind. For thirty yards the motor ran along the ground, then suddenly it rose to a height of about five yards, and appearing like a great white bird, it soared half-way down the course. M. Santos Dumont, startled by some spectators in his way, twisted his rudder quickly, and the machine came heavily to the ground, damaging one of its wings. The experiment, however was a triumph, for actual flight was achieved; and it seems as though it were only a matter of time for the conquest of the air to be accomplished. The 235 yards were traversed in twenty-one seconds.

(b)

Figure 10.5. (a) Santos-Dumont in 14-bis; (b) News of the flight of 14-bis.

Santos-Dumont continued to develop airplanes, as the Demoiselle. This plane was designed for sports competitions, capable of flying up to 2 kilometres and reaching 96 km/h. Later, it was used for pilot training during World War I.

(a) (b)

Figure 10.6. (a) Santos-Dumont in *Demoiselle*; (b) Plaque of Alberto Santos-Dumont in Avenue des Champs-Élysées, París.

On 19 October 1906, Santos-Dumont won a flying competition over Paris with his airship number 6. The award was presented to him at a dinner at the famous Maxim's restaurant. There he met the jeweller, Louis Cartier. The jeweller learned that the pilot couldn't check his pocket watch during the flight because he needed both hands to fly the plane. Cartier designed and gifted Santos-Dumont with a new gold watch, square and flat, attached to the wrist thanks to a strap and buckle. He had just created the first men's wristwatch. Santos-Dumont used it as a stopwatch on his next flights. This watch, called Cartier-Santos, is still manufactured today.

(a) (b)

Figure 10.7. (a) Santos-Dumont, 1916; (b) Cartier-Santos watch.

11. ¿Quién construyó el puente de Brooklyn?

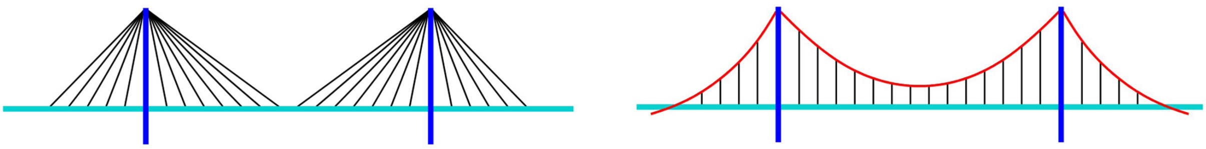
The Brooklyn Bridge is an icon of New York City.

The bridge spans the East River between the boroughs of Manhattan and Brooklyn. Opened on May 24, 1883, the Brooklyn Bridge was the first fixed crossing of the East River. It was also the longest suspension bridge in the world at the time of its opening, with a main span of 486 m and a deck 38 m above mean high water. The bridge was originally called the New York and Brooklyn Bridge or the East River Bridge but was officially renamed the Brooklyn Bridge in 1915.

(a) (b)

Figure 11.1. (a), (b) Brooklyn Bridge in New York, between Manhattan and Brooklyn.

The Brooklyn Bridge is an emblem of nineteenth-century engineering because of how innovative the use of steel as a large-scale building material was at the time. It uses a hybrid cable-stayed/suspension bridge design, with both vertical and diagonal suspender cables. It was the first bridge suspended by steel cables. Its stone towers are neo-Gothic, with characteristic pointed arches.



(a) (b)

Figure 11.2. (a) A cable-stayed bridge has one or more towers, from which the cables support the bridge deck; (b) A suspension bridge has a deck that hangs below the suspension cables between the towers, with vertical suspension cables.

Originally, the bridge was designed to house two double-track carriageways and cavalry at the ends, two tram tracks in the centre, and a raised pedestrian platform. It currently consists of six lanes for cars, three in each direction.

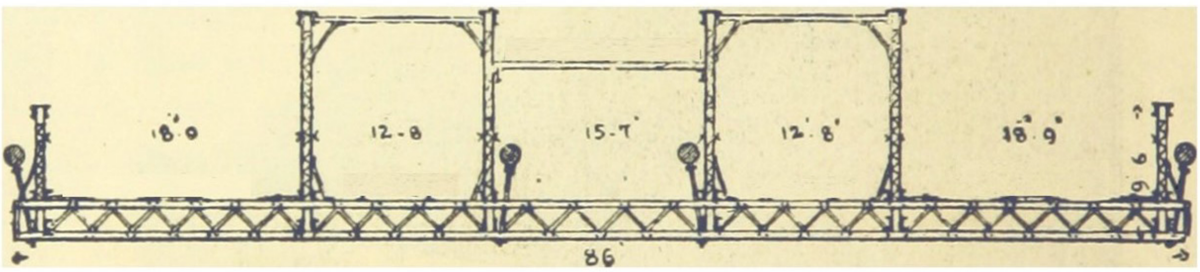
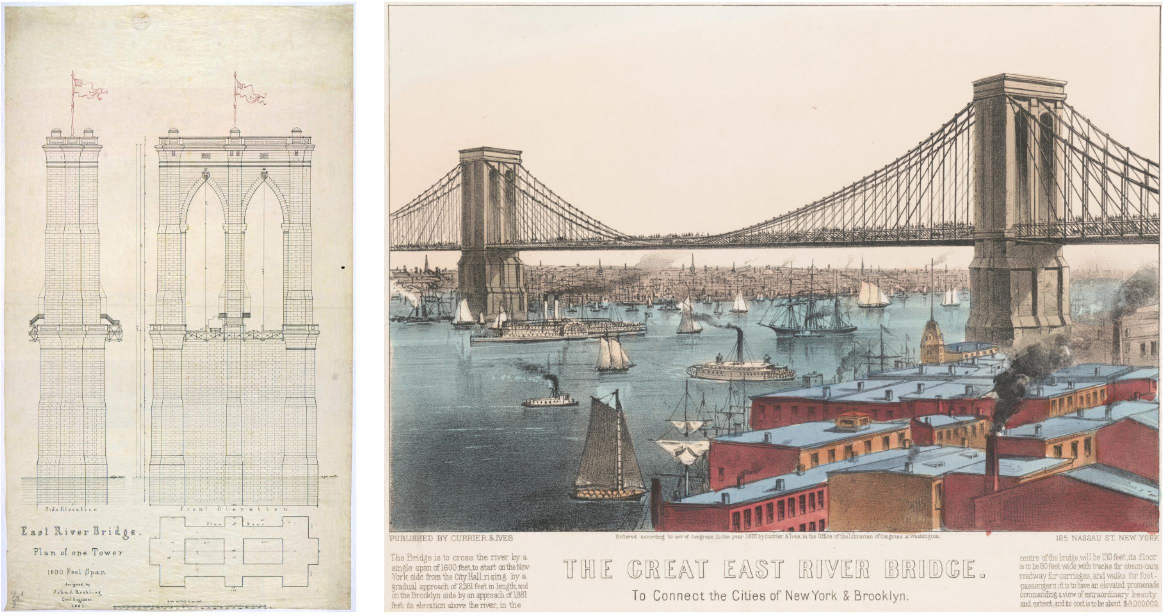


Figure 11.3. Initial design of the Brooklyn Bridge

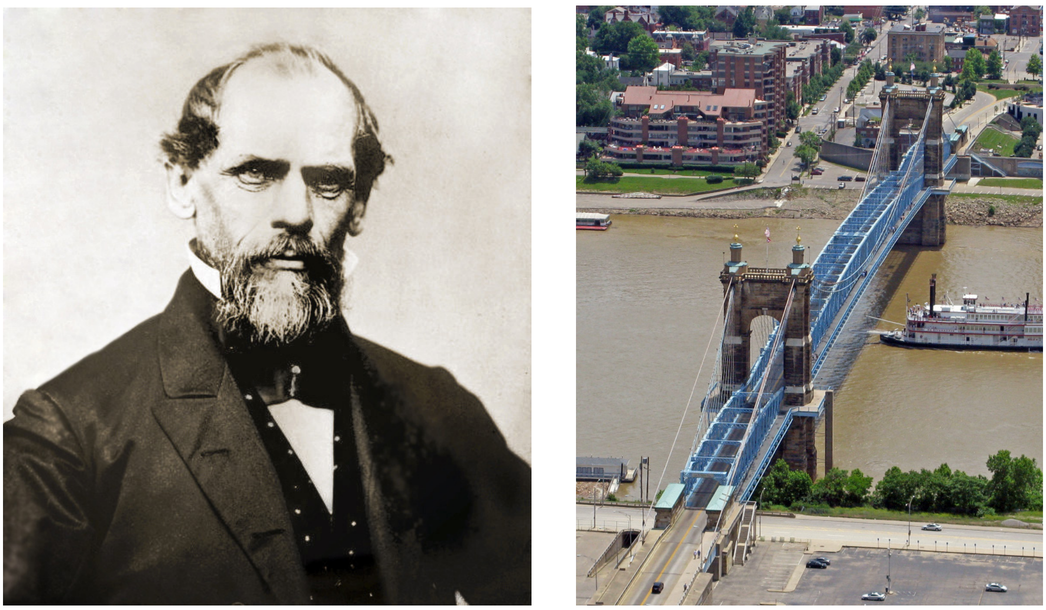
Proposals for a bridge connecting Manhattan and Brooklyn were first made in the early 19th century. At the time, the only travel between the two cities was by a few ferry lines. In February 1867, the New York State Senate passed a bill that allowed the construction of a suspension bridge from Brooklyn to Manhattan. In April 1867, the cities of New York and Brooklyn were authorized to subscribe to $5 million in capital stock, which would fund the bridge's construction by the New York and Brooklyn Bridge Company. The bridge was built between 1870 and 1883.



(a) (b)

Figure 11.4. (a) Plan of the Brooklyn Bridge Tower, 1867; (b) Expected wiew of the bridge.

The chief engineer appointed in 1867 to build the Brooklyn Bridge was John Roebling (1806 – 1869), a German-born American civil engineer. He was an experienced engineer on wire rope suspension bridges, as the ones in Pittsburgh, Niagara, or Cincinnati. Unfortunately, he died in 1869, just before starting the works.

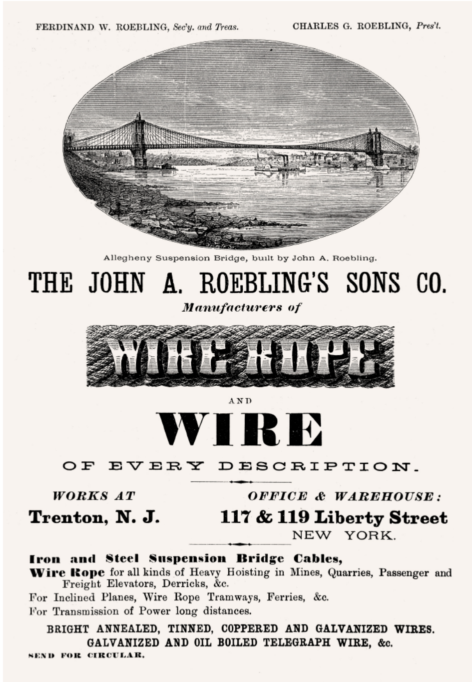


(a) (b)

Figure 11.5. (a) John Roebling, 1867; (b) John Roebling Suspension Bridge in Cincinnati.

Washington Roebling (1837–1926), John Roebling's 32-year-old son, was then hired to fill his father's role. He acquired higher education in engineering at the Rensselaer Polytechnic Institute in Troy, New York, and worked with his father in several suspension bridges. In 1868, Washington became assistant engineer on the Brooklyn Bridge and was named chief engineer after his father's death in mid-1869.

(a)



(b)

Figure 11.6. (a) Washington Roebling, 1854; (b) Advertisement of Roebling's & Sons, 1879.

But, very early at the beginning of the works, in 1870, he suffered a decompression sickness contracted while working in the caissons for the bridge piers, deep beneath the river's surface. It affected him so severely that he became bed ridden. Thus, her wife, Emily Warren Roebling, was driven into the forefront of engineering.

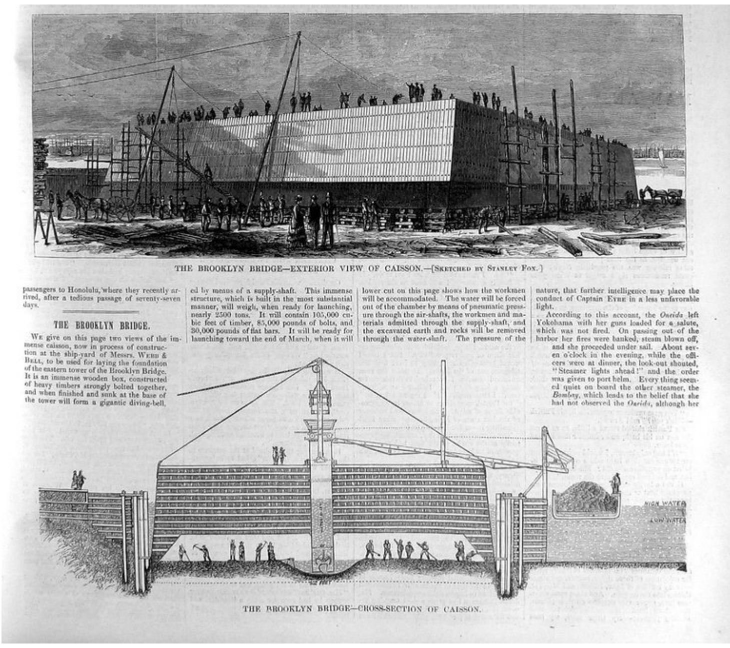


Figure 11.7. Pressurized caissons of Brooklyn Bridge piers.

Emily Warren Roebling (1843–1903) is known for her contributions over a period of more than 10 years to the completion of the Brooklyn Bridge. She had studied mathematics and science, and she began taking down copious notes on what her husband said remained to be done with the bridge. She also began studies of her own on the technical issues, learning about strength of materials, stress analysis, cable construction, and calculation of catenary curves. She took over much of the chief engineer duties, including day-to-day supervision and project management.

(a) (b)

Figure 11.8. (a) Emily Roebling, 1896; (b) Brooklyn Bridge under construction.

For the decade after Washington was confined to his sick bed, Emily Roebling was dedicated to the completion of the Brooklyn Bridge. Emily and her husband jointly planned the bridge's continued construction. She dealt with politicians, competing engineers, and all those associated with work on the bridge, to the point where people believed she was behind the bridge's design. Emily Roebling was the first to cross the bridge by carriage at the open ceremony in 1883.

The excellent works of Emily Warren Roebling as engineer were recognized by the American Society of Civil Engineers. A plaque in the Brooklyn Bridge, raised in 1951 by the Brooklyn Engineers Club, commemorates her contribution to complete the construction of the bridge.

Figure 11.9. Commemorative plaque, 1951.

Upon completion of her work on the Brooklyn Bridge, Roebling shifted to supporting several women's causes. She also wrote several essays and argued for greater women's rights and railed against discriminatory practices targeted at women. She continued her education and received a law degree from New York University in 1899, at the age of 56.

Estudo de caso *Edição portuguesa*

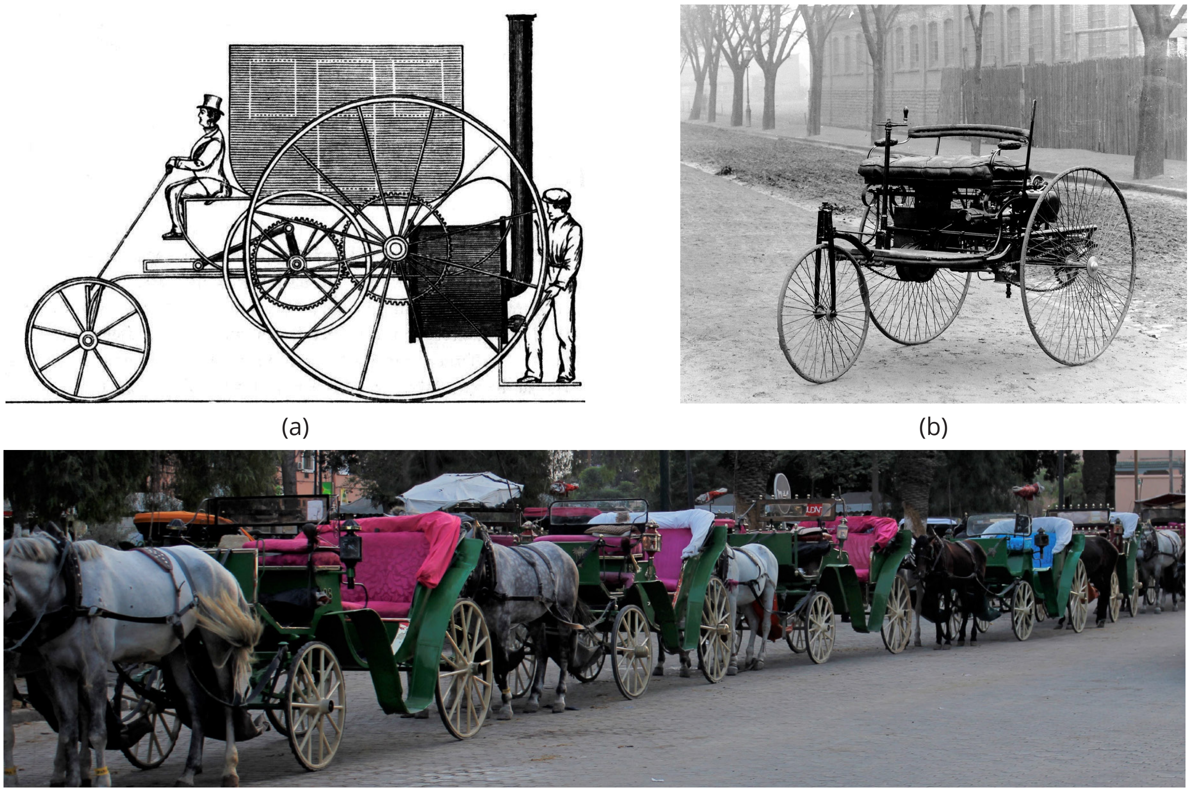
ESTUDO DE CASO

Edição portuguesa

https://www.merlot.org/merlot/viewSite.htm?id=9164405

1. Quem definiu o "cavalo-vapor" como unidade de potência?

Nos anos iniciais dos automóveis, poder-se-ia imaginar cavalos puxando o automóvel a vapor de Richard Trevithick em 1801, que dificilmente poderia subir uma ladeira, ou o carro com motor a gás patenteado por Karl Benz em 1886. Os primeiros veículos com motores tinham a mesma estrutura das carruagens a cavalo, nas quais o cavalo foi substituído pelo motor. O "cavalo-vapor" era uma unidade adequada, pois tinha significado.



(a) (b) (c)

Figura 1.1. (a) O carro a vapor de Richard Trevithick em 1801; (b) O carro a gás de Karl Benz em 1886; (c) Carruagens puxadas por cavalos.

Mas quem definiu o "cavalo-vapor" como unidade de potência? A resposta é que a definição foi cunhada por um engenheiro. O engenheiro escocês James Watt (1736 – 1819) começou a sua carreira profissional como um construtor de instrumentos, depois trabalhou como engenheiro civil e, finalmente, fundou a companhia Boulton & Watt para produzir máquinas a vapor. Ele aumentou a eficiência da máquina e é o detentor de várias patentes.

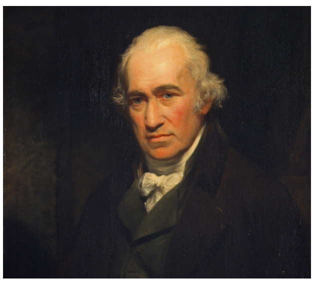
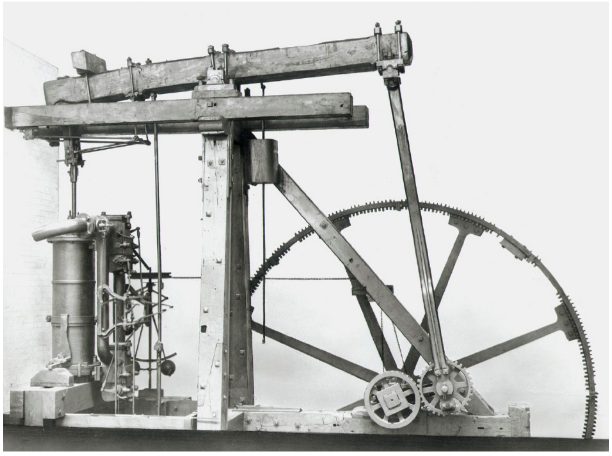
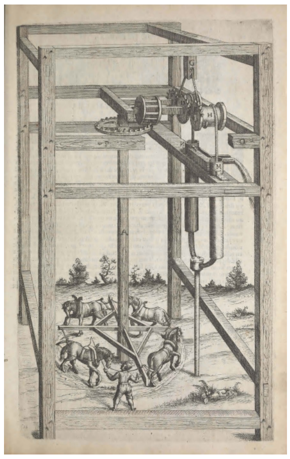


Figura 1.2. Retrato de James Watt.

Watt definiu o motor e suas qualidades de uma forma comercial e inteligente. Dado que o motor, naquele tempo, tinha que competir com o cavalo como fonte de energia na indústria da mineração, ele resolveu usar o cavalo como unidade de medida.



(a)



(b)

Figura 1.3. (a) Motor a vapor Boulton&Watt, 1788. (b) Bomba hidráulica para uma mina, por Salomon de Caus em 1615.

Existiria uma maneira melhor de apresentar as qualidade da máquina a vapor do que indicando o número de cavalos que ela poderia substituir? A questão a ser resolvida era encontrar um equivalente numérico para o fazer.

Watt supôs que um "cavalo" padrão poderia puxar 180 libras e determinou que um cavalo poderia mover a roda de um moinho 144 vezes em uma hora (ou seja 2.4 vezes por minuto). A roda do moinho tinha 12 pés de raio. Portanto, o cavalo andava 24 x 2π × 12 pés em um minuto. A potência é calculada pelo produto da força pela distância dividido pelo tempo.

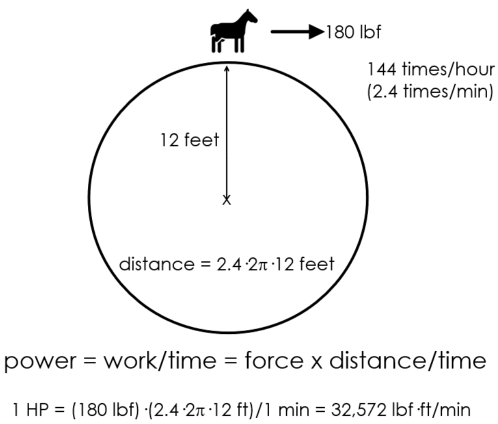


Figura 1.4. Definição de "cavalo-vapor" por James Watt.

1 HP (Watt) = força x distância/tempo = (180 lbf) x (2,4 x 2π x 12 ft) / 1 min = 32,572 ft·lbf/min)

O resultado foi aproximado para 33,000 lbf.ft/min. A definição formal de "cavalo-vapor" foi publicada por James Watt em em 1809.

A ideia era não era somente brilhante, mas a unidade resultante, o "cavalo-vapor", tinha profundo significado para os seus conteporâneos. Watt não somente melhorou a máquina a vapor para a indústria da mineração, ele também a tornou de mais fácil entendimento para as pessoas em geral.

Uma unidade foi criada refletindo a experiência das pessoas e isto tinha grande sentido, pois permitia estabelecer um diálogo entre o homem e a natureza. A significância de uma medida tradicional, como o "cavalo-vapor", constitui uma de suas maiores virtudes.

2. ¿ James Watt definiu a unidade de potência “watt” com o seu próprio nome?

Estamos habituados a ter uma infinidade de aparelhos eletrodomésticos que facilitam as nossas vidas. Se virarmos estes dispositivos, encontraremos em cada um uma etiqueta técnica. Em todas elas poderemos encontrar uma linha com o símbolo W, que é designado “watt”. Ele nos informa sobre a potência do dispositivo. Qual é a origem deste nome?

(a) (b)

Figura 2.1. (a) cafeteira e (b) torradeira, com seus rótulos técnicos.

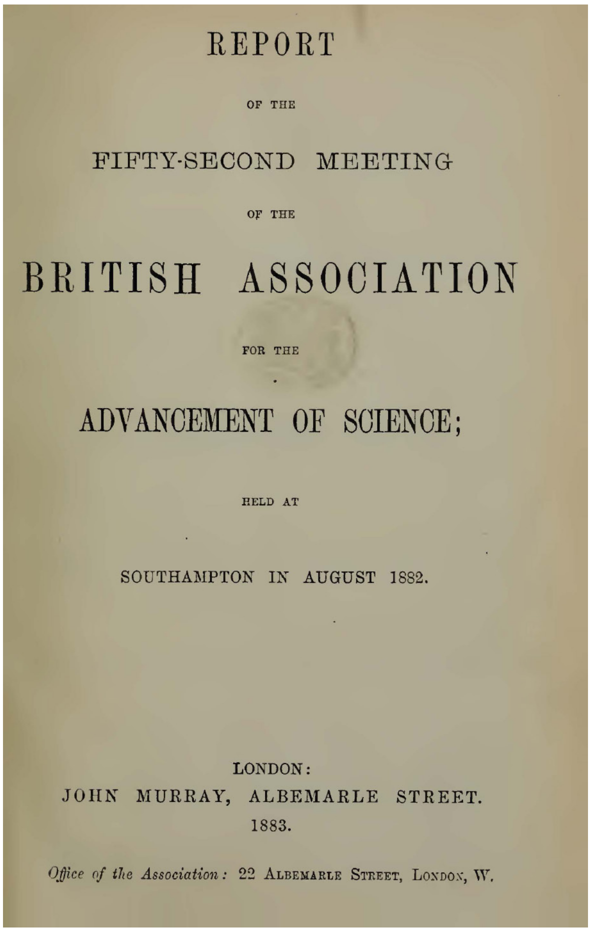
Como é muito famoso em todo o mundo, muitas pessoas poderiam associar este nome ao engenheiro escocês James Watt. Mas será que James Watt definiu a unidade “watt” com seu próprio nome?

James Watt definiu a potência como “cavalo-vapor”, HP, mas não definiu a Unidade de Potência do Sistema Internacional de Unidades, o “watt” (W) O “watt”, como uma unidade de potência, foi proposto e definido pelo engenheiro eletricista alemão Carl Wilhem Siemens.

Sir Carl Wilhelm Siemens (1823 – 1883) era um engenheiro e empresário alemão-britânico. Também é conhecido como Charles William Siemens, uma vez que se tornou cidadão britânico. Era um brilhante empresário e, ao mesmo tempo, um famoso pesquisador científico. Trabalhou em várias atividades industriais e ganhou reconhecimento internacional como cientista.

Figura 2.2. O engenheiro germano-britânico Carl Wilhelm Siemens.

Durante o século XIX, o uso de dínamos para produzir eletricidade e motores elétricos para transformar a energia elétrica em mecânica tornou-se generalizado. A necessidade de uma unidade de potência relacionada com magnitudes elétricas (*volt, ampere, ohm*) cresceu ao longo dos anos. Em 1882, Carl Wilhelm Siemens, presidente da British Association for the Advancement of Science, propôs a adoção de "watt" no seu relatório presidencial anual para a associação. A unidade de potência proposta no sistema CGS foi nomeada "watt" em homenagem ao engenheiro James Watt.



REPORT

OF THE

FIFTY-SECOND MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

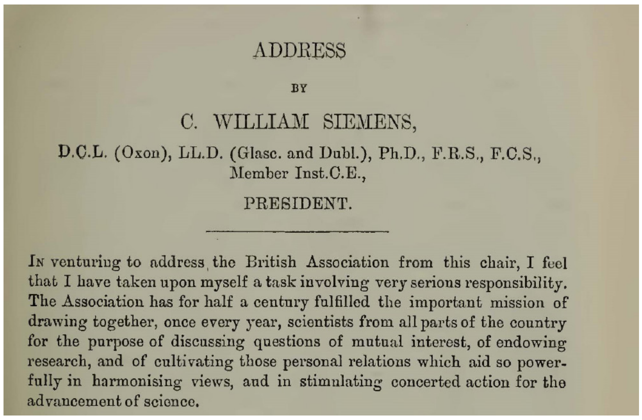
ADVANCEMENT OF SCIENCE;

HELD AT

SOUTHAMPTON IN AUGUST 1882.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1883.

Office of the Association: 22 ALBEMARLE STREET, LONDON, W.



ADDRESS

BY

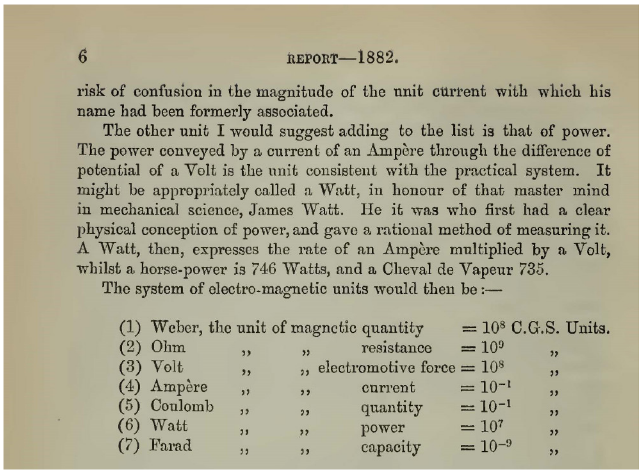
C. WILLIAM SIEMENS,

D.C.L. (Oxon), LL.D. (Glasc. and Dubl.), Ph.D., F.R.S., F.C.S., Member Inst.C.E.,

PRESIDENT.

IN venturing to address the British Association from this chair, I feel that I have taken upon myself a task involving very serious responsibility. The Association has for half a century fulfilled the important mission of drawing together, once every year, scientists from all parts of the country for the purpose of discussing questions of mutual interest, of endowing research, and of cultivating those personal relations which aid so powerfully in harmonising views, and in stimulating concerted action for the advancement of science.

(b)



6 REPORT—1882.

risk of confusion in the magnitude of the unit current with which his name had been formerly associated.

The other unit I would suggest adding to the list is that of power. The power conveyed by a current of an Ampère through the difference of potential of a Volt is the unit consistent with the practical system. It might be appropriately called a Watt, in honour of that master mind in mechanical science, James Watt. He it was who first had a clear physical conception of power, and gave a rational method of measuring it. A Watt, then, expresses the rate of an Ampère multiplied by a Volt, whilst a horse-power is 746 Watts, and a Cheval de Vapeur 735.

The system of electro-magnetic units would then be:—

(1) Weber, the unit of magnetic quantity				$= 10^8$	C.G.S. Units.
(2) Ohm	,,	,,	resistance	$= 10^9$	,,
(3) Volt	,,	,,	electromotive force	$= 10^8$	,,
(4) Ampère	,,	,,	current	$= 10^{-1}$	,,
(5) Coulomb	,,	,,	quantity	$= 10^{-1}$	,,
(6) Watt	,,	,,	power	$= 10^7$	,,
(7) Farad	,,	,,	capacity	$= 10^{-9}$	,,

(a) (c)

Figura 2.3. (a) Edição de agosto de 1882 da Associação Britânica para o Avanço da Ciência. (b) comunicação do presidente da associação, C. William Siemens, aos associados, (c) proposta de C. William Siemens para, entre outros, a unidade de potência "watt" em homenagem a James Watt.

O "watt" foi definido da seguinte forma:

1 *watt* = 1 *ampere* x 1 *volt*

O reconhecimento internacional desta unidade foi alcançado antes do final do século XIX. No mesmo relatório de 1882, Siemens propôs o *joule* (J) como unidade de energia e trabalho, que foi definitivamente aceito pela British Association em 1888.

De 1908 a 1948, a definição de "watt" estava relacionada com grandezas elétricas. Desde 1948, a definição de "watt" baseia-se no *joule* de energia:

1 *watt* = 1 *joule/segundo*

Há muitas unidades científicas com nomes de pessoas, grande parte delas nomeadas há muito tempo. A maioria das denominações ocorreu na década de 1860-70 para o sistema CGS e na década de 1870-80 para o Sistema Internacional. O caso mais frequente é que a unidade recebeu o nome de alguém para homenagear o descobridor ou porque ninguém podia propor um nome melhor. Por convenção, o nome da unidade é escrito com minúsculas, mas a sua abreviatura com maiúscula.

3. Algumas temperaturas são medidas em graus Rankine. Quem era o Sr. Rankine?

Em alguns livros de engenharia dos EUA que lidam com conceitos de temperatura, encontramos a menção de uma temperatura medida numa escala chamada Rankine. Muitas vezes, as relações entre esta escala de temperatura e as de Celsius (°C), Fahrenheit (°F) e Kelvin (K) são descritas pelos respectivos fatores de conversão:

$$K = (5/9)R = (5/9)(^{o}F + 459.67) = ^{o}C + 273.15$$

Assim como as outras escalas de temperatura bem conhecidas, parece que esta escala foi nomeada em homenagem a um certo Sr. Rankine.

A escala Rankine foi nomeada em homenagem ao engenheiro escocês William John Macquorn Rankine (1820 - 1872). William Rankine trabalhou como engenheiro mecânico e civil. Para além da sua carreira como engenheiro profissional, a partir de 1855 foi Professor de Engenharia Civil e Mecânica na Universidade de Glasgow. Foi um dos grandes contribuidores para a ciência da termodinâmica. Muitos dos seus estudos focaram-se na Eficiência dos Motores Térmicos e na Ciência da Energia.

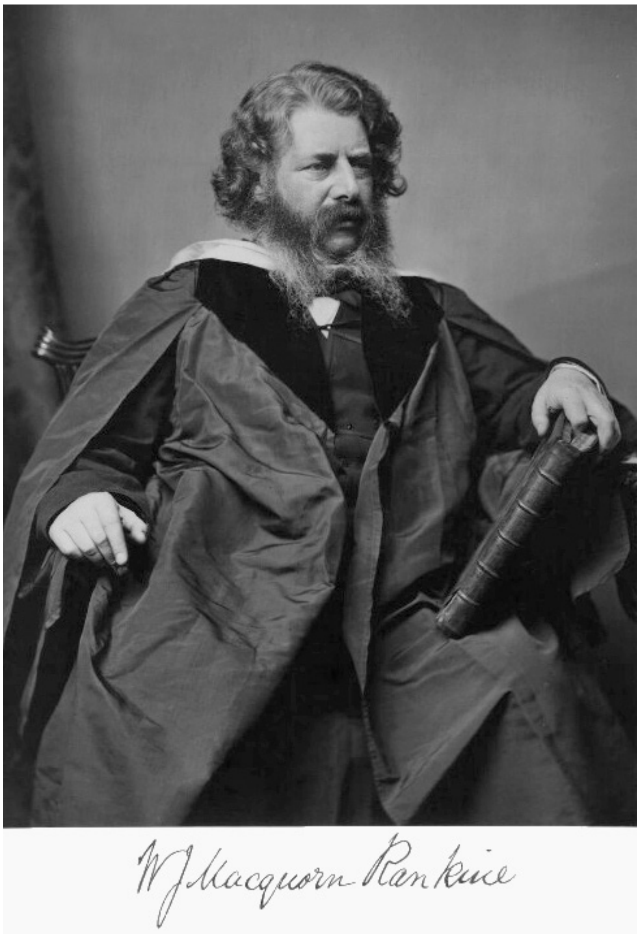
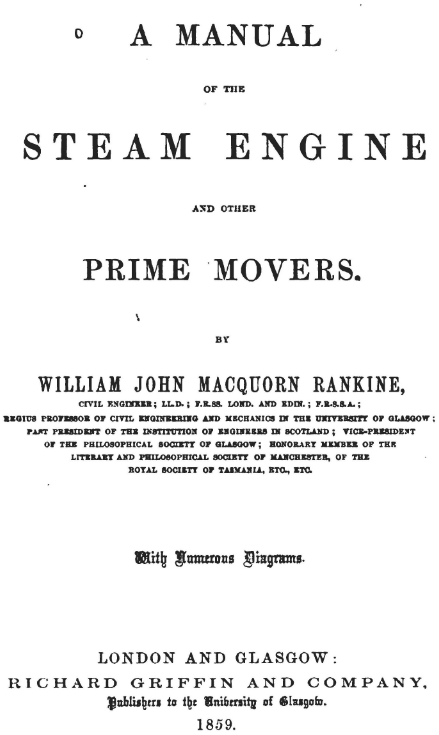


Figura 3.1. O engenheiro escocês William John Macquorn Rankine.

Escreveu vários tratados de engenharia, sendo a máquina a vapor e outros prime movers um manual de referência durante muitos anos no século XIX. Obteve reconhecimento internacional e tornou-se membro de instituições de prestígio como a Royal Society of Edinburgh e a Royal Society of London.

William Rankine publicou, em 1859, o seu Manual da Máquina a Vapor e outros Motores Primários. Na parte III, Rankine descreve, primeiro, os fornos e caldeiras que fornecem calor a partir de combustível queimado e, em segundo lugar, o motor pelo qual o fluido aquecido executa o trabalho através do mecanismo de condução. Anteriormente, discutiu as leis das relações entre os fenômenos do calor e da energia mecânica, que constituem os Princípios da Termodinâmica, sobre os quais dependem o trabalho e a eficiência dos motores térmicos.


A MANUAL

OF THE

STEAM ENGINE

AND OTHER

PRIME MOVERS.

BY

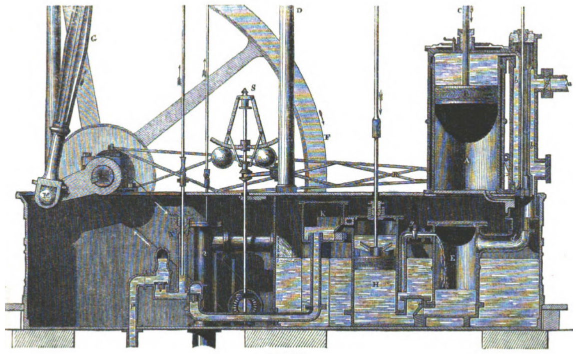
WILLIAM JOHN MACQUORN RANKINE,

CIVIL ENGINEER; LL.D.; F.R.SS. LOND. AND EDIN.; F.R.S.S.A.;
REGIUS PROFESSOR OF CIVIL ENGINEERING AND MECHANICS IN THE UNIVERSITY OF GLASGOW;
PAST PRESIDENT OF THE INSTITUTION OF ENGINEERS IN SCOTLAND; VICE-PRESIDENT
OF THE PHILOSOPHICAL SOCIETY OF GLASGOW; HONORARY MEMBER OF THE
LITERARY AND PHILOSOPHICAL SOCIETY OF MANCHESTER, OF THE
ROYAL SOCIETY OF TASMANIA, ETC., ETC.

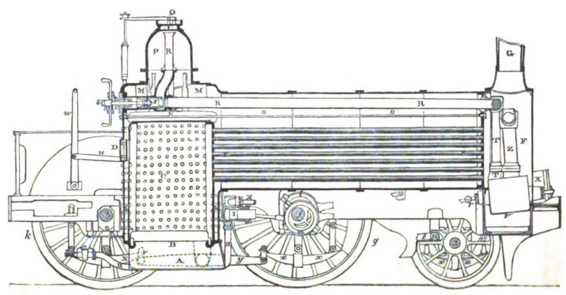
With Numerous Diagrams.

LONDON AND GLASGOW:
RICHARD GRIFFIN AND COMPANY,
Publishers to the University of Glasgow.
1859.

(a)



(b)



(c)

Figura 3.2. (a) Capa do livro *Steam Engine and Other Prime Movers* (1859). (b) Secção longitudinal de uma máquina a vapor rotativa de dupla ação, por W. Rankine. (c) Secção longitudinal de uma locomotiva a vapor de seis rodas, por W. Rankine.

Ao apresentar os conceitos e ideias de temperatura, Rankine introduz a definição das escalas de temperatura absoluta em relação às escalas comuns. Assim, em relação à escala Fahrenheit, propõe a respectiva Temperatura Absoluta onde o zero absoluto corresponde a -461,2^{o}F. Esta escala de temperatura absoluta será nomeada posteriormente como escala Rankine.

No que diz respeito aos dados disponíveis até 1859, os cálculos da Rankine para o Zero Absoluto da escala Celsius levaram ao valor de -274, muito próximo dos -273,15 dos cálculos atuais. Esta escala corresponde à atual escala de Kelvin, proposta em 1848 por William Thomson (Lord Kelvin). Os cálculos de Rankine para o Zero Absoluto da escala de Fahrenheit levaram ao valor de -461,2. O valor de hoje é de -459,67.

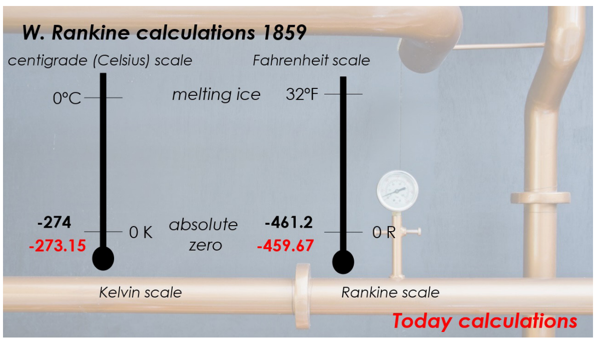


Figura 3.3. Comparação das escalas de temperatura Celsius, Fahrenheit, Kelvin e Rankine.

No entanto, a escala Rankine é muito pouco utilizada. Parece que durante a segunda metade do século XX, as pessoas nos Estados Unidos estavam criando programas e usando equações que precisavam de uma temperatura absoluta, e usaram Rankine antes de Kelvin se tornar dominante para cálculos científicos. A razão pela qual as pessoas ainda a usam na indústria aeroespacial é que há muitos programas que foram desenvolvidos usando Rankine, então, para ser compatível com esses programas antigos, é muitas vezes mais simples apenas usar Rankine nos novos programas também.

4. A unidade SI para a condutância elétrica, "siemens", tem alguma relação com a empresa Siemens AG©?

No Sistema Internacional de Unidades, há um conjunto de unidades derivadas. Entre eleas, podemos encontrar o nome "siemens", cujo símbolo é a letra maiúscula S, correspondente à propriedade condutância elétrica.

SI derived units with special names and symbols[3]: 15

Name	Symbol	Quantity	In SI base units	In other SI units
radian[N 1]	rad	plane angle	m/m	1
steradian[N 1]	sr	solid angle	m^2/m^2	1
hertz	Hz	frequency	s^{-1}	
newton	N	force, weight	$kg{\cdot}m{\cdot}s^{-2}$	
pascal	Pa	pressure, stress	$kg{\cdot}m^{-1}{\cdot}s^{-2}$	N/m^2
joule	J	energy, work, heat	$kg{\cdot}m^2{\cdot}s^{-2}$	$N{\cdot}m = Pa{\cdot}m^3$
watt	W	power, radiant flux	$kg{\cdot}m^2{\cdot}s^{-3}$	J/s
coulomb	C	electric charge	$s{\cdot}A$	
volt	V	electrical potential difference (voltage), emf	$kg{\cdot}m^2{\cdot}s^{-3}{\cdot}A^{-1}$	W/A = J/C
farad	F	capacitance	$kg^{-1}{\cdot}m^{-2}{\cdot}s^4{\cdot}A^2$	$C/V = C^2/J$
ohm	Ω	resistance, impedance, reactance	$kg{\cdot}m^2{\cdot}s^{-3}{\cdot}A^{-2}$	$V/A = J{\cdot}s/C^2$
siemens	S	electrical conductance	$kg^{-1}{\cdot}m^{-2}{\cdot}s^3{\cdot}A^2$	Ω^{-1}
weber	Wb	magnetic flux	$kg{\cdot}m^2{\cdot}s^{-2}{\cdot}A^{-1}$	$V{\cdot}s$
tesla	T	magnetic flux density	$kg{\cdot}s^{-2}{\cdot}A^{-1}$	Wb/m^2
henry	H	inductance	$kg{\cdot}m^2{\cdot}s^{-2}{\cdot}A^{-2}$	Wb/A
degree Celsius	°C	temperature relative to 273.15 K	K	
lumen	lm	luminous flux	$cd{\cdot}sr$	$cd{\cdot}sr$
lux	lx	illuminance	$cd{\cdot}sr{\cdot}m^{-2}$	lm/m^2
becquerel	Bq	activity referred to a radionuclide (decays per unit time)	s^{-1}	
gray	Gy	absorbed dose (of ionising radiation)	$m^2{\cdot}s^{-2}$	J/kg
sievert	Sv	equivalent dose (of ionising radiation)	$m^2{\cdot}s^{-2}$	J/kg
katal	kat	catalytic activity	$mol{\cdot}s^{-1}$	

Notes

1. ^ a b The radian and steradian are defined as dimensionless derived units.

Figura 4.1. Unidades derivadas do Sistema Internacional.

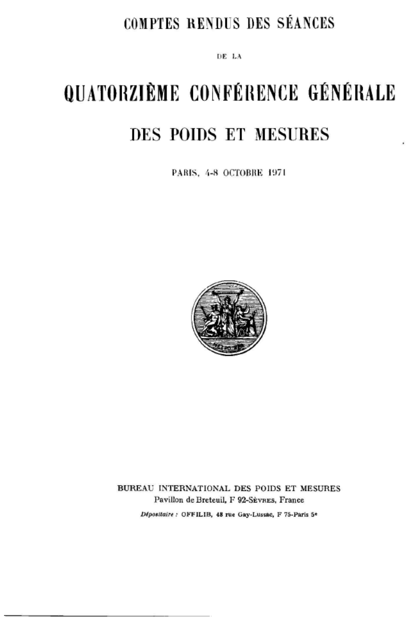
Além disso, podemos encontrar em todo o mundo o nome Siemens associado, por exemplo, a eletrodomésticos, motores elétricos, trens ou sistemas de automação industrial.

(a) (b) (c)

Figura 4.2. Produtos da empresa Siemens AG© (a) Motores elétricos; (b) Sistemas de automação industrial; (c) Trens.

A unidade SI para a condutância elétrica, "siemens", tem alguma relação com a empresa Siemens AG©?

A 14ª Conferência Geral sobre Pesos e Medidas aprovou a adição do "siemens" como unidade derivada em 1971.



COMPTES RENDUS DES SÉANCES

DE LA

QUATORZIÈME CONFÉRENCE GÉNÉRALE

DES POIDS ET MESURES

PARIS, 4-8 OCTOBRE 1971

BUREAU INTERNATIONAL DES POIDS ET MESURES
Pavillon de Breteuil, F 92-Sèvres, France

(a)

Tableau 4. Les 22 unités SI ayant un nom spécial et un symbole particulier

Grandeur dérivée	Nom spécial de l'unité	Expression de l'unité en unités de base (a)	Expression de l'unité en d'autres unités SI
angle plan	radian (b)	rad = m/m	
angle solide	stéradian (c)	$sr = m^2/m^2$	
fréquence	hertz (d)	$Hz = s^{-1}$	
force	newton	$N = kg\ m\ s^{-2}$	
pression, contrainte	pascal	$Pa = kg\ m^{-1}\ s^{-2}$	
énergie, travail, quantité de chaleur	joule	$J = kg\ m^2\ s^{-2}$	N m
puissance, flux énergétique	watt	$W = kg\ m^2\ s^{-3}$	J/s
charge électrique	coulomb	C = A s	
différence de potentiel électrique (e)	volt	$V = kg\ m^2\ s^{-3}\ A^{-1}$	W/A
capacité électrique	farad	$F = kg^{-1}\ m^{-2}\ s^4\ A^2$	C/V
résistance électrique	ohm	$\Omega = kg\ m^2\ s^{-3}\ A^{-2}$	V/A
conductance électrique	siemens	$S = kg^{-1}\ m^{-2}\ s^3\ A^2$	A/V
flux d'induction magnétique	weber	$Wb = kg\ m^2\ s^{-2}\ A^{-1}$	V s
induction magnétique	tesla	$T = kg\ s^{-2}\ A^{-1}$	Wb/m^2
inductance	henry	$H = kg\ m^2\ s^{-2}\ A^{-2}$	Wb/A
température Celsius	degré Celsius (f)	°C = K	
flux lumineux	lumen	lm = cd sr (g)	cd sr
éclairement lumineux	lux	$lx = cd\ sr\ m^{-2}$	lm/m^2
activité d'un radionucléide (d, h)	becquerel	$Bq = s^{-1}$	
dose absorbée, kerma	gray	$Gy = m^2\ s^{-2}$	J/kg
équivalent de dose	sievert (i)	$Sv = m^2\ s^{-2}$	J/kg
activité catalytique	katal	$kat = mol\ s^{-1}$	

(b)

Figura 4.3. (a) Publicação da Décima Quarta Conferência Geral sobre Pesos e Medidas, 4-8 de outubro de 1971; (b) Quadro 4, com as unidades derivadas do Sistema Internacional.

O "siemens" (símbolo: S) é a unidade derivada de condutância elétrica. Em equações, a condutância é representada por G. Um condutor tem uma condutância de 1 siemens se uma diferença potencial elétricao de 1 volt produzir 1 ampere de corrente nele. É o inverso da resistência. Assim, um "siemens" é igual ao inverso de um *ohm* (Ω^{-1}).

$$G = 1/R = I/V$$

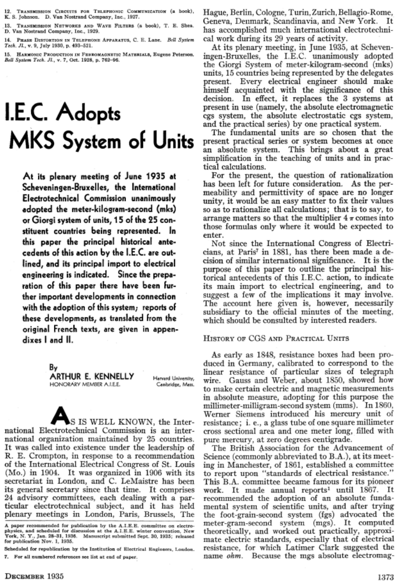
Unidade: *siemens;* [S] = [A/V] = [Ω^{-1}], Ω, *ohm*; A, *ampere*; V, *volt*

Pode ser expresso também apenas em termos de unidades base do Sistema Internacional. A mesma palavra "siemens" é usada tanto para o singular quanto para o plural. A unidade "siemens" foi nomeada em homenagem ao engenheiro Ernst Werner von Siemens.

Figura 4.4. Werner von Siemens.

Werner von Siemens (1816 - 1892) foi um brilhante engenheiro eletricista alemão, empresário e talentoso inventor e cientista. Em 1847, fundou a empresa Siemens e Halske, de construção de telégrafo após a invenção do telégrafo de ponteiro. Em poucas décadas, a empresa tornou-se uma fabricante líder de equipamentos elétricos operando internacionalmente. Esta empresa é a atual empresa Siemens AG©. Além disso, a Siemens tem sido intensamente dedicada à pesquisa científica. Descobriu o princípio do dínamo-elétrico e, assim, estabeleceu as bases para o uso da eletricidade como fonte de energia. Durante a sua vida, o engenheiro elétrico eletricista pioneiro recebeu inúmeras honrarias em reconhecimento dos seus serviços à ciência e à sociedade.

Em 1971, a unidade "siemens" não era inteiramente nova. Foi utilizada como unidade de condutância elétrica por engenheiros eletricistas desde 1935, uma vez que a Comissão Eletrotécnica Internacional recomendou a sua utilização na reunião plenária em Scheveningen-Bruxelas. Há que salientar que Werner von Siemens contribuiu em grande parte para os estudos técnicos e científicos dea resistência elétrica durante o século XIX.


12. Transmission Circuits for Telephonic Communication (a book), K. S. Johnson. D. Van Nostrand Company, Inc., 1927.
13. Transmission Networks and Wave Filters (a book), T. E. Shea. D. Van Nostrand Company, Inc., 1929.
14. Phase Distortion in Telephone Apparatus, C. E. Lane. *Bell System Tech. Jl.*, v. 9, July 1930, p. 493–521.
15. Harmonic Production in Ferromagnetic Materials, Eugene Peterson. *Bell System Tech. Jl.*, v. 7, Oct. 1928, p. 762–96.

I.E.C. Adopts MKS System of Units

At its plenary meeting of June 1935 at Scheveningen-Bruxelles, the International Electrotechnical Commission unanimously adopted the meter-kilogram-second (mks) or Giorgi system of units, 15 of the 25 constituent countries being represented. In this paper the principal historical antecedents of this action by the I.E.C. are outlined, and its principal import to electrical engineering is indicated. Since the preparation of this paper there have been further important developments in connection with the adoption of this system; reports of these developments, as translated from the original French texts, are given in appendixes I and II.

By
ARTHUR E. KENNELLY
HONORARY MEMBER A.I.E.E.
Harvard University, Cambridge, Mass.

As is well known, the International Electrotechnical Commission is an international organization maintained by 25 countries. It was called into existence under the leadership of R. E. Crompton, in response to a recommendation of the International Electrical Congress of St. Louis (Mo.) in 1904. It was organized in 1906 with its secretariat in London, and C. LeMaistre has been its general secretary since that time. It comprises 24 advisory committees, each dealing with a particular electrotechnical subject, and it has held plenary meetings in London, Paris, Brussels, The Hague, Berlin, Cologne, Turin, Zurich, Bellagio-Rome, Geneva, Denmark, Scandinavia, and New York. It has accomplished much international electrotechnical work during its 29 years of activity.

At its plenary meeting, in June 1935, at Scheveningen-Bruxelles, the I.E.C. unanimously adopted the Giorgi System of meter-kilogram-second (mks) units, 15 countries being represented by the delegates present. Every electrical engineer should make himself acquainted with the significance of this decision. In effect, it replaces the 3 systems at present in use (namely, the absolute electromagnetic cgs system, the absolute electrostatic cgs system, and the practical series) by one practical system.

The fundamental units are so chosen that the present practical series or system becomes at once an absolute system. This brings about a great simplification in the teaching of units and in practical calculations.

For the present, the question of rationalization has been left for future consideration. As the permeability and permittivity of space are no longer unity, it would be an easy matter to fix their values so as to rationalize all calculations; that is to say, to arrange matters so that the multiplier 4π comes into those formulas only where it would be expected to enter.

Not since the International Congress of Electricians, at Paris[7] in 1881, has there been made a decision of similar international significance. It is the purpose of this paper to outline the principal historical antecedents of this I.E.C. action, to indicate its main import to electrical engineering, and to suggest a few of the implications it may involve. The account here given is, however, necessarily subsidiary to the official minutes of the meeting, which should be consulted by interested readers.

History of CGS and Practical Units

As early as 1848, resistance boxes had been produced in Germany, calibrated to correspond to the linear resistance of particular sizes of telegraph wire. Gauss and Weber, about 1850, showed how to make certain electric and magnetic measurements in absolute measure, adopting for this purpose the millimeter-milligram-second system (mms). In 1860, Werner Siemens introduced his mercury unit of resistance; i. e., a glass tube of one square millimeter cross sectional area and one meter long, filled with pure mercury, at zero degrees centigrade.

The British Association for the Advancement of Science (commonly abbreviated to B.A.), at its meeting in Manchester, of 1861, established a committee to report upon "standards of electrical resistance." This B.A. committee became famous for its pioneer work. It made annual reports[1] until 1867. It recommended the adoption of an absolute fundamental system of scientific units, and after trying the foot-grain-second system (fgs) advocated the meter-gram-second system (mgs). It computed theoretically, and worked out practically, approximate electric standards, especially that of electrical resistance, for which Latimer Clark suggested the name *ohm*. Because the mgs absolute electromag-

A paper recommended for publication by the A.I.E.E. committee on electrophysics, and scheduled for discussion at the A.I.E.E. winter convention, New York, N. Y., Jan. 28–31, 1936. Manuscript submitted Sept. 30, 1935; released for publication Nov. 1, 1935.

Scheduled for republication by the Institution of Electrical Engineers, London.

7. For all numbered references see list at end of paper.

December 1935 1373

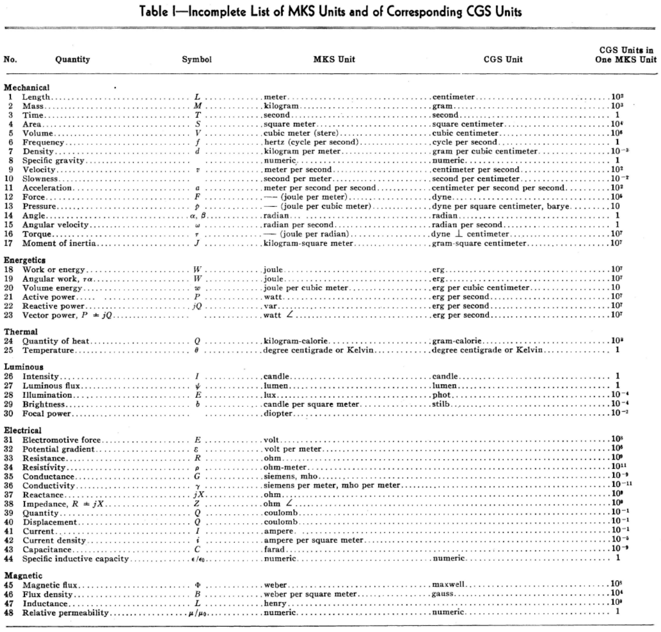


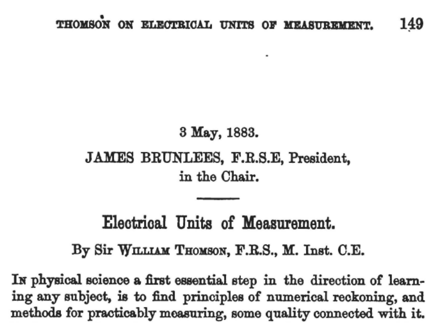
Table I—Incomplete List of MKS Units and of Corresponding CGS Units

No.	Quantity	Symbol	MKS Unit	CGS Unit	CGS Units in One MKS Unit
Mechanical					
1	Length	L	meter	centimeter	10^2
2	Mass	M	kilogram	gram	10^3
3	Time	T	second	second	1
4	Area	S	square meter	square centimeter	10^4
5	Volume	V	cubic meter (stere)	cubic centimeter	10^6
6	Frequency	f	hertz (cycle per second)	cycle per second	1
7	Density	d	kilogram per meter	gram per cubic centimeter	10^{-3}
8	Specific gravity		numeric	numeric	1
9	Velocity	v	meter per second	centimeter per second	10^2
10	Slowness		second per meter	second per centimeter	10^{-2}
11	Acceleration	a	meter per second per second	centimeter per second per second	10^2
12	Force	F	—— (joule per meter)	dyne	10^5
13	Pressure	p	—— (joule per cubic meter)	dyne per square centimeter, barye	10
14	Angle	α, β	radian	radian	1
15	Angular velocity	ω	radian per second	radian per second	1
16	Torque	τ	—— (joule per radian)	dyne ⊥ centimeter	10^7
17	Moment of inertia	J	kilogram-square meter	gram-square centimeter	10^7
Energetics					
18	Work or energy	W	joule	erg	10^7
19	Angular work, $\tau\alpha$	W	joule	erg	10^7
20	Volume energy	w	joule per cubic meter	erg per cubic centimeter	10
21	Active power	P	watt	erg per second	10^7
22	Reactive power	jQ	var	erg per second	10^7
23	Vector power, $P \pm jQ$		watt ∠	erg per second	10^7
Thermal					
24	Quantity of heat	Q	kilogram-calorie	gram-calorie	10^3
25	Temperature	θ	degree centigrade or Kelvin	degree centigrade or Kelvin	1
Luminous					
26	Intensity	I	candle	candle	1
27	Luminous flux	ψ	lumen	lumen	1
28	Illumination	E	lux	phot	10^{-4}
29	Brightness	b	candle per square meter	stilb	10^{-4}
30	Focal power		diopter		10^{-2}
Electrical					
31	Electromotive force	E	volt		10^8
32	Potential gradient	ε	volt per meter		10^6
33	Resistance	R	ohm		10^9
34	Resistivity	ρ	ohm-meter		10^{11}
35	Conductance	G	siemens, mho		10^{-9}
36	Conductivity	γ	siemens per meter, mho per meter		10^{-11}
37	Reactance	jX	ohm		10^9
38	Impedance, $R \pm jX$	Z	ohm ∠		10^9
39	Quantity	Q	coulomb		10^{-1}
40	Displacement	Q	coulomb		10^{-1}
41	Current	I	ampere		10^{-1}
42	Current density	i	ampere per square meter		10^{-5}
43	Capacitance	C	farad		10^{-9}
44	Specific inductive capacity	ϵ/ϵ_0	numeric	numeric	1
Magnetic					
45	Magnetic flux	Φ	weber	maxwell	10^8
46	Flux density	B	weber per square meter	gauss	10^4
47	Inductance	L	henry		10^9
48	Relative permeability	μ/μ_0	numeric	numeric	1

(a) (b)

Figura 4.5. (a) Publicação dos acordos da Comissão Eletrotécnica Internacional de 1935; (b) Quadro I, com unidades MKS (Kenelly, 1935).

Como a condutância elétrica é o inverso da resistência elétrica (Ω^{-1}), o primeiro nome proposto para esta unidade foi mho, antes de ser nomeado "siemens" em 1971. Como o inverso de um *ohm*, mho é a palavra ohm escrita ao contrário, por sugestão de Sir William Thomson (Lord Kelvin) em 1883. Thomson acrescentou, como a ajuda, que a pronúncia adequada de «mho» poderia ser obtida tomando um fonógrafo e fazê-lo girar ao contrário. O seu símbolo é era uma letra grega invertida, a letra ômega.

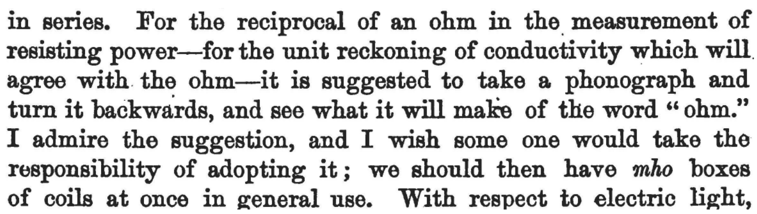

THOMSON ON ELECTRICAL UNITS OF MEASUREMENT. 149

3 May, 1883.
JAMES BRUNLEES, F.R.S.E, President, in the Chair.

Electrical Units of Measurement.

By Sir William Thomson, F.R.S., M. Inst. C.E.

In physical science a first essential step in the direction of learning any subject, is to find principles of numerical reckoning, and methods for practicably measuring, some quality connected with it.


in series. For the reciprocal of an ohm in the measurement of resisting power—for the unit reckoning of conductivity which will agree with the ohm—it is suggested to take a phonograph and turn it backwards, and see what it will make of the word "ohm." I admire the suggestion, and I wish some one would take the responsibility of adopting it; we should then have *mho* boxes of coils at once in general use. With respect to electric light,

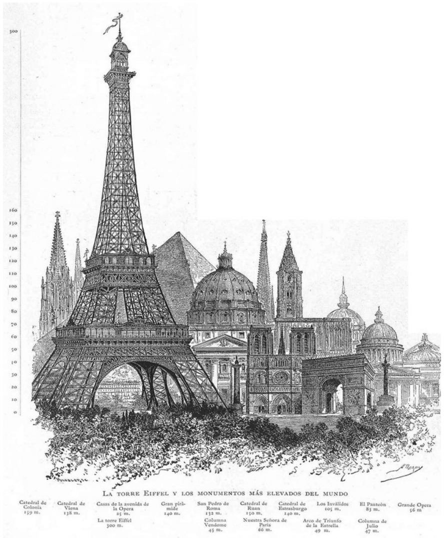
(a) (b)

Figura 4.6. (a) A proposta de William Thomson (Lord Kelvin) sobre unidades elétricas, 1883; (b) Denominação proposta para a unidade de condutância elétrica.

5. Quem deu o nome à Torre Eiffel?

Provavelmente, já ouviu falar da Torre Eiffel, a famosa torre de Paris, França. É uma torre de ferro e foi a peça central da Feira Mundial de 1889. A torre tem 330 metros de altura, a mesma altura de um edifício de 81 andares. Era a estrutura mais alta feita pelo homem até 1930. A Torre foi classificada Patrimônio Mundial da UNESCO em 1991.

(a)

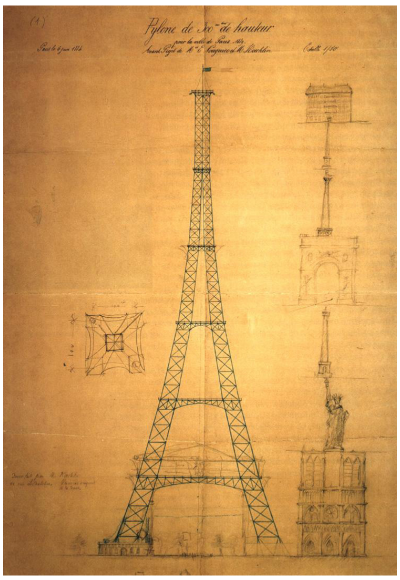


(b)

Figura 5.1. (a) Cartaz da Feira Universal de Paris, 1889; (b) Comparação das alturas de edifícios bem conhecidos na publicação La Ilustración Artística, 1889, 367, pp.3.

O projeto da torre é atribuído a Maurice Koechlin e Émile Nouguier, dois engenheiros, e Stephen Sauvestre, um arquiteto. Foi concebido como "um grande pilar, composto por quatro vigas de reticulado que se separam na base e se juntam no topo, unidas por treliças metálicas em intervalos regulares", em palavras de Koechlin. Note a pilha de edifícios esboçados, com Notre Dame na parte inferior, indicando a escala da torre proposta.

A patente foi depositada em 1884. A torre foi construída de 1887 a 1889.



(a)

(b)

Figura 5.2. (a) Esboço de Maurice Koechlin e Émile Nouguier e comparação do empilhamento de edifícios conhecidos; (b) Torre Eiffel, Património Mundial da UNESCO em 1991.

Os projetistas trabalhavam para a Compagnie des Établissements Eiffel, a empresa do engenheiro Gustave Eiffel. A Torre Eiffel foi nomeada em homenagem a Alexandre Gustave Eiffel (1832 - 1923), um engenheiro civil francês.

Figura 5.3. Gustave Eiffel, 1890.

Graduado pela École Centrale des Arts et Manufactures em Paris, fez o seu nome de engenheiro com várias pontes para a rede ferroviária francesa. Em 1868 foi cofundador da Eiffel e Cia. e começou a trabalhar em outros países da Europa e no estrangeiro.

(a)

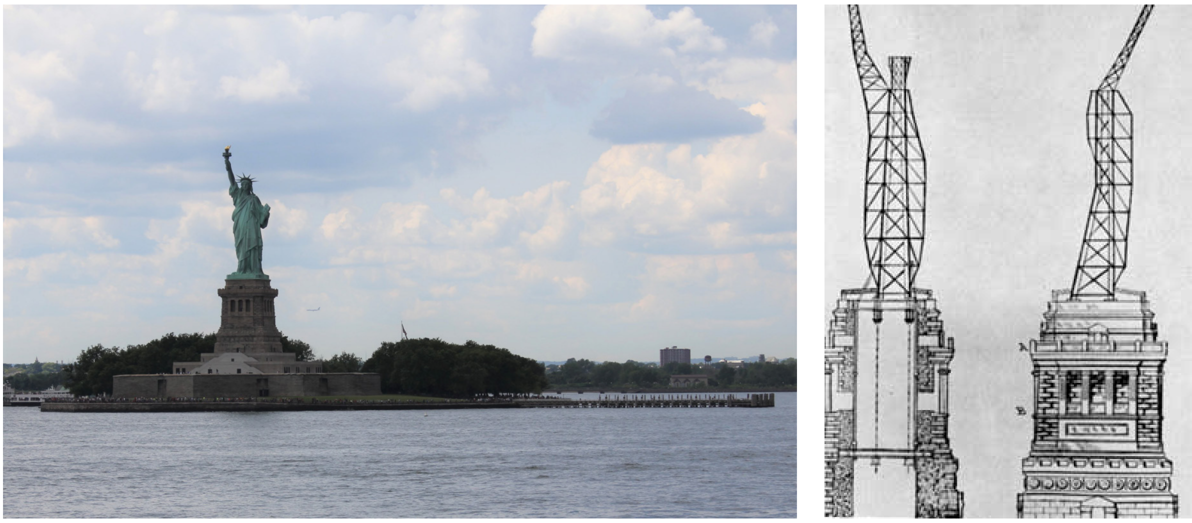
(b)

(c)

(d)

Figura 5.4. (a) Ponte de Bordéus, França, 1861; (b) Estação ferroviária, Budapeste, 1877; (c) Ponte Maria Pia no Porto, Portugal, 1877; (d) Ponte Belvárosi em Szeged, Hungria, 1881.

Em 1881, Eiffel concebeu uma estrutura composta por um pilar de quatro patas para apoiar o revestimento de cobre que compõe o corpo da Estátua da Liberdade em New York. Toda a estátua foi erguida nas oficinas de Eiffel em Paris antes de ser desmontada e enviada para os Estados Unidos.

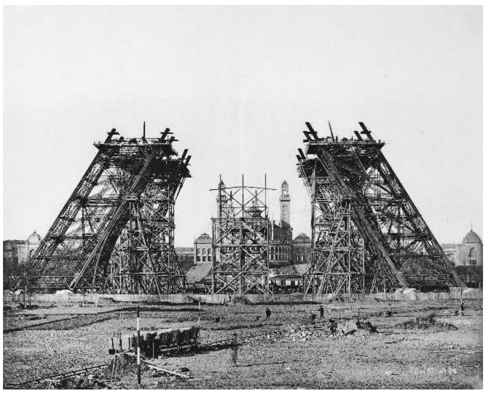


(a) (b)

Figura 5.5. (a) Estátua da Liberdade, Nova Iorque; (b) Estrutura interna da Estátua da Liberdade.

A Torre Eiffel é a obra mais famosa de Gustave Eiffel. A patente 164 364 foi depositada em 18 de setembro de 1884. A torre foi construída de 1887 a 1889. Os principais trabalhos estruturais foram concluídos no final de março de 1889 e, em 31 de março, Eiffel celebrou por liderar um grupo de funcionários do governo e representantes da imprensa para o topo da torre. Como os elevadores ainda não estavam em funcionamento, a subida foi feita a pé e demorou mais de uma hora.

(a)



(b)

(c)

(d)

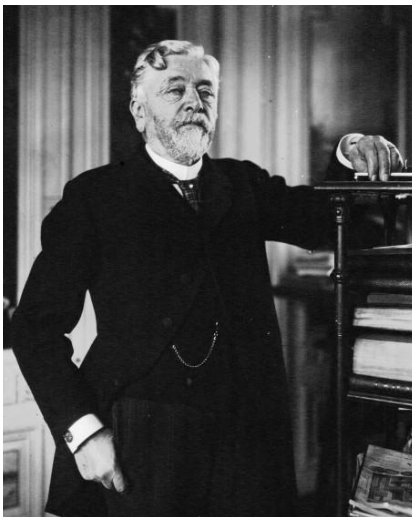
(e)

(f)

(g)

Figura 5.6. Construção da Torre Eiffel (a) 1 de julho de 1887; (b) 2 de dezembro de 1887; (c) 3 de março de 1888; (d) 4 de maio de 1888; (e) 5 de agosto de 1888; (f) 6 de dezembro de 1888; (g) 7 de março de 1889.

Em 1893, Eiffel demitiu-se da direção da Compagnie des Établissements Eiffel e o seu nome desapareceu do nome da empresa. Iniciou, então, uma carreira como pesquisador em aerodinâmica e a sua contribuição nesta área é provavelmente de igual importância para o seu trabalho como engenheiro, embora muito menos conhecido. Nessa altura, tem mais de 70 anos. Começa-lhe uma nova carreira de cientista, que durará vinte anos.

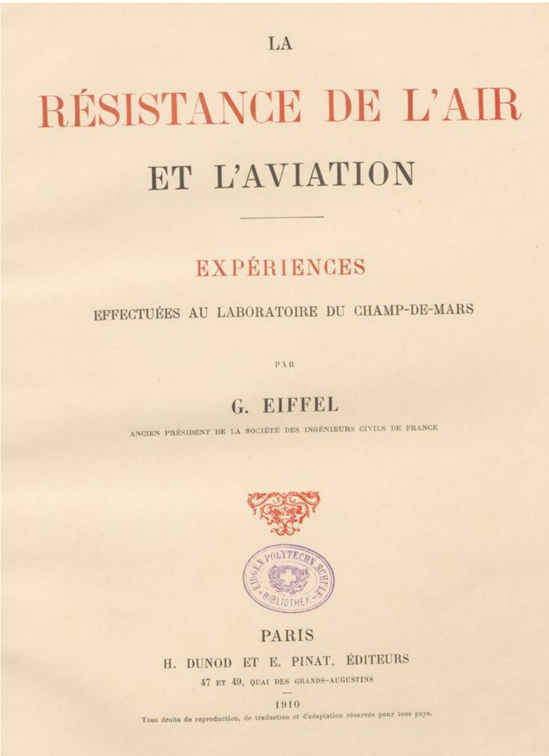


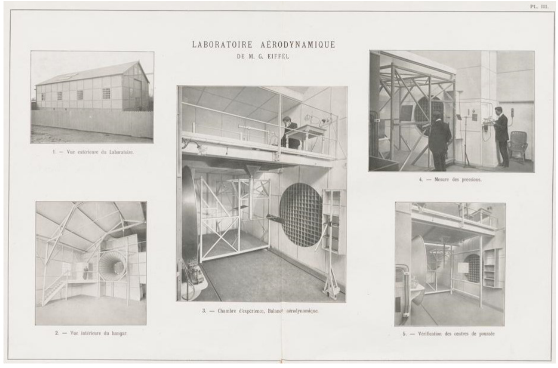
(a)

(b)

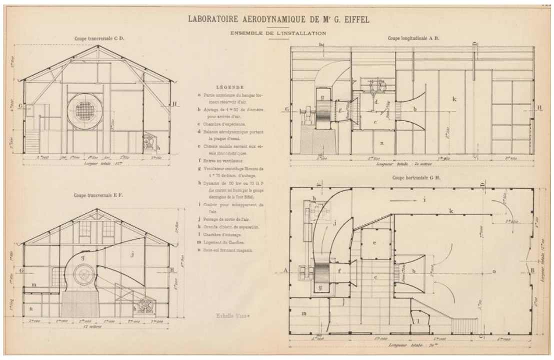
Figura 5.7. (a) Gustave Eiffel, 1910; (b) Eiffel com um modelo de avião.

Em 1909, Eiffel construiu o seu primeiro túnel de vento no sopé da Torre Eiffel no Champ de Mars. Esta instalação esteve operacional até 1911 para estudar aerodinâmica. No início de 1912, instalou no distrito de Auteuil um novo túnel de vento com maior desempenho. Sendo bem sucedido com o seu primeiro conjunto de testes, o túnel de vento de Eiffel estava então disponível para os pioneiros na sua conquista do ar: Farman, Bleriot, Voisin, Bréguet.





(b)



(a) (c)

Figura 5.8. (a) Capa do livro de Eiffel sobre aerodinâmica, 1910; b) Fotografias do laboratório de Eiffel; (c) Planos do laboratório de Eiffel.

Uma das principais inovações de Eiffel foi a adição de um difusor ao túnel de vento. Foi objeto de uma patente datada de 28 de novembro de 1911. Esta invenção foi rica em consequências, pois permitiu que Eiffel reduzisse drasticamente a energia elétrica necessária para tal instalação. A partir desta data, todos os túneis de vento foram equipados com um difusor.

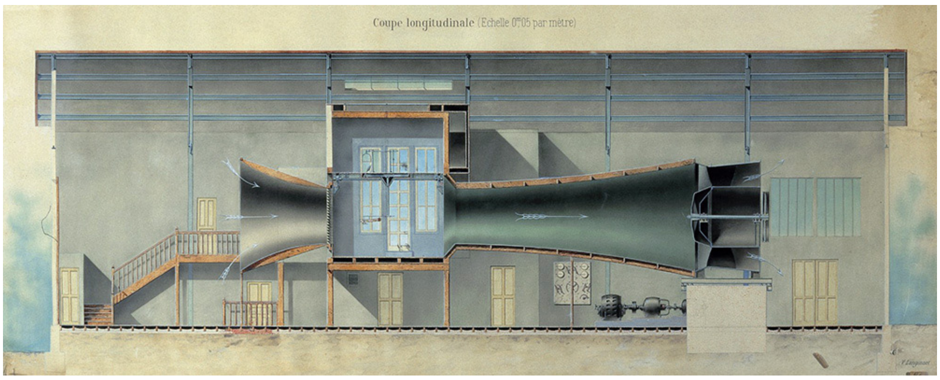


Figura 5.9. Túnel de vento Eiffel.

Os seus estudos sobre o desempenho dos aviões foram publicados em vários livros e revistas. Em 1917, chegou a depositar uma patente para um avião de caça de alta velocidade.

A contribuição de Eiffel para esta ciência emergente da aerodinâmica foi reconhecida nos EUA, onde recebeu a Medalha de Ouro de Langley em 1913, que só tinha sido atribuída a Wilbur e Orville Wright antes.

6. Quem deu o nome aos prêmios Nobel?

Os prêmios Nobel, conhecidos em todo o mundo, são cinco prémios distintos atribuídos àqueles que contribuíram com maiores benefíciso à humanidade. Os prêmios Nobel são atribuídos nas áreas da Física, Química, Fisiologia ou Medicina, Literatura e Paz desde 1901. O Prêmio de Ciências Econômicas foi acrescentado em 1969. Os prêmios Nobel são amplamente considerados como os prêmios mais prestigiosos disponíveis nas respetivas áreas.

Entre 1901 e 2017, os prêmios Nobel foram atribuídos 585 vezes a 923 pessoas e organizações. O Prêmio Nobel não foi atribuído entre 1940 e 1942 devido ao início da Segunda Guerra Mundial. Cada laureado recebe uma medalha de ouro, um diploma e um prêmio monetário.

(a) (b)

Figura 6.1. (a) Medalha do Prêmio Nobel; b) Diploma do Prêmio Nobel.

Entre os laureados, há algumas curiosidades. Seis laureados receberam mais de um prêmio. O Comitê Internacional da Cruz Vermelha recebeu o Prêmio Nobel da Paz três vezes, mais do que qualquer outro. O Alto Comissariado das Nações Unidas para os Refugiados (ACNUR) foi premiado com o Nobel da Paz duas vezes. Em Física, foi atribuído a John Bardeen duas vezes. O mesmo em Química para Frederick Sanger. Dois laureados foram premiados duas vezes, mas não no mesmo campo: Marie Curie (Física e Química) e Linus Pauling (Química e Paz). Entre os 892 laureados com o Nobel, 48 são mulheres (até 2021). Seis laureados com o Nobel não foram autorizados a aceitar o Prêmio Nobel pelos seus governos: quatro alemães (1936-1939), um chinês (2010) e um russo (1958). Dois laureados com o Nobel, Jean-Paul Sartre (Literatura, 1964) e Lê Đức Thọ (Paz, 1973), recusaram o prêmio.

Quem deu o nome aos prêmios Nobel?

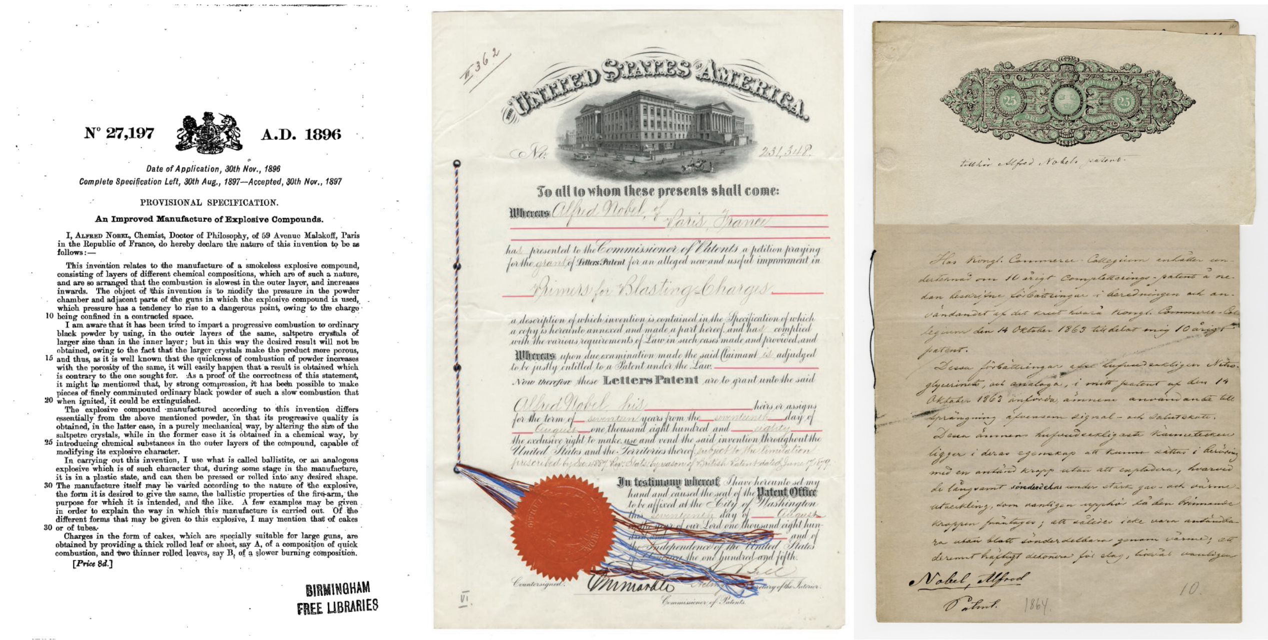
Os prêmios Nobel foram nomeados pelo seu criador, Alfred Bernhard Nobel (1833 - 1896). Nobel era um químico, engenheiro, inventor, empresário e filantropo sueco. Nasceu em Estocolmo, onde viveu a sua infância. Em 1842 mudou-se com a família para São Petersburgo, onde a família tinha um negócio de fabricação de máquinas-ferramentas e explosivos. O interesse de Alfred Nobel pela tecnologia e engenharia foi herdado do seu pai.

(a) (b)

Figura 6.2. (a) Alfred Nobel, jovem (b) Alfred Nobel, adulto.

Nobel tornou-se um excelente inventor e engenheiro. Registrou a sua primeira patente para um medidor de gás em 1857. Durante a sua vida, Nobel obteve registro de 355 patentes em a nível internacional.

De volta à Suécia em 1859, Nobel dedicou-se ao estudo dos explosivos e inventou um detonador em 1863 e a dinamite em 1867, uma substância mais fácil e segura de manusear do que a nitroglicerina, que é mais instável. A dinamite foi patenteada nos EUA e no Reino Unido e foi utilizada extensivamente na mineração e na construção de redes de transportes em nível internacional.



N° 27,197 A.D. 1896

Date of Application, 30th Nov., 1896
Complete Specification Left, 30th Aug., 1897—Accepted, 30th Nov., 1897

PROVISIONAL SPECIFICATION.

An Improved Manufacture of Explosive Compounds.

I, Alfred Nobel, Chemist, Doctor of Philosophy, of 59 Avenue Malakoff, Paris in the Republic of France, do hereby declare the nature of this invention to be as follows:—

This invention relates to the manufacture of a smokeless explosive compound, consisting of layers of different chemical compositions, which are of such a nature, and are so arranged that the combustion is slowest in the outer layer, and increases inwards. The object of this invention is to modify the pressure in the powder chamber and adjacent parts of the guns in which the explosive compound is used, which pressure has a tendency to rise to a dangerous point, owing to the charge being confined in a contracted space.

I am aware that it has been tried to impart a progressive combustion to ordinary black powder by using, in the outer layers of the same, saltpetre crystals of larger size than in the inner layer; but in this way the desired result will not be obtained, owing to the fact that the larger crystals make the product more porous, and thus, as it is well known that the quickness of combustion of powder increases with the porosity of the same, it will easily happen that a result is obtained which is contrary to the one sought for. As a proof of the correctness of this statement, it might be mentioned that, by strong compression, it has been possible to make pieces of finely comminuted ordinary black powder of such a slow combustion that when ignited, it could be extinguished.

The explosive compound manufactured according to this invention differs essentially from the above mentioned powder, in that its progressive quality is obtained, in the latter case, in a purely mechanical way, by altering the size of the saltpetre crystals, while in the former case it is obtained in a chemical way, by introducing chemical substances in the outer layers of the compound, capable of modifying its explosive character.

In carrying out this invention, I use what is called ballistite, or an analogous explosive which is of such character that, during some stage in the manufacture, it is in a plastic state, and can then be pressed or rolled into any desired shape. The manufacture itself may be varied according to the nature of the explosive, the form it is desired to give the same, the ballistic properties of the fire-arm, the purpose for which it is intended, and the like. A few examples may be given in order to explain the way in which this manufacture is carried out. Of the different forms that may be given to this explosive, I may mention that of cakes or of tubes.

Charges in the form of cakes, which are specially suitable for large guns, are obtained by providing a thick rolled leaf or sheet, say A, of a composition of quick combustion, and two thinner rolled leaves, say B, of a slower burning composition.

[*Price 8d.*]

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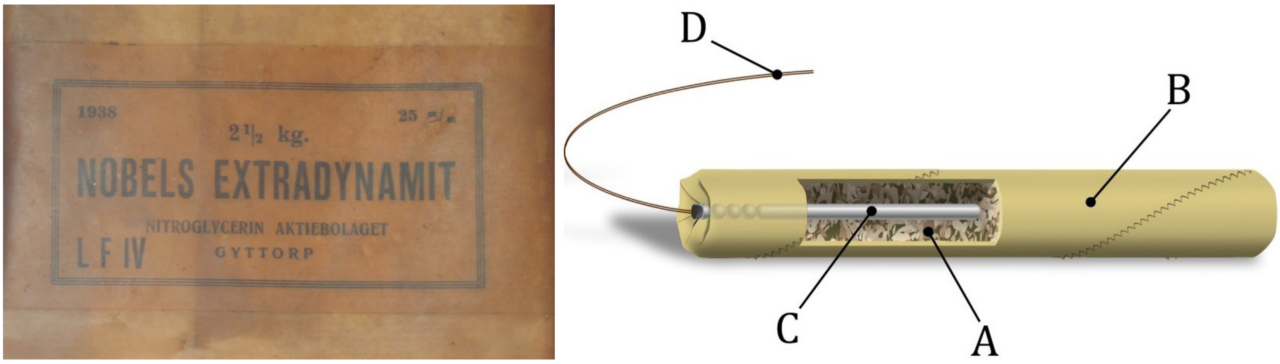
(a) (b) (d)

Figura 6.3. Patentes de explosivos de Alfred Nobel (a) Grã-Bretanha (b) Estados Unidos da América; c) Suécia.

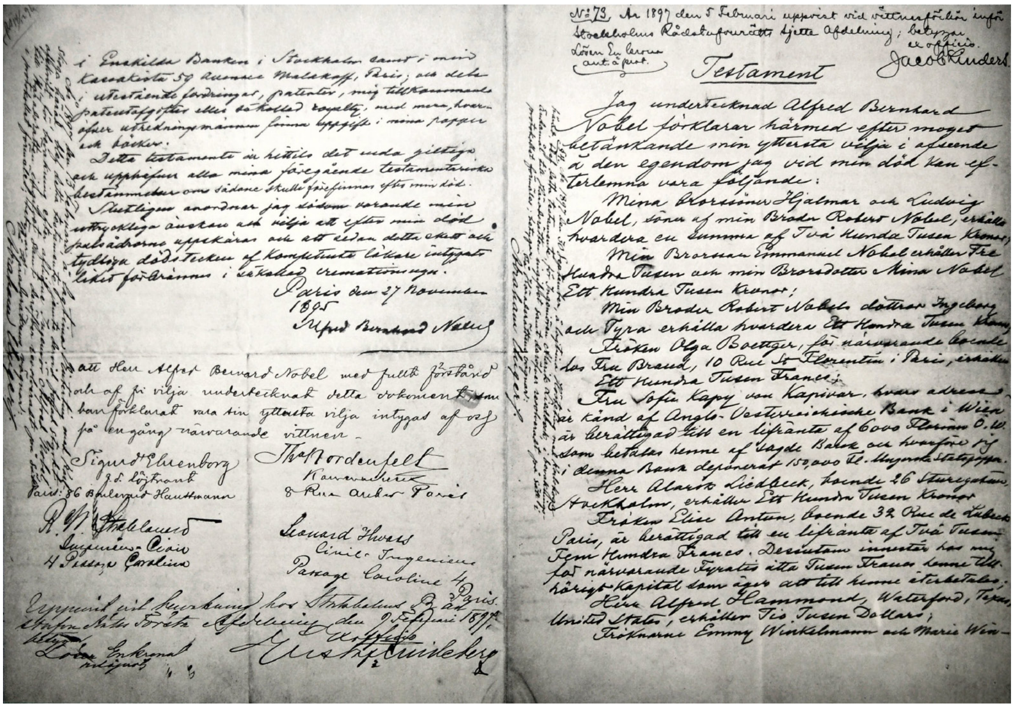
Para melhorar a imagem do seu negócio das controvérsias anteriores associadas a explosivos perigosos e à guerra, Nobel também considerou nomear a substância altamente poderosa "Pó de Segurança do Nobel", mas estabeleceu-se com dinamite, referindo-se à palavra grega para "poder" (δύναμις). No final da sua vida, o seu negócio tinha estabelecido mais de 90 fábricas de armamento, apesar do seu caráter aparentemente pacifista.



(a) (b)

Figura 6.4. (a) Caixa de dinamite Nobel (b) Cartucho de dinamite: [A] Terra de diatomáceas (ou qualquer outro tipo de material absorvente) embebida em nitroglicerina, [B] Revestimento protetor em torno do material explosivo, [C] Detonador, [D] Fio ligado ao detonador.

Nobel decidiu doar postumamente a maior parte da sua riqueza para custear o Prêmio Nobel como o seu melhor legado. Em 1895, assinou o seu último testamento e pôs de lado a maior parte do seu espólio para estabelecer os Prêmios Nobel, a serem atribuídos anualmente sem distinção de nacionalidade.



i Enskilda Banken i Stockholm samt i mina kassaskåp 59 Avenue Malakoff, Paris; äro dels i utestående fordringar, patenter, mig tillkommande patentafgifter eller så kallade royalty, med mera, hvarom mina utredningsmän finna upplysning i mina papper och böcker.
Detta testamente är hittils det enda gällande och upphäfver alla mina föregående testamentariska bestämmelser om sådane skulle förefinnas efter min död.
Slutligen anordnar jag såsom varande min uttryckliga önskan och vilja att efter min död pulsådrorna uppskäras och att sedan detta skett och tydliga dödstecken af kompetente läkare intygats liket förbrännes i så kalladt crematorium.
Paris den 27 November 1895
Alfred Bernhard Nobel

Att Herr Alfred Bernhard Nobel med fullt förstånd och af fri vilja undertecknat detta dokument som han förklarat vara sin yttersta vilja intyga af oss på en gång närvarande vittnen:
Sigurd Ehrenborg, f.d. Löjtnant, Paris: 84 Boulevard Haussmann
Th. Nordenfelt, Konstruktör, 8 Rue Auber Paris
R. W. Strehlenert, Ingenieur Civil, 4 Passage Caroline
Leonard Hwass, Civil-Ingenieur, Passage Caroline 4

Testament

Jag undertecknad Alfred Bernhard Nobel förklarar härmed efter moget betänkande min yttersta vilja i afseende å den egendom jag vid min död kan efterlemna vara följande:
Mina Brorsöner Hjalmar och Ludvig Nobel, söner af min Broder Robert Nobel, erhålla hvardera en Summa af Två Hundra Tusen Kronor;
Min Brorson Emmanuel Nobel erhåller Tre Hundra Tusen och min Brorsdotter Mina Nobel Ett Hundra Tusen Kronor;
Min Broder Robert Nobels döttrar Ingeborg och Tyra erhålla hvardera Ett Hundra Tusen Kronor;
Fröken Olga Boettger, för närvarande boende hos Fru Brand, 10 Rue St Florentin i Paris, erhåller Ett Hundra Tusen Francs;
Fru Sofie Kapy von Kapivar, hvars adress är känd af Anglo-Oesterreichische Bank i Wien är berättigad till en lifränta af 6000 Florin Ö.W. som betalas henne af sagde Bank och hvarför jag i denna Bank deponerat 150.000 Fl. Ungersk Statspapper.
Herr Alarik Liedbeck, boende 26 Sturegatan Stockholm, erhåller Ett Hundra Tusen Kronor;
Fröken Elise Antun, boende 32 Rue de Lubeck Paris, är berättigad till en lifränta af Två Tusen Fem Hundra Francs. Dessutom innestår hos mig för närvarande Fyrtioåtta Tusen Francs henne tillhörigt Kapital som äger att till henne återbetalas.
Herr Alfred Hammond, Waterford, Texas, United States, erhåller Tio Tusen Dollars;
Fröknarne Emmy Winkelmann och Marie Win-

Figura 6.5. Testamento de Alfred Nobel, 1895.

Nobel foi eleito membro da Real Academia Sueca das Ciências em 1884, a mesma instituição que mais tarde escolheria laureados para dois dos prêmios Nobel, e recebeu um doutoramento honorário pela Universidade de Uppsala em 1893. O elemento químico Nobelium, com o símbolo No e número atômico 102, foi nomeado em homenagem a Alfred Nobel. Como todos os elementos com número atômico superior a 100, o nobelium só pode ser produzido em aceleradores de partículas.

Nobel também foi poeta e dramaturgo com gosto pelo melodramático, embora a maioria dos seus escritos permanecessem inéditos. Nobel escreveu a peça teatral Nemesis no último ano da sua vida e o script teve uma publicação limitada após a sua morte em 1896. Após um século, a primeira, e até agora, a única produção foi no Teatro Intima de Strindberg, em Estocolmo, em 2005.

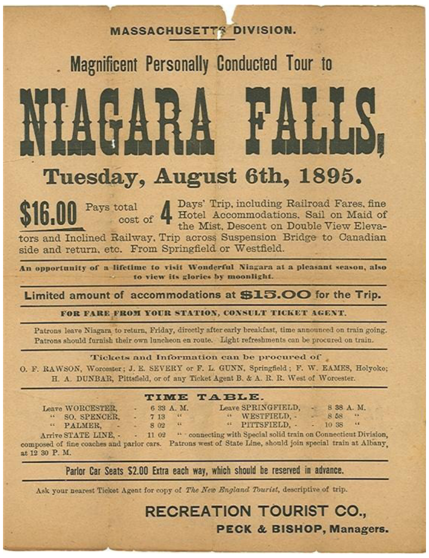
(a) (b)

Figura 6.6. (a) Intima Theater de Strindberg em Estocolmo; (b) Biblioteca privada de Alfred Nobel em Björkborn Manor, Karlskoga, Suécia.

O enorme interesse de Alfred Nobel pela literatura e pela escrita reflete-se nas suas coleções de livros. Após a sua morte, deixou uma biblioteca privada com mais de 1500 volumes, a maioria ficção na língua original, obras dos grandes escritores do século XIX, mas também os clássicos e obras de filósofos, teólogos, historiadores e outros cientistas.

7. Quem foi o designer do "Aero Car" nas Cataratas do Niágara?

As Cataratas do Niágara são algumas das maiores, mais belas e famosas quedas de água do mundo. Elas são constituídas por um grupo de três quedas de água no extremo sul do Desfiladeiro do Niágara, abrangendo a fronteira entre a província de Ontário, no Canadá, e o estado de Nova Iorque, nos Estados Unidos. As Cataratas são formadas pelo rio Niágara, que drena o Lago Erie para o Lago Ontário. As Cataratas do Niágara são famosas pela sua beleza e são uma valiosa fonte de energia hidroelétrica. O equilíbrio dos usos recreativos, comerciais e industriais tem sido um desafio para os administradores das quedas desde o século XIX.



(a)

(b)

Figura 7.1. (a) Anúncio das Cataratas do Niágara, 1895; (b) Vista panorâmica das Cataratas do Niágara.

Uma das principais atrações turísticas das Cataratas do Niágara é o Whirlpool Aero Car, um passeio inesquecível sobre as águas vibrantes do rio Niagara. Vislumbra-se vistas espetaculares do redemoinho do Niagara Whirlpool e das corredeiras do rio.

(a)

(b)

Figura 7.2. (a) Vista panorâmica do Aero-Car; (b) Carro do Aero-Car.

Em 1913, o Niagara Parks foi abordado por um grupo de empresários espanhóis interessados em construir um novo teleférico que levaria os visitantes através do Whirlpool do Niagara. Proporcionaria uma perspetiva inteiramente nova do desfiladeiro com vistas abertas sobre o fenômeno natural abaixo.

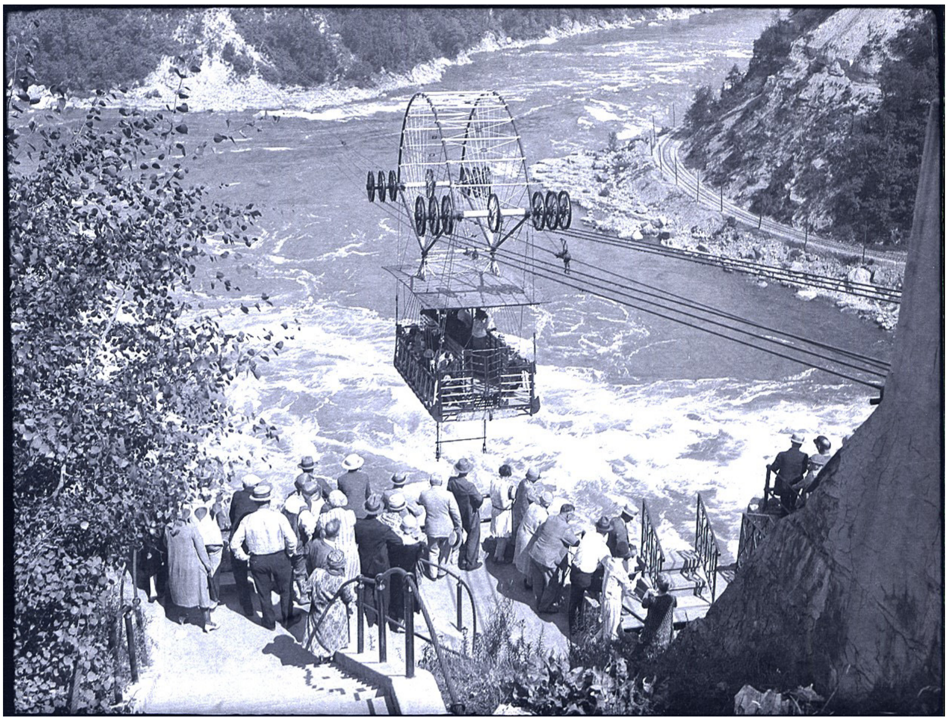
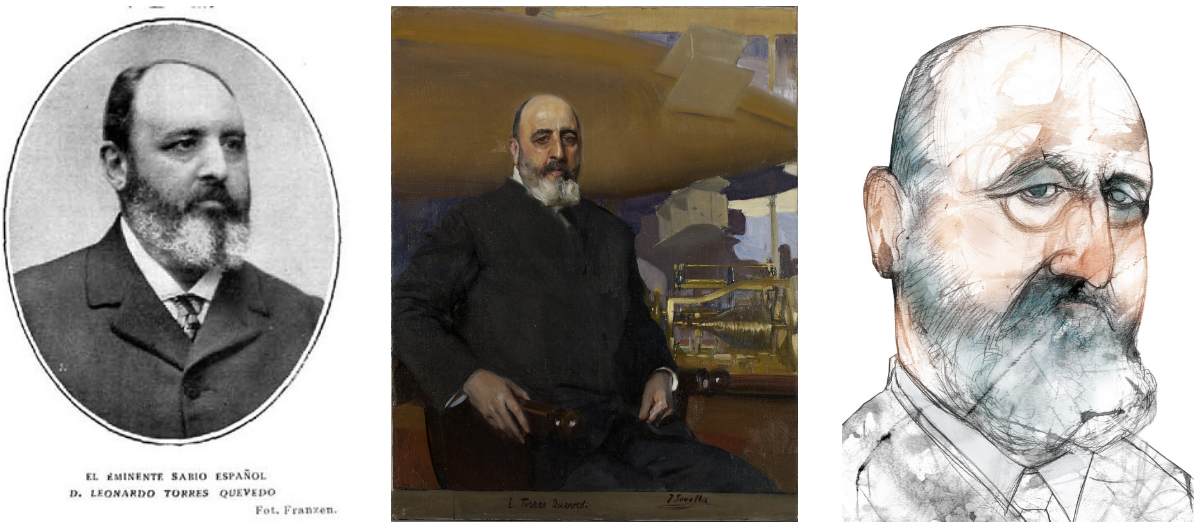


Figura 7.3. Aero-Car em 1926.

Quem foi o designer do "Aero Car" nas Cataratas do Niágara?

O autor foi Leonardo Torres Quevedo (1852 – 1936), engenheiro civil e matemático espanhol do final do século XIX e início do século XX. Torres foi pioneiro no desenvolvimento das máquinas de controle por rádio e de cálculo automatizado, bem como nos princípios de operação de controle remoto sem fios. Foi também um inovador projetista de dirigíveis e cabos aerostáticos, como o Whirlpool Aero Car localizado nas Cataratas do Niágara. Foi autor de um grande número de patentes em todo o mundo.

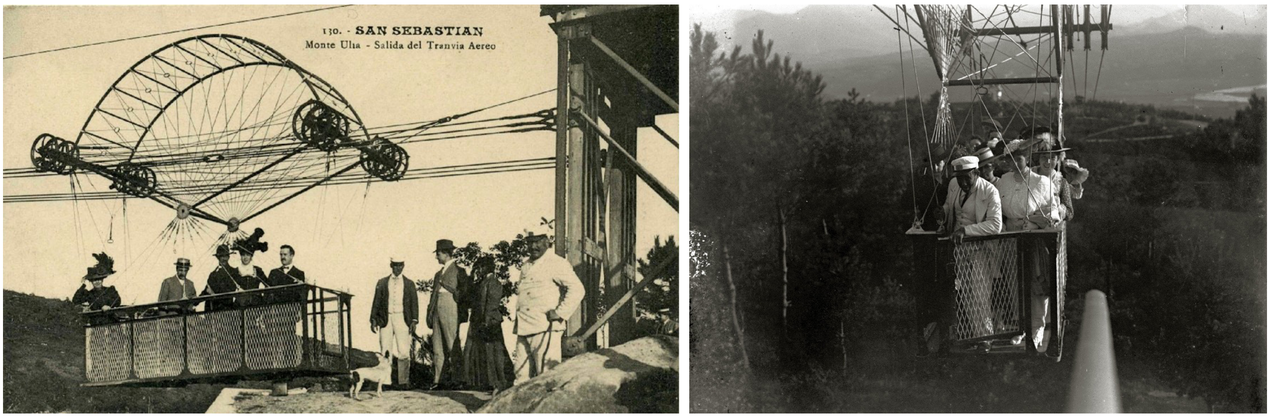


(a) (b) (c)

Figura 7.4. Leonardo Torres Quevedo. (a) Fotografía de C. Franzen, 1916 (b) Retrato por J. Sorolla, 1917; (c) Retrato por E. Merle, FECYT, 2011.

Recebeu inúmeras honrarias em reconhecimento dos seus serviços à ciência e à sociedade. Foi Presidente da Real Academia de Ciências Exatas, Físicas e Naturais em Madrid em 1910. Em 1920, ingressou na Real Academia Espanhola e na Academia Francesa de Ciências. Foi nomeado Doutor Honoris Causa da Sorbonne em Paris em 1922.

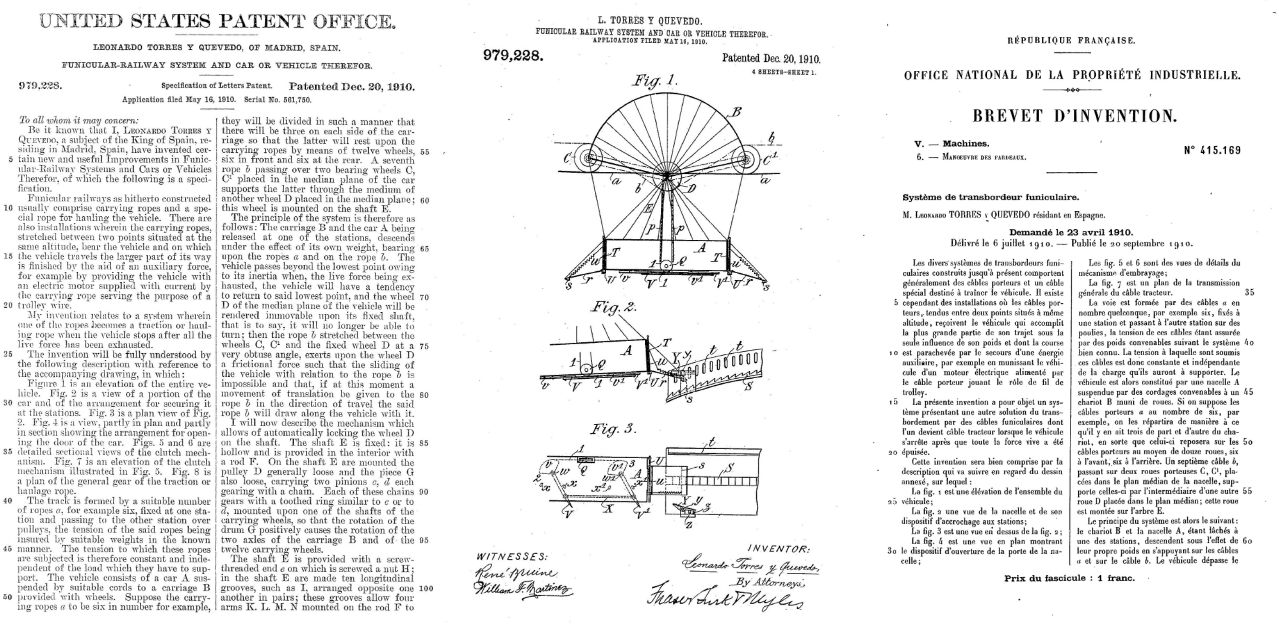
A experimentação de Torres na área dos cabos e teleféricos começou já em 1887. Em 1907, Torres construiu o primeiro cabo adequado para o transporte público de pessoas, no monte Ulía em San Sebastián, Espanha. O problema da segurança foi resolvido através de um sistema engenhoso de múltiplos cabos de apoio. O projeto resultante foi muito forte e resistiu perfeitamente à ruptura de um dos cabos de suporte.



(a) (b)

Figura 7.5. Teleférico de Monte Ulía, San Sebastián. (a)1907; (b) 1916.

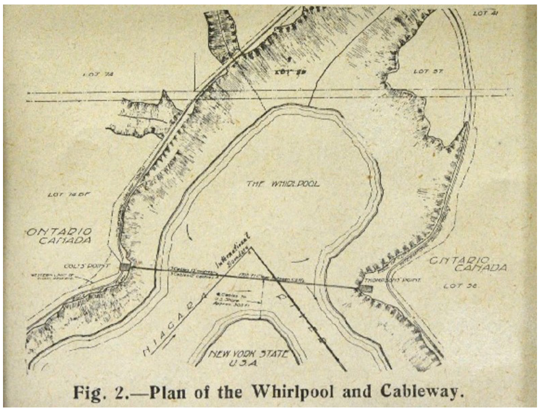
Projetado e patenteado pelo engenheiro espanhol, o Whirlpool Aero Car tem subido no Desfiladeiro do Niágara desde 1916. Desenhou a tração seguindo os princípios da instalação semelhante em San Sebastián.



(a) (b) (c)

Figura 7.6. Patentes para o teleférico Torres Quevedo, 1910. (a) Patente US979228A (b) Patente US979228A, esquema; (c) Patente FR415169A.

Embora viaje entre dois pontos na costa canadense, este antigo teleférico irá levá-lo através da fronteira internacional entre o Canadá e os Estados Unidos um total de quatro vezes devido à forma das curvas do rio. O carro transportaria até 40 passageiros de cada vez e seria suspenso 76 metros acima da água por uma série de cabos de aço. A tensão das linhas de cabo era para ser mantida por um contrapeso de 10 toneladas alojado no seu terminal Thompson Point. O carro é alimentado por um motor elétrico de 37 kW e viaja a aproximadamente 7 km/h.



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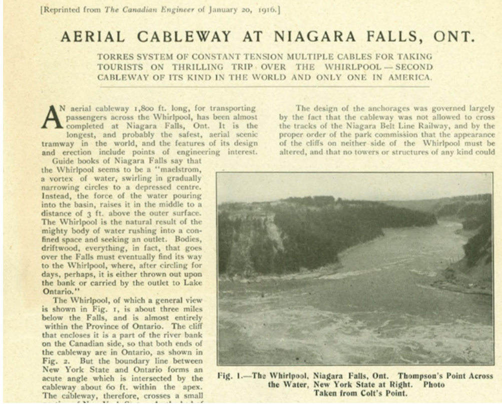

[Reprinted from *The Canadian Engineer* of January 20, 1916.]

AERIAL CABLEWAY AT NIAGARA FALLS, ONT.

TORRES SYSTEM OF CONSTANT TENSION MULTIPLE CABLES FOR TAKING TOURISTS ON THRILLING TRIP OVER THE WHIRLPOOL — SECOND CABLEWAY OF ITS KIND IN THE WORLD AND ONLY ONE IN AMERICA.

AN aerial cableway 1,800 ft. long, for transporting passengers across the Whirlpool, has been almost completed at Niagara Falls, Ont. It is the longest, and probably the safest, aerial scenic tramway in the world, and the features of its design and erection include points of engineering interest.

Guide books of Niagara Falls say that the Whirlpool seems to be a "maelstrom, a vortex of water, swirling in gradually narrowing circles to a depressed centre. Instead, the force of the water pouring into the basin, raises it in the middle to a distance of 3 ft. above the outer surface. The Whirlpool is the natural result of the mighty body of water rushing into a confined space and seeking an outlet. Bodies, driftwood, everything, in fact, that goes over the Falls must eventually find its way to the Whirlpool, where, after circling for days, perhaps, it is either thrown out upon the bank or carried by the outlet to Lake Ontario."

The Whirlpool, of which a general view is shown in Fig. 1, is about three miles below the Falls, and is almost entirely within the Province of Ontario. The cliff that encloses it is a part of the river bank on the Canadian side, so that both ends of the cableway are in Ontario, as shown in Fig. 2. But the boundary line between New York State and Ontario forms an acute angle which is intersected by the cableway about 60 ft. within the apex. The cableway, therefore, crosses a small

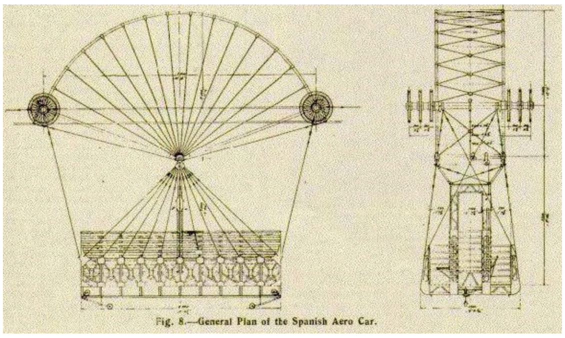
The design of the anchorages was governed largely by the fact that the cableway was not allowed to cross the tracks of the Niagara Belt Line Railway, and by the proper order of the park commission that the appearance of the cliffs on neither side of the Whirlpool must be altered, and that no towers or structures of any kind could

Fig. 1.—The Whirlpool, Niagara Falls, Ont. Thompson's Point Across the Water, New York State at Right. Photo Taken from Colt's Point.

(b)

Figura 7.7. (a) Mapa da rota do Aero-Car entre o Canadá e os Estados Unidos; (b) Notícias do Aero-Car em *The Canadian Engineer*, 1916.

A construção começou em 1915 e as operações iniciaram a em 8 de agosto de 1916. Os primeiros passageiros incluíam dignitários espanhóis, e o carro foi adornado com bandeiras de quatro nações, Canadá, Espanha, Estados Unidos e França. Em 1984, a atração sofreu melhorias substanciais para modernizar os seus componentes mecânicos. No entanto, a carruagem não foi alterada, com o intuito de preservar a sua integridade histórica. Por mais de 100 anos, sem acidentes dignos de menção, o histórico Whirlpool Aero Car tem oferecido aos passageiros vistas espetaculares do redemoinho Niagara Whirlpool e das corredeiras de águas brancas do rio Niágara.



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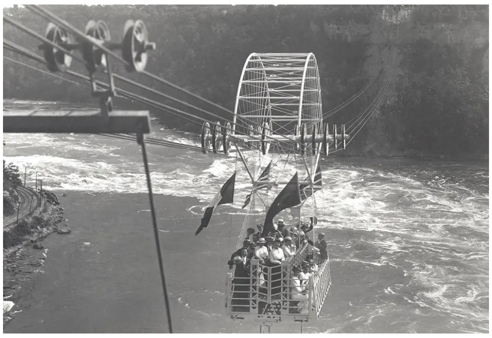
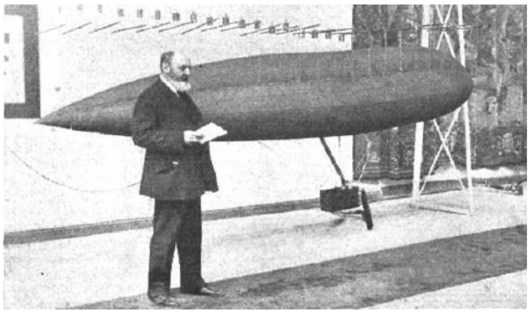


(b)

Figura 7.8. (a) Mapa do Aero-Car de Torres Quevedo; (b) Inauguração do Aero-Car.

Outras obras de Torres Quevedo diziam foram relacionadas ao projeto e à construção de dirigíveis aerostáticos. Desde 1902, desenvolveu um novo tipo de dirigível com uma estrutura interna de cabos flexíveis que dava rigidez ao dirigível através da pressão interior. Em 1905, construiu o primeiro dirigível espanhol para o Exército e, desde 1911, começou a colaboração entre Torres e a companhia francesa Astra. Os dirigíveis Astra-Torres foram amplamente utilizados durante a Primeira Guerra Mundial, principalmente para proteção naval e inspeção.



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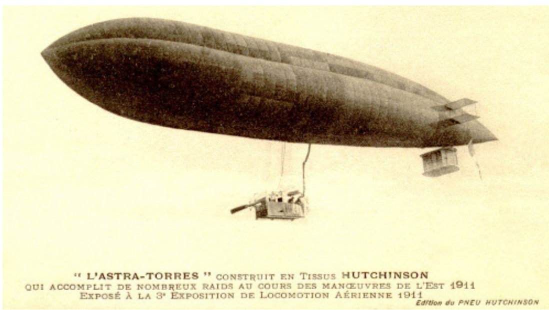


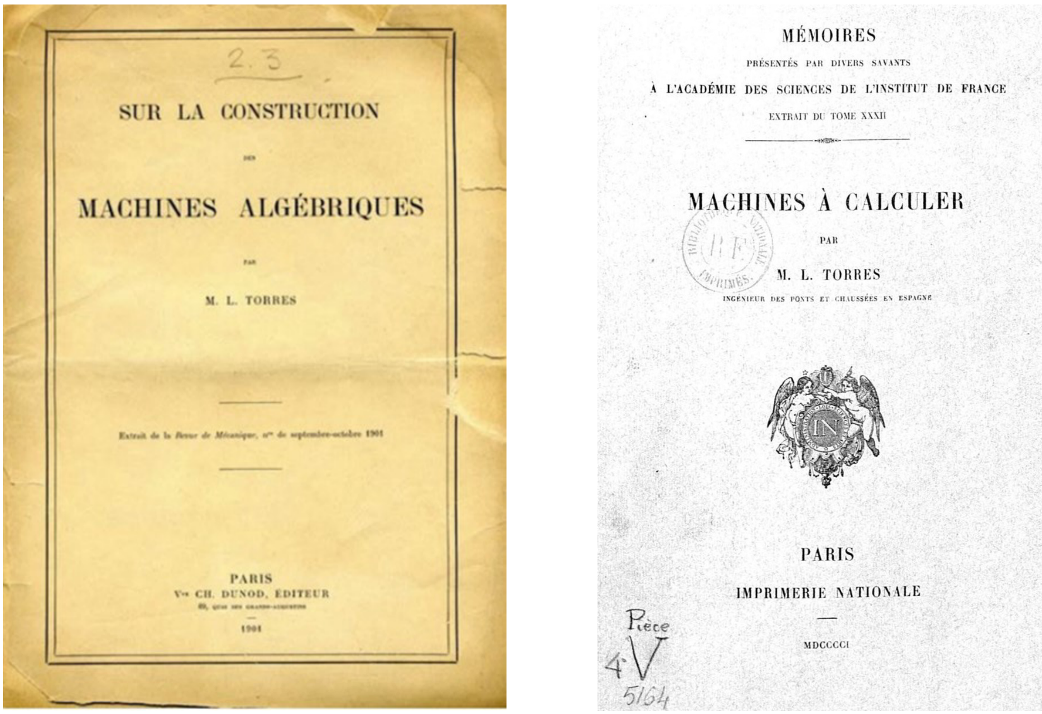
(b)

Figura 7.9. (a) Torres Quevedo e o seu dirigível; (b) Dirigível Astra-Torres, 1911.

Torres também foi pioneiro no campo do controle remoto. Em 1903, apresentou o Telekino na Academia Francesa de Ciências. O Telekino consistia de um robô que executava comandos transmitidos por ondas eletromagnéticas. Foi patenteado em França, Espanha, Grã-Bretanha e Estados Unidos. Em 2007, o prestigiado Instituto de Engenheiros Eletricistas e Eletrônicos dedicou um marco em Engenharia Elétrica e de Computação ao Telekino.

Figura 7.10. Placa comemorativa da IEEE.

Finalmente, de todo o trabalho realizado por Torres Quevedo ao longo da sua vida, a sua fama mais universal deve-se, provavelmente, ao seu trabalho em "automáticas". Ele fez importantes contribuições para máquinas algébricas - os antecessores de computadores analógicos - e máquinas aritméticas - os antecessores dos computadores digitais modernos



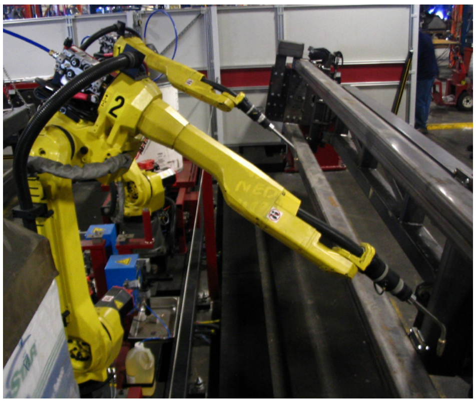
(a) (b)

Figura 7.11. Publicações de Torres Quevedo (a) Machines Algébriques, 1901; (b) Machines à calculer, 1901.

Em 1900, apresentou na Academia Francesa de Ciências um relatório com uma solução teórica geral e completa para estas máquinas. Também construiu alguns dispositivos eletromecânicos capazes de fazer cálculos matemáticos.

8. Quem é considerado o "pai da robótica"?

A robótica é um ramo interdisciplinar da ciência da computação e da engenharia. Envolve a concepção, construção, operação e utilização de robôs que podem ajudar e assistir os seres humanos. Os robôs podem ser usados em muitas situações para diferentes fins: processos de fabricação, exploração espacial, prótese humana ou cirurgia assistida por robô. E alguns deles se assemelham aos humanos na aparência



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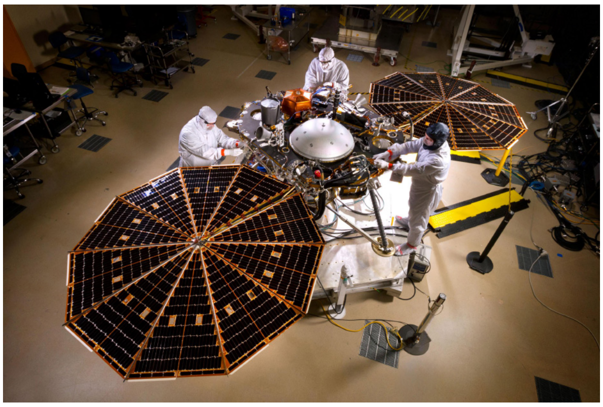

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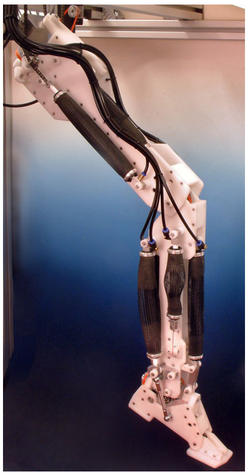

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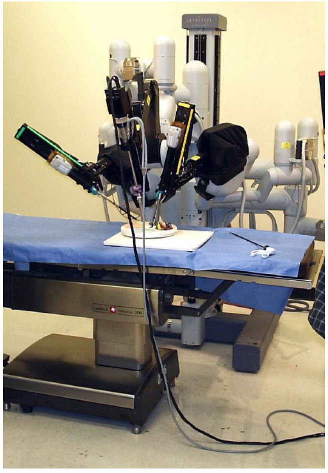

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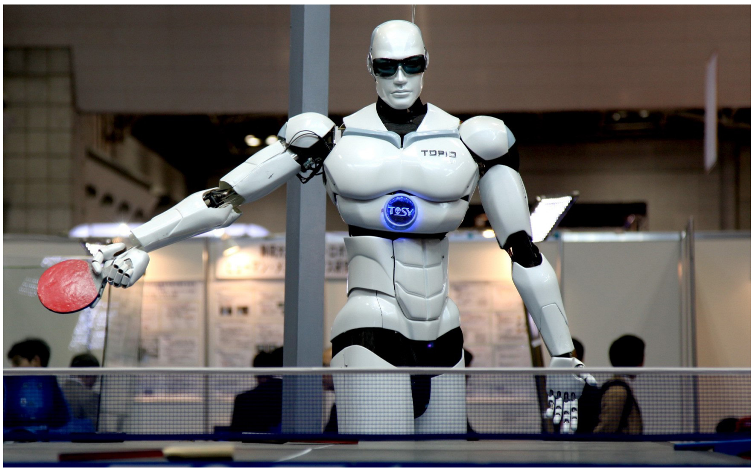


(e)

Figura 8.1. (a) Robô de soldadura; (b) Robô de exploração espacial; (c) Próteses robóticas; (d) Cirurgia robótica assistida; (e) Robô humanoide.

Na Europa, desde a Idade Média, há muitos exemplos de autômatos, os antecessores dos robôs. Eles incluem vários relógios astronômicos mecânicos com figuras de autômatos que começaram a aparecer no século 14. Um dos mais famosos é o relógio astronômico de Praga, anexo à Antiga Câmara Municipal de Praga, a capital da República Checa. O relógio foi instalado pela primeira vez em 1410, tornando-se o terceiro relógio astronômico mais antigo do mundo e o relógio mais antigo ainda em funcionamento. Outro está na Catedral de Santa María em Burgos, Espanha. Chama-se Papamoscas, um autômato articulado que abre a boca para dar o badalar das horas.

(a)

(b)

(c)

Figura 8.2. (a) Relógio Astronómico de Praga, República Checa; (b) Relógio Glockenspiel em Graz, Áustria; (c) Relógio Papamoscas, Catedral de Burgos, Espanha.

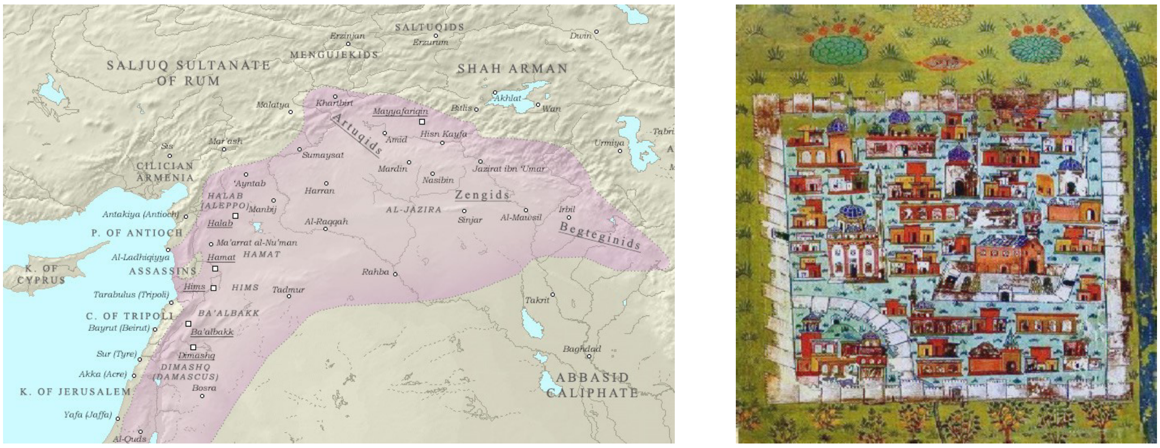
Mas, serão estes autômatos, antecessores dos robôs modernos, os primeiros da história?

A ideia de autômatos tem origem nas mitologias de muitas culturas ao redor do mundo. Engenheiros e inventores de civilizações antigas, incluindo China, Grécia, Índia, Pérsia e Egito, tentaram construir máquinas autooperantes, algumas semelhantes a animais e humanos. A maioria delas foi concebida como mágicas ou brinquedos para o entretenimento de reis e imperadores.

Mas, no século 13, engenheiros do Oriente Médio produziram autômatos para manipular o ambiente para o conforto humano. Além de preservar, divulgar e desenvolver o trabalho dos gregos, sua maior contribuição foi o conceito de aplicação prática.

Um desses engenheiros do Oriente Médio é considerado hoje o "pai da robótica".

Ismail Al Jazari (1136 - 1206) oi um polímata do Oriente Médio: erudito, inventor, engenheiro mecânico, artesão, artista e matemático. Ele nasceu na área da Alta Mesopotâmia e serviu como engenheiro-chefe da dinastia Artuqids, um reino regional, para quem projetou mais de uma centena de engenhosos dispositivos. Passou quase 25 anos em Diyarbakir, nas margens do rio Tigris.



(a) (b)

Figura 8.3. (a) Mapa do reino regional de Artuquids dentro do sultanato Aiúbida, c. 1193; (b) Mapa do Diyarbakir, séc. XVI.

Em 1206, ele deu ao mundo um catálogo de suas máquinas incomparáveis, conhecido hoje como O Livro do Conhecimento de Engenhosos Dispositivos Mecânicos. Al Jazari continua a descrever as melhorias que ele fez no trabalho de seus antecessores, e descreve uma série de dispositivos, técnicas e componentes que são inovações originais que não aparecem nos trabalhos anteriores. Ele apenas descreve dispositivos que ele mesmo construiu. O estilo do livro assemelha-se ao de um livro moderno "faça você mesmo".

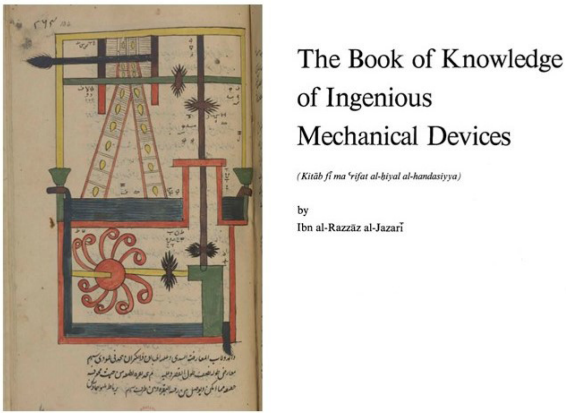


Figura 8.4. The Book of Knowledge of Ingenious Mechanical Devices.

Seu projeto de um barco com quatro músicos - um harpista, um flautista e dois bateristas - destinado a tocar músicas é considerado por muitos como o primeiro robô programável da história. Tinha uma bateria programável com excêntricos que esbarram em pequenas alavancas que operavam a percussão. O baterista poderia ser obrigado a tocar ritmos diferentes e padrões de bateria diferentes se os excentricos fossem movidos.

(a) (b) (c)

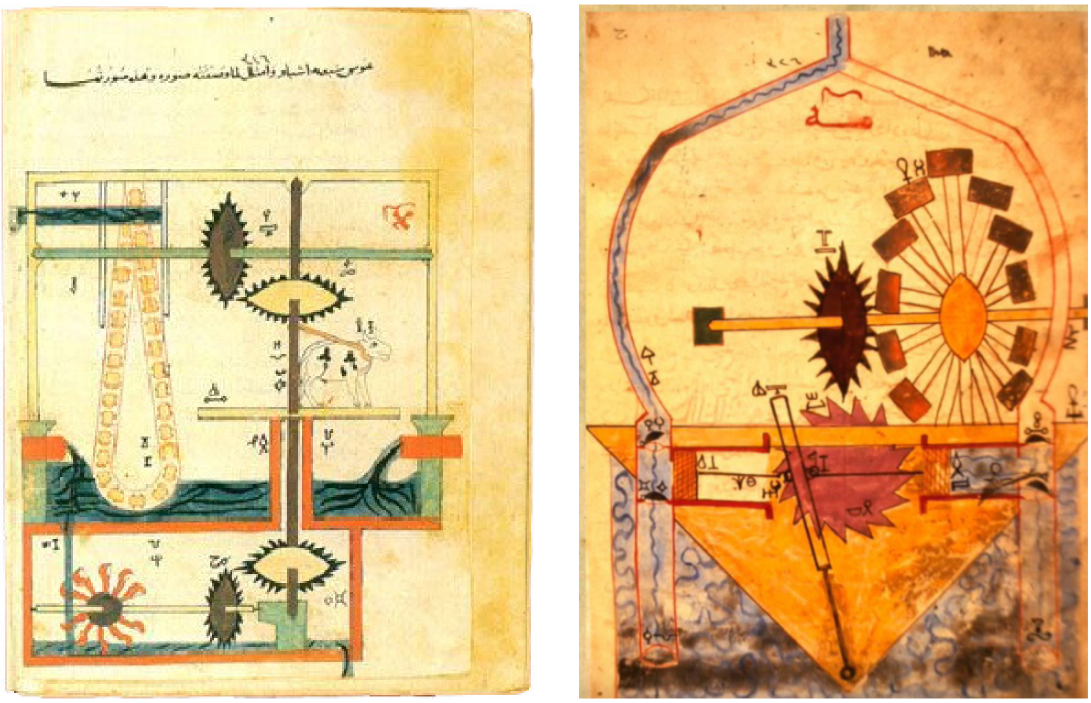
Figura 8.5. Al Jazari Autômato. (a) Autômato musical; (b) Autômato musical com mecanismo; c) Mecanismo de excentricos.

Outros autômatos eram um relógio de água dos bateristas, um autômato de lavagem das mãos com mecanismo de descarga e uma fonte de pavão com servos automatizados

(a) (b) (c)

Figura 8.6. Al Jazari Autômato. (a) Relógio de água dos percussionistas; (b) Autômato para lavagem das mãos; (c) Fonte do pavão.

Al Jazari inventou cinco máquinas para elevar a água, bem como moinhos de água e rodas d'água com excêntricos em seu eixo usados para operar os autômatos. Foi nestas máquinas de elevação de água que introduziu as suas ideias mais importantes e componentes de novos mecanismos.



(a) (b)

Figura 8.7. Al Jazari Autômato. (a) Saqiya (cadeia de vasos); (b) Bomba de sucção de dupla ação com válvulas e movimento alternativo do êmbolo.

Outras invenções foram uma diversidade de relógios: o relógio de velas, o relógio de elefante e o relógio do castelo.

(a) (b) (c)

Figura 8.8. Al Jazari Autômato. a) Relógio de velas; b) Relógio de elefante; (c) Relógio do castelo.

Além de suas realizações como inventor e engenheiro, Al Jazari também foi um artista. Em *The Book of Knowledge of Ingenious Mechanical Devices*, ele deu instruções de suas invenções e as ilustrou usando pinturas em miniatura, um estilo medieval da arte islâmica.

Ele é lembrado principalmente por este livro, mas suas invenções desempenhariam um papel fundamental na vida civil por muitos anos. A maioria das suas inovações esteve séculos à frente das realizações da ciência europeia. Muitos autores de história da tecnologia mencionam que, dois séculos depois, o inventor renascentista italiano Leonardo da Vinci pode ter sido influenciado pelos autômatos clássicos de Al Jazari ao projetar seus próprios autômatos.

Figura 8.9. Modelo de robô de Leonardo da Vinci com funcionamento interno. Possivelmente construído por Leonardo da Vinci c. 1495.

As máquinas automáticas fabricadas por Al Jazari formaram as pedras angulares das ciências mecânicas e cibernéticas de hoje. Al Jazari criou marcos da tecnologia de hoje, usando a ciência e a tecnologia de uma forma extraordinária de acordo com as condições da época, dando as bases da ciência de controle automático de hoje.

9. Quem foi o inventor da panela de pressão?

Provavelmente, temos uma panela de pressão na nossa cozinha. É um recipiente hermético que aumenta a velocidade de cozimento de alguns alimentos, reduzindo o tempo necessário para a sua preparação e reduzindo consideravelmente o seu consumo de energia. O cozimento sob pressão é o processo de cozimento de alimentos com vapor e água sob alta pressão, ou em um líquido de cozimento à base de água. Geralmente, leva vários minutos para que a panela de pressão atinja as condições de cozimento desejadas. Em alguns modelos, o peso do regulador de pressão começa a levitar acima do bico, permitindo que o excesso de vapor escape.

(a) (b)

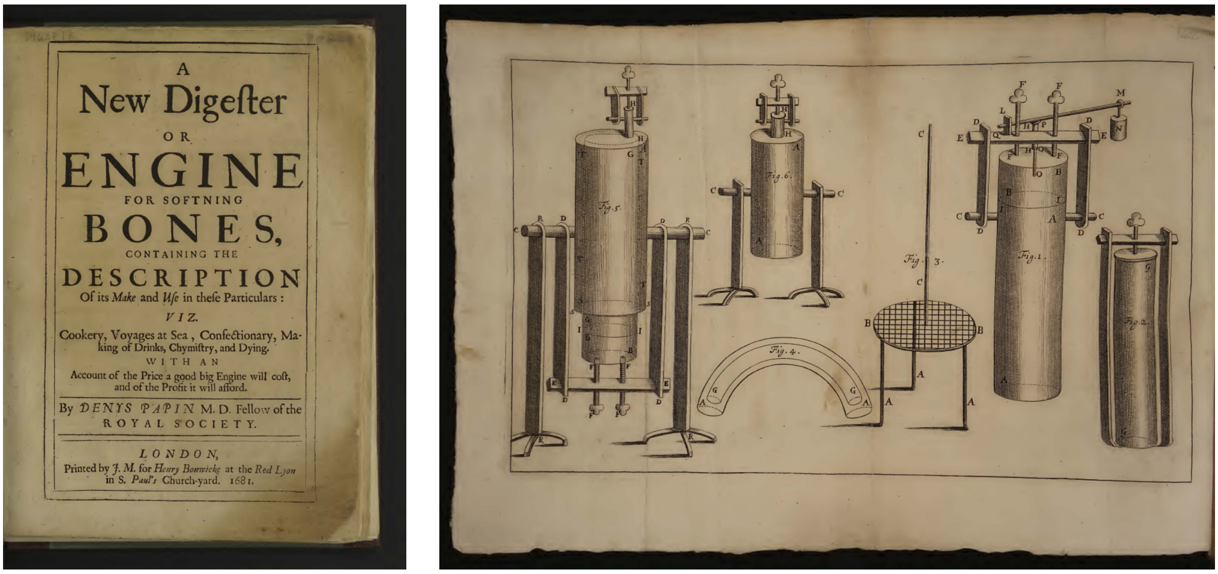
Figura 9.1. Panela de pressão. (a) Componentes: recipiente, tampa e válvula; (b) Conjunto.

Quem foi o inventor da panela de pressão?

O inventor da panela de pressão foi Denis Papin, um físico, matemático, engenheiro e inventor francês. Em 1669, obteve um diploma em medicina na Universidade de Angers, mas nunca exerceu esta profissão; dedicou-se ao estudo da física e das máquinas. Viveu na França, na Inglaterra e na Alemanha, sendo um dos principais cientistas e inventores do seu tempo.

Figura 9.1. Denis Papin, 1689.

Em 1680, Papin apresentou a sua invenção do Digestor a Vapor à Royal Society of London como um estudo científico. Mais tarde, foi eleito membro da Sociedade. Em 1681, surgiu em Londres um primeiro livro de memórias, para relatar a primeira série de experiências realizadas com esta máquina, intitulada *A New Digester or Machine for Softening Bones*, contendo a descrição da sua construção e utilização. Ele funciona expelindo ar do recipiente e retendo o vapor produzido a partir do líquido em ebulição.



(a) (b)

Figura 9.3. (a) Página da edição inglesa de 1681, *Steam Digester*; (b) desenhos do *Steam Digester*.

À pressão padrão, o ponto de ebulição da água é de 100°C. Com qualquer alimento que contenha ou seja cozido com água, uma vez que a temperatura atinja o ponto de ebulição, qualquer excesso de calor faz com que parte da água se transforme em vapor de forma eficiente, mantendo a temperatura do alimento em 100°C.

Em uma panela de pressão hermética, quando a água ferve, o vapor fica preso na panela, o que aumenta a pressão. No entanto, o ponto de ebulição da água aumenta com a pressão. Em uma panela de pressão hermética, o volume e a quantidade de vapor são fixos, de modo que a temperatura pode ser controlada diretamente ajustando a pressão, com uma válvula de liberação de pressão. Por exemplo, se a pressão atingir 2 bar ou 200 kPa, a água terá atingido uma temperatura de cerca de 120°C, o que coze os alimentos muito mais rapidamente.

Panela de pressão, pressãos e temperaturas

Total pressão	Pressão manométrica em relação à atmosfera	Temperatura	Tempo de cozedura aproximado versus ebulição
1.0 bar	**0.0 bar**	**100ºC (212ºF)**	**100%**
1.1 bar	0.1 bar	103ºC (217ºF)	80%
1.2 bar	0.2 bar	105ºC (221ºF)	70%
1.3 bar	0.3 bar	107ºC (225ºF)	61%
1.4 bar	0.4 bar	110ºC (230ºF)	50%
1.5 bar	0.5 bar	112ºC (234ºF)	43%
1.6 bar	0.6 bar	114ºC (237ºF)	38%
1.7 bar	0.7 bar	116ºC (241ºF)	33%
1.8 bar	0.8 bar	117ºC (243ºF)	31%
1.9 bar	0.9 bar	119ºC (246ºF)	27%
2.0 bar	**1.0 bar**	**121ºC (250ºF)**	**23%**

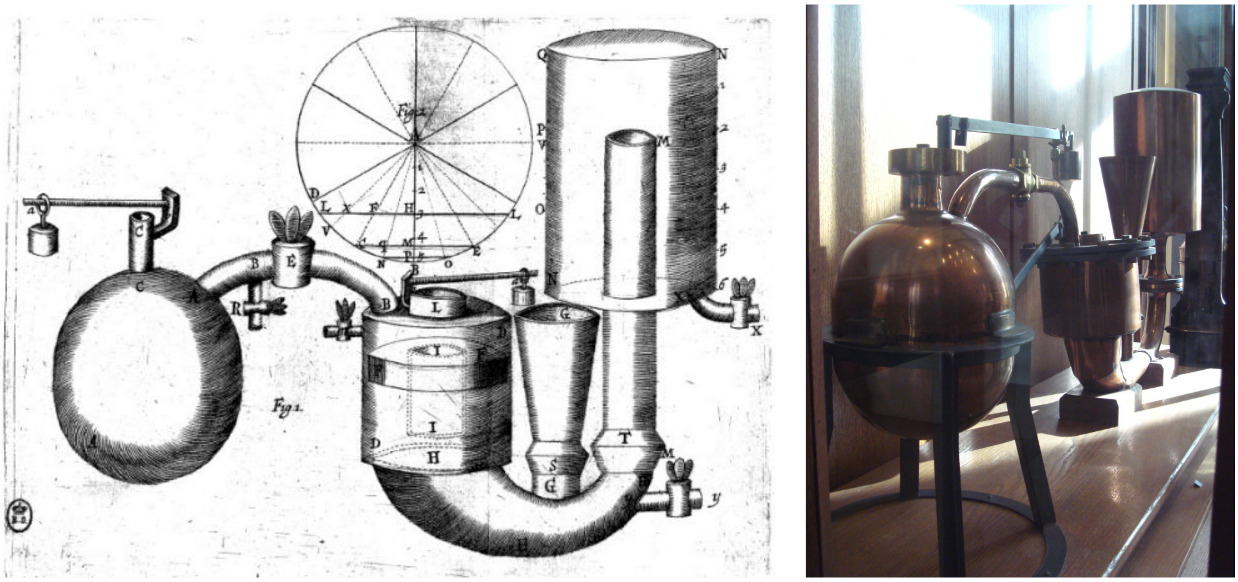
Figura 9.4. Evolução da temperatura de ebulição da água com pressão.

Mesmo que, naquela época, não houvesse possibilidade de transformar esta invenção num produto de uso geral pelas pessoas, o seu projeto design foi a base das primeiras panelas de pressão que, no início do século XX, começaram a fazer parte dos utensílios habituais nas nossas cozinhas.

(a) (b) (c)

Figura 9.5. (a) Panela de pressão, finais do século XVIII; (b) Panela de pressão, c. 1864; (c) Super Cocotte, 1973.

Ao longo de sua carreira, Papin inventou muitos outros dispositivos: uma máquina de elevação de água, uma máquina para combater incêndios, o primeiro sistema de pistão-cilindro a vapor, um modelo de um submarino movido a vapor e uma máquina a vapor para bombear água. Este motor é contemporâneo das primeiras máquinas a vapor britânicas operacionais do início do século XVIII.



(a) (b)

Figura 9.6. Máquina a vapor de Papin. (a) esquema, c. 1705; (b) Reconstrução.

Ao longo da sua carreira, Denis Papin colaborou com outros grandes cientistas do seu tempo, como Christiaan Huygens, Gottfried Leibniz e Robert Boyle

10. Mais pesado que o ar: primeiro pioneiro na Europa.

Muitas histórias da antiguidade envolvem o desejo de voar, como a lenda grega de Ícaro e Dédalo, e o Vimana em antigos épicos indianos. Algumas das primeiras tentativas registradas com planadores foram as do poeta andaluz e de língua árabe Abbas ibn Firnas do século 9 e do monge inglês do século XI Eilmer de Malmesbury. Leonardo da Vinci pesquisou o design das asas das aves e projetou uma aeronave movida pelo homem.

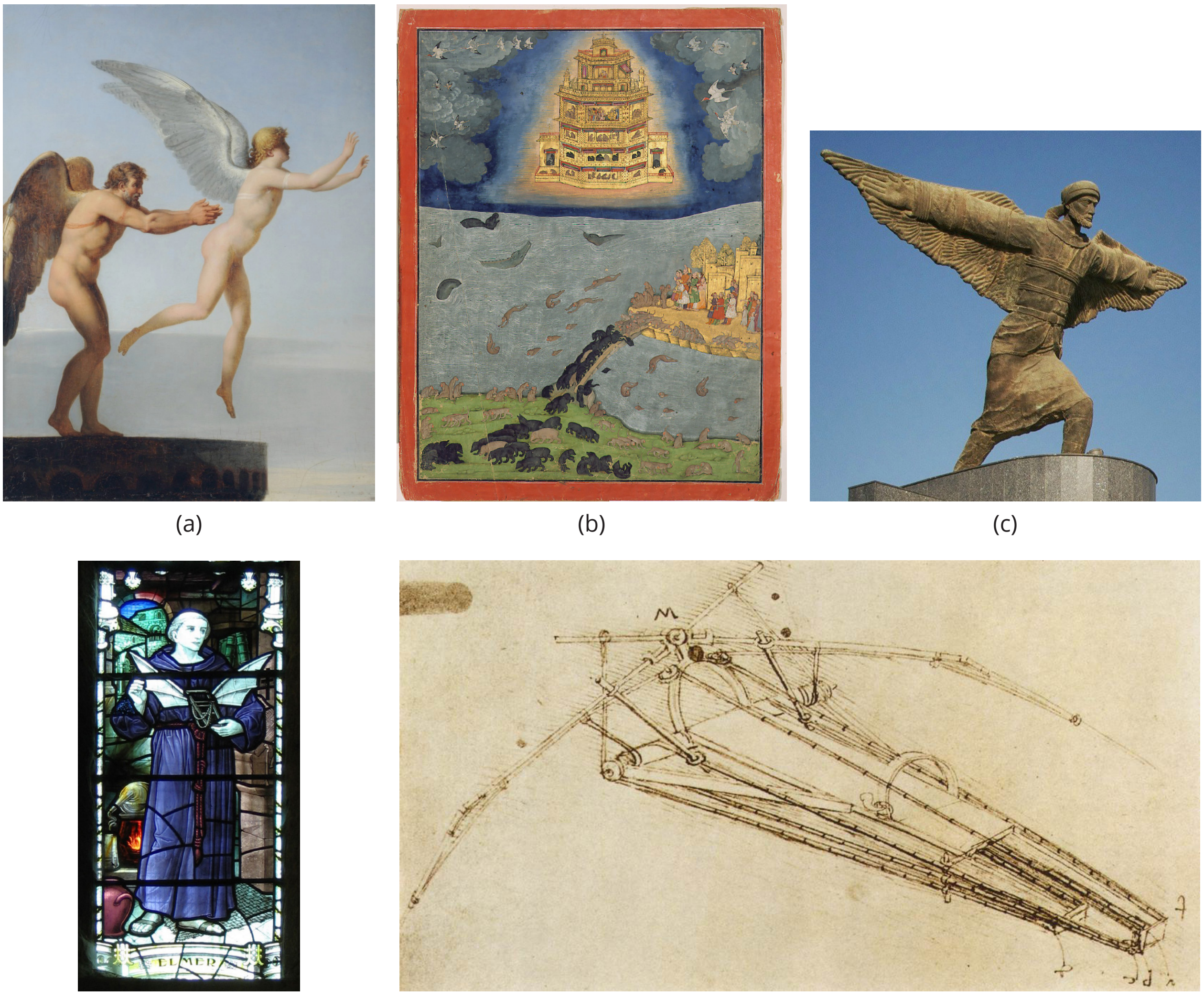


Figura 10.1. (a) Ícaro e Dédalo, Musée des Beaux-Arts et de la Dentelle d'Alençon; (b) A carruagem celestial Vimana, ilustração do Ramayana; (c) Estátua de Ibn Firnas no aeroporto de Bagdá; (d) Monge Eilmer, Malmesbury Abbey; (e) Leonardo da Vinci, máquina voadora.

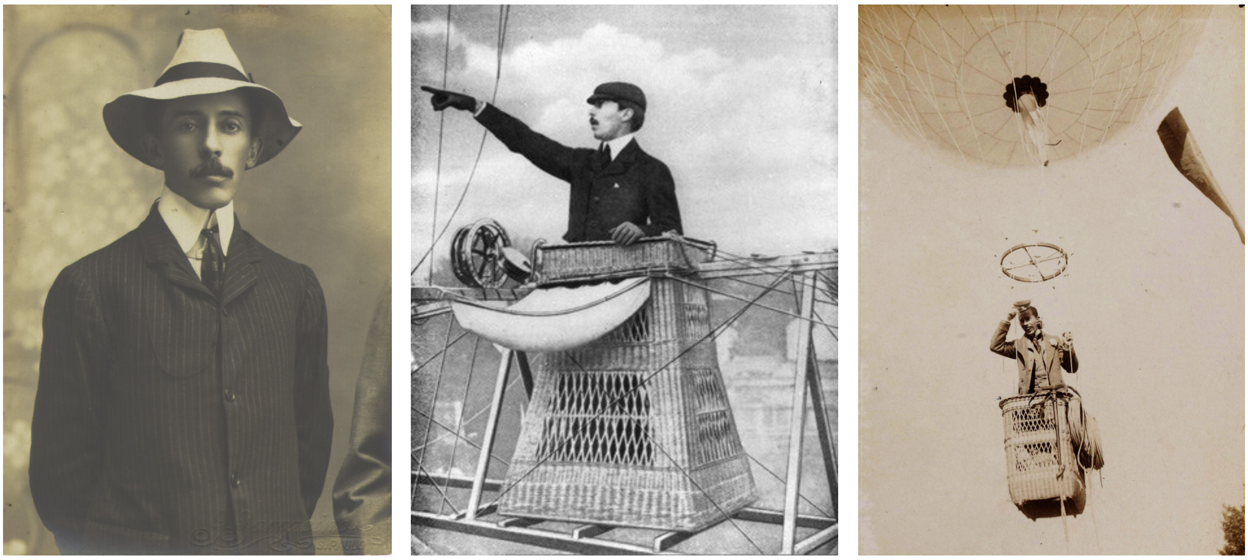
Desde então, muitos pioneiros da aviação contribuíram para o desenvolvimento de aviões práticos. Os aviões modernos são uma máquina voadora de asa fixa com sistemas separados para elevação, propulsão e controle.

Os irmãos Wright, Orville e Wilbur Wright, foram pioneiros da aviação americana geralmente creditados por inventar, construir e pilotar o primeiro avião de sucesso do mundo. A invenção inovadora dos irmãos foi a criação de um sistema de controle de três eixos, que permitia ao piloto dirigir a aeronave de forma eficaz e manter seu equilíbrio. O primeiro voo de Orville Wright, de 37 metros em 12 segundos, fez o primeiro voo tripulado controlado e motorizado mais pesado do que o ar em Kitty Hawk, Carolina do Norte, em 17 de dezembro de 1903. Em seus primeiros voos, os irmãos Wright usaram trilhos guia e uma catapulta para tirá-lo do chão.

Figura 10.2. Primeiro voo dos irmãos Wright em Kitty Hawk, Carolina do Norte, em 17 de dezembro de 1903.

Em 1906, o brasileiro Alberto Santos Dumont fez o que se dizia ser o primeiro voo de avião, decolando sem ajuda de um sistema de lançamento externo. Estabeleceu o primeiro recorde mundial reconhecido pelo Aéro-Club de France e pela Fédération Aéronautique Internationale ao voar 220 metros em menos de 22 segundos.

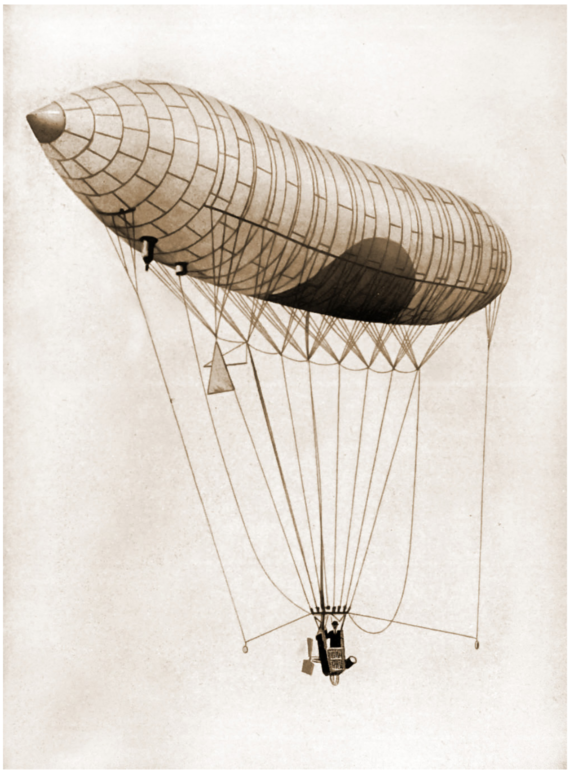
Alberto Santos Dumont foi um aeronauta, esportista e inventor brasileiro. Embora nunca tenha se formado, seguiu alguns cursos de engenharia e desenvolveu um admirável talento prático e mecânico e, desde então, de gênio inventivo. Muito jovem, destacou-se como alpinista e desportista automobilista. Aos 24 anos, Santos Dumont partiu para a França, onde passou a maior parte da vida adulta. Lá, tornou-se aeronauta profissional.



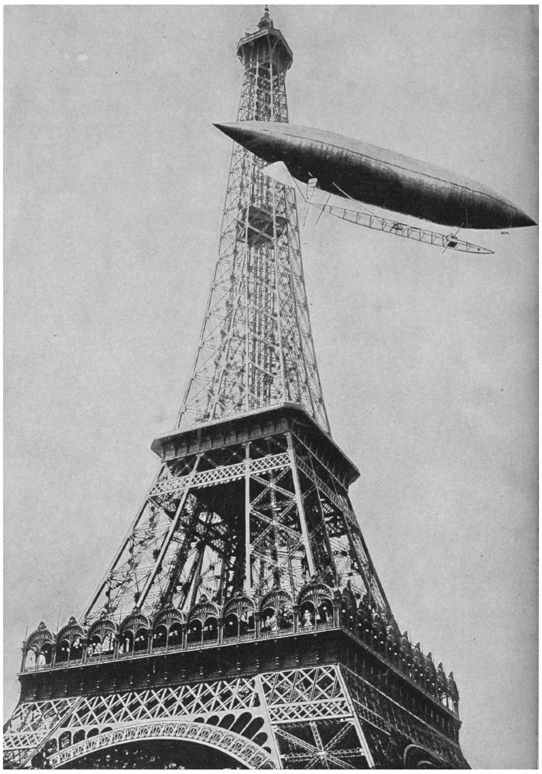
(a) (b) (c)

Figura 10.3. Alberto Santos Dumont (a) Retrato, 1903; (b) A bordo de um balão de ar quente; (c) Decolagem em 4 de julho de 1898 no Brasil.

De 1898 até 1903, ele construiu até 13 dirigíveis, mais leves que o ar, movidos por motores de combustão interna. Ele voou ao redor da Torre Eiffel em seus dirigíveis várias vezes, como parte de competições de dirigíveis.



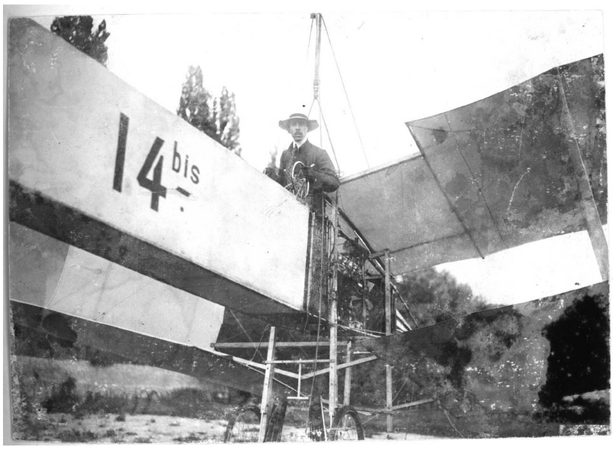
(a)



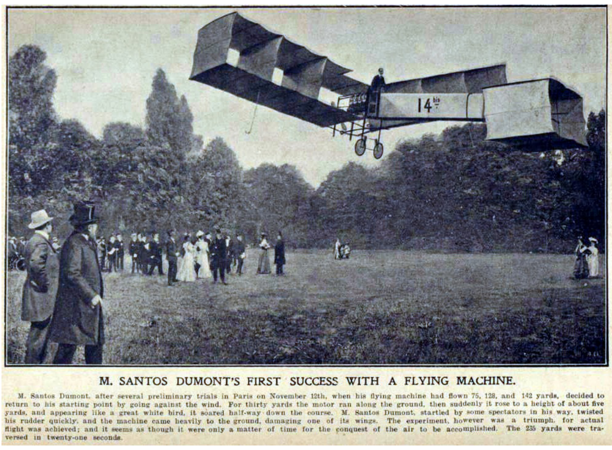
(b)

Figura 10.4. (a) Dirigível Santos Dumont Nº1, 1898; (b) Voo de Santos Dumont ao redor da Torre Eiffel.

Em 1904, vários prêmios de aviação foram criados na França, para estimular o desenvolvimento de aeronaves mais pesadas do que o ar. Decolagem, controle e pouso eram as grandes preocupações. A Fédération Aéronautique Internationale, criada em 1905, era responsável por registrar as manifestações oficiais. Depois de desenvolver vários protótipos, Santos Dumont apresentou o avião 14-bis, um biplano com duas superfícies octogonais inseridas como ailerons melhorando o controle, e o leme na frente, como a configuração dos irmãos Wright. Em 12 de novembro de 1906, ele foi capaz de voar 220 metros, por 21 segundos a uma velocidade média de 37,4 km/h.



(a)



(b)

Figura 10.5. (a) Santos Dumont no 14-bis; (b) Notícia do voo do 14-bis.

Santos Dumont continuou a desenvolver aviões, como o Demoiselle. Este avião foi concebido para competições desportivas, capaz de voar até 2 quilómetros e atingir os 96 km/h. Mais tarde, foi usado para treinamento de pilotos durante a Primeira Guerra Mundial.

(a) (b)

Figura 10.6. (a) Santos Dumont no *Demoiselle;* (b) Placa de Alberto Santos Dumont em Avenue des Champs-Élysées, Paris.

Em 19 de outubro de 1906, Santos Dumont venceu uma competição de voo sobre Paris com seu dirigível número 6. O prêmio foi-lhe entregue num jantar no famoso restaurante Maxim's. Lá conheceu o joalheiro, Louis Cartier. O joalheiro descobriu que o piloto não podia verificar seu relógio de bolso durante o voo porque precisava das duas mãos para pilotar o avião. Cartier projetou e presenteou Santos Dumont com um novo relógio de ouro, quadrado e plano, preso ao pulso graças a uma alça e fivela. Tinha acabado de criar o primeiro relógio de pulso masculino. Santos Dumont usou-o como cronômetro nos seus próximos voos. Este relógio, chamado Cartier-Santos, ainda é fabricado hoje.

(a) (b)

Figura 10.7. (a) Santos-Dumont, 1916; (b) Relógio Cartier-Santos.

11. Quem construiu a Ponte do Brooklyn?

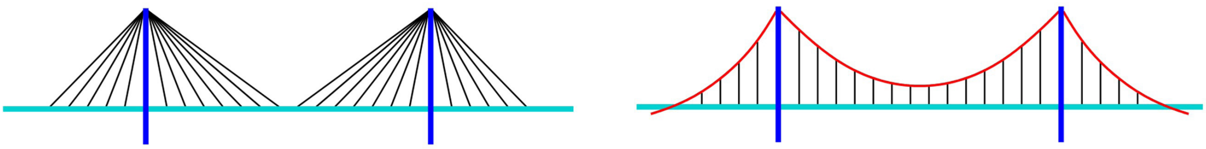
A Ponte do Brooklyn é um ícone da cidade de Nova York.

A ponte atravessa o East River entre os bairros de Manhattan e Brooklyn. Inaugurada em 24 de maio de 1883, a Ponte do Brooklyn foi a primeira travessia fixa do East River. Era também a ponte suspensa mais longa do mundo na altura da sua abertura, com um vão principal de 486 m e um deck 38 m acima da média de águas altas. A ponte foi originalmente chamada de New York and Brooklyn Bridge ou East River Bridge, mas foi oficialmente renomeada para Brooklyn Bridge em 1915.

(a) (b)

Figura 11.1. (a), (b) A ponte do Brooklyn em New York, entre Manhattan e Brooklyn.

A Ponte do Brooklyn é um emblema da engenharia do século XIX por causa de quão inovador era o uso do aço como um material de construção em grande escala na época. Utiliza um design híbrido de ponte suspensa/estaiada por cabo, com cabos suspensos verticais e diagonais. Foi a primeira ponte suspensa por cabos de aço. As suas torres de pedra são neogóticas, com arcos ogivais característicos.



(a) (b)

Figura 11.2. (a) Uma ponte estaiada tem uma ou mais torres, a partir das quais os cabos suportam o deck da ponte; (b) Uma ponte suspensa tem um tabuleiro que fica pendurado abaixo dos cabos de suspensão entre as torres, com cabos de suspensão verticais.

Originalmente, a ponte foi projetada para abrigar duas faixas duplas para carruagens e cavalaria nas extremidades, duas faixas de bonde no centro e uma plataforma elevada para pedestres. Atualmente é composta por seis faixas para carros, três em cada sentido.

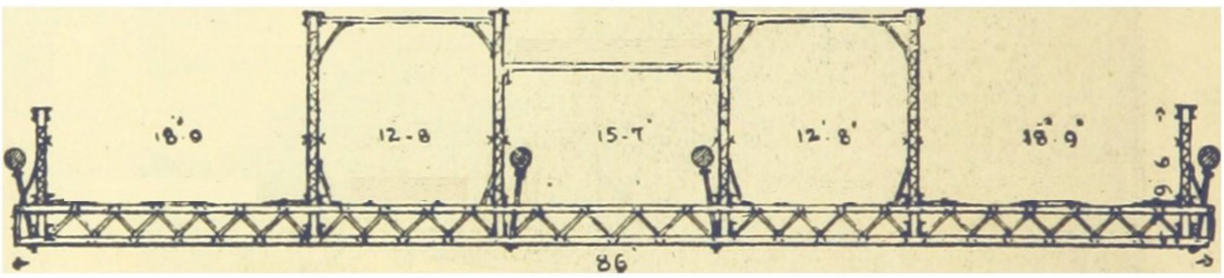
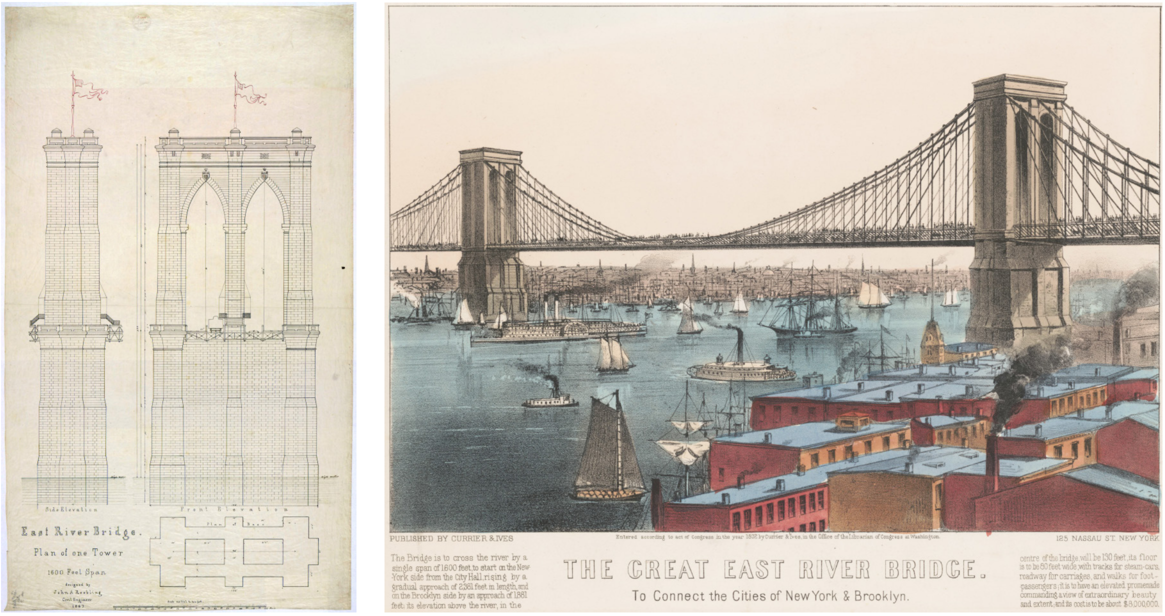


Figura 11.3. Projeto inicial da Ponte do Brooklyn.

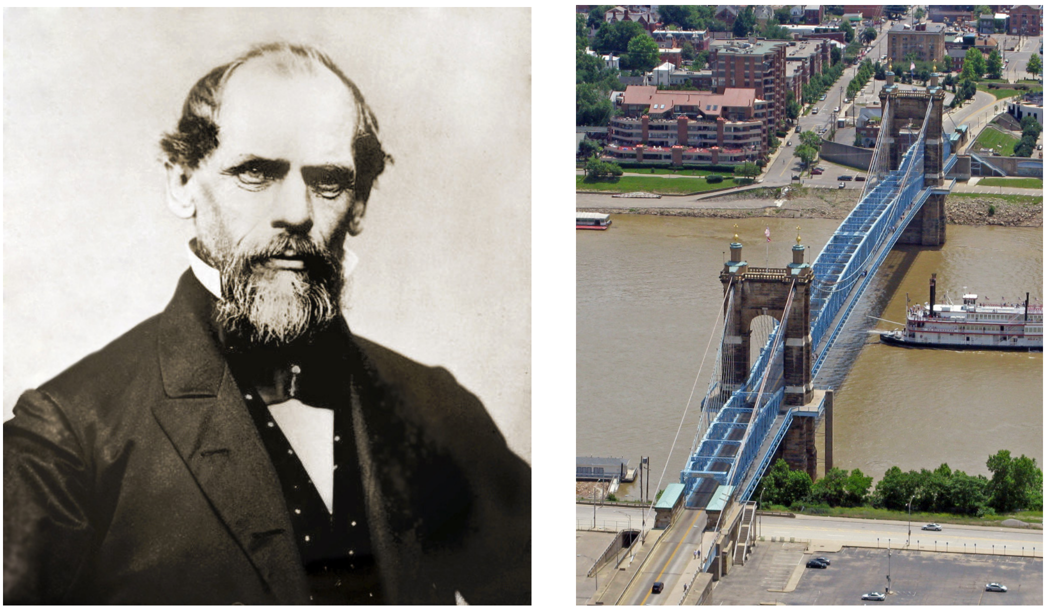
As propostas para uma ponte ligando Manhattan e Brooklyn foram feitas pela primeira vez no início do século 19. Na época, a única viagem entre as duas bairros era por algumas linhas de ferry. Em fevereiro de 1867, o Senado do Estado de Nova York aprovou um projeto de lei que permitia a construção de uma ponte suspensa do Brooklyn para Manhattan. Em abril de 1867, as cidades de Nova York e Brooklyn foram autorizadas a subscrever US$ 5 milhões em capital social, que financiaria a construção da ponte pela New York and Brooklyn Bridge Company. A ponte foi construída entre 1870 e 1883.



(a) (b)

Figura 11.4. (a) Plano da Torre da Ponte do Brooklyn, 1867; (b) Imagem esperada da ponte.

O engenheiro-chefe nomeado em 1867 para construir a Ponte do Brooklyn foi John Roebling, um engenheiro civil americano nascido na Alemanha. Ele era um engenheiro experiente em pontes suspensas de cabo de aço, como as de Pittsburgh, Niagara ou Cincinnati. Infelizmente, ele morreu em 1869, pouco antes de iniciar as obras.

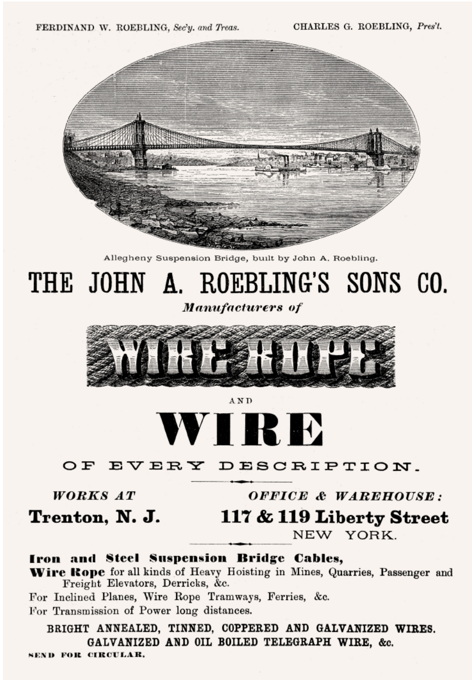


(a) (b)

Figura 11.5. (a) John Roebling, 1867; (b) Ponte suspensa de John Roebling em Cincinnati.

Washington Roebling, o filho de 32 anos de John Roebling, foi então contratado para ocupar o lugar do pai. Obteve formação superior em engenharia no Rensselaer Polytechnic Institute em Troy, Nova Iorque, e trabalhou com o pai em várias pontes suspensas. Em 1868, Washington tornou-se engenheiro assistente na Ponte do Brooklyn e foi nomeado engenheiro-chefe após a morte de seu pai em meados de 1869.

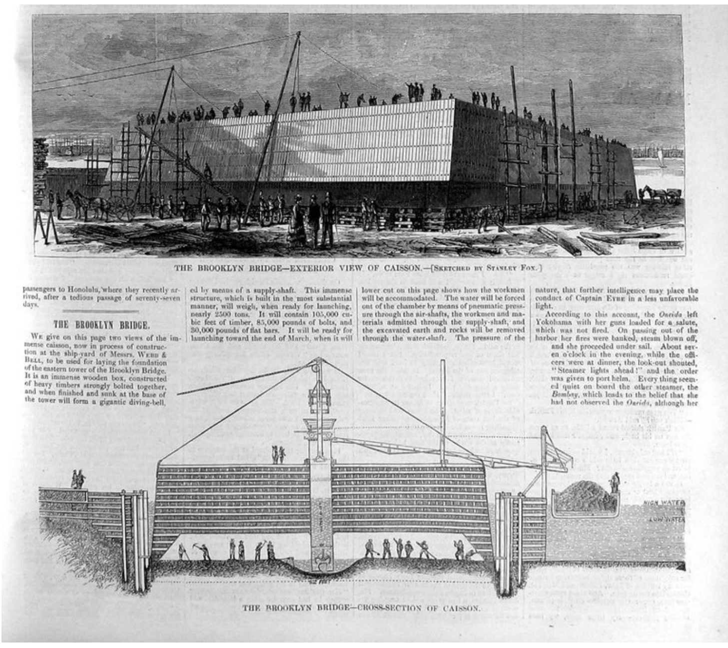
(a)



(b)

Figura 11.6. (a) Washington Roebling, 1854; (b) Anúncio de Roebling's & Sons, 1879.

Mas, muito cedo no início das obras, em 1870, sofreu uma doença de descompressão contraída enquanto trabalhava nos caixotes para os pilares da ponte, no fundo da superfície do rio. Isso o afetou tão gravemente que ele ficou acamado. Assim, sua esposa, Emily Warren Roebling, foi levada para a liderança da engenharia.



THE BROOKLYN BRIDGE—EXTERIOR VIEW OF CAISSON.—[SKETCHED BY STANLEY FOX.]

passengers to Honolulu, where they recently arrived, after a tedious passage of seventy-seven days.

THE BROOKLYN BRIDGE.

WE give on this page two views of the immense caisson, now in process of construction at the ship-yard of Messrs. WEBB & BELL, to be used for laying the foundation of the eastern tower of the Brooklyn Bridge. It is an immense wooden box, constructed of heavy timbers strongly bolted together, and when finished and sunk at the base of the tower will form a gigantic diving-bell, ed by means of a supply-shaft. This immense structure, which is built in the most substantial manner, will weigh, when ready for launching, nearly 2500 tons. It will contain 105,000 cubic feet of timber, 85,000 pounds of bolts, and 30,000 pounds of flat bars. It will be ready for launching toward the end of March, when it will lower cut on this page shows how the workmen will be accommodated. The water will be forced out of the chamber by means of pneumatic pressure through the air-shafts, the workmen and materials admitted through the supply-shaft, and the excavated earth and rocks will be removed through the water-shaft. The pressure of the

nature, that farther intelligence may place the conduct of Captain EYRE in a less unfavorable light.

According to this account, the *Oneida* left Yokohama with her guns loaded for a salute, which was not fired. On passing out of the harbor her fires were banked, steam blown off, and she proceeded under sail. About seven o'clock in the evening, while the officers were at dinner, the look-out shouted, "Steamer lights ahead!" and the order was given to port helm. Every thing seemed quiet on board the other steamer, the *Bombay*, which leads to the belief that she had not observed the *Oneida*, although her

THE BROOKLYN BRIDGE—CROSS-SECTION OF CAISSON.

Figura 11.7. Caixotes pressurizados dos pilares da Ponte do Brooklyn.

Emily Warren Roebling é conhecida por suas contribuições ao longo de um período de mais de 10 anos para a conclusão da Ponte do Brooklyn. Ela tinha estudado matemática e ciências, e ela começou a tomar notas copiosas sobre o que seu marido disse que ainda faltava fazer com a ponte. Ela também começou a estudar por conta própria sobre as questões técnicas, aprendendo sobre resistência de materiais, análise de tensão, construção de cabos e cálculo de curvas de catenária. Ela assumiu grande parte das funções de engenheira-chefe, incluindo supervisão diária e gerenciamento de projetos.

(a) (b)

Figura 11.8. (a) Emily Roebling, 1896; (b) Ponte do Brooklyn em construção.

Durante a década em que Washington ficou confinada à sua cama doente, Emily Roebling dedicou-se à conclusão da Ponte do Brooklyn. Emily e o marido planejaram em conjunto a continuação da construção da ponte. Ela lidou com políticos, engenheiros concorrentes e todos aqueles associados ao trabalho na ponte, a ponto de as pessoas acreditarem que ela estava por trás do projeto da ponte. Emily Roebling foi a primeira a atravessar a ponte de carruagem na cerimônia de abertura em 1883.

Os excelentes trabalhos de Emily Warren Roebling como engenheira foram reconhecidos pela Sociedade Americana de Engenheiros Civis. Uma placa na Ponte do Brooklyn, instalada em 1951 pelo Brooklyn Engineers Club, comemora sua contribuição para concluir a construção da ponte.

Figura 11.9. Placa comemorativa, 1951.

Após a conclusão de seu trabalho na Ponte do Brooklyn, Roebling passou a apoiar várias causas femininas. Ela também escreveu vários ensaios e defendeu mais direitos das mulheres e protestou contra práticas discriminatórias direcionadas às mulheres. Ela continuou sua educação e recebeu um diploma de direito da Universidade de Nova York em 1899, com a idade de 56 anos.

Étude de cas *Édition française*

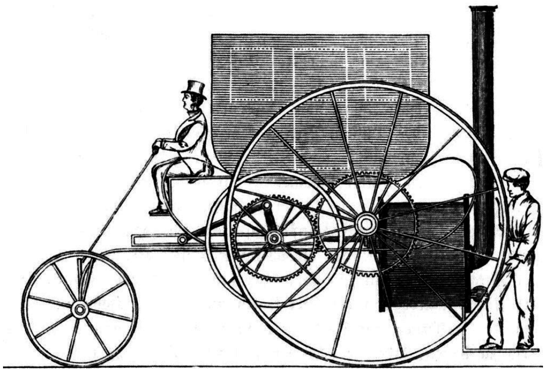
ÉTUDE DE CAS

Édition française

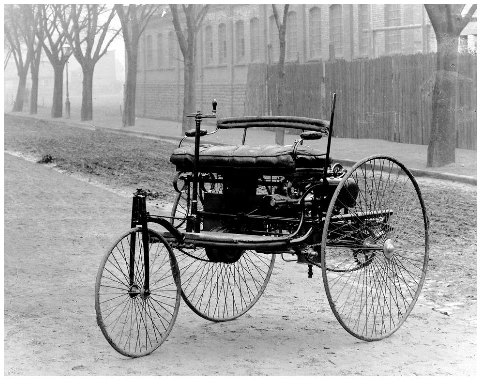
https://www.merlot.org/merlot/viewSite.htm?id=9164671

1. qui a défini le « cheval-vapeur » comme l'unité de puissance ?

Aux premières années de l'automobile, nous pouvons imaginer des chevaux tirant l'automobile à vapeur de Richard Trevithick en 1801, qui pouvait à peine monter une pente, ou la voiture à moteur à essence brevetée par Karl Benz en 1886. Les premiers véhicules à moteur conservaient la structure des calèches dans lesquelles le cheval était remplacé par un moteur. Le « cheval-vapeur » était une unité appropriée et significative.



(a)



(b)

(c)

Figure 1.1. (a) La voiture à vapeur de Richard Trevithick en 1801; (b) La voiture à gaz de Karl Benz en 1886; (c) Calèches.

Qui a défini le « cheval-vapeur » comme l'unité de puissance ? La réponse, c'est que la définition a été élaborée par un ingénieur. L'ingénieur écossais James Watt (1736 – 1819) a commencé sa carrière professionnelle en tant que fabricant d'instruments, après il a travaillé comme ingénieur civil et, finalement, il a fondé la société Boulton & Watt produisant des machines à vapeur. Il a amélioré l'efficacité de la machine et il est devenu titulaire de plusieurs brevets.

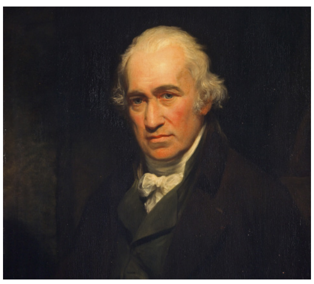
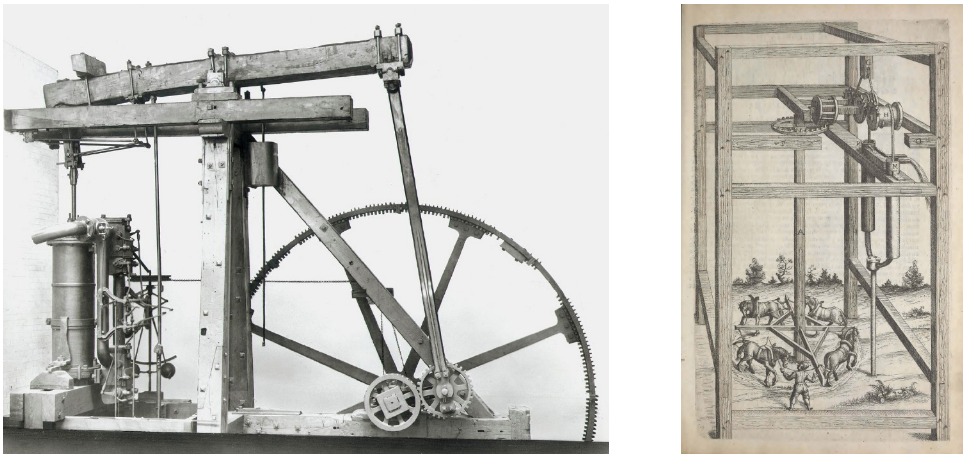


Figure 1.2. Portrait deJames Watt.

Watt a défini le moteur et ses qualités d'une façon commerciale et intelligente. Comme la machine à vapeur devait rivaliser, à cette époque, le cheval comme source d'énergie dans l'industrie minière, il a décidé d'utiliser le cheval comme unité de mesure.



(a) (b)

Figure 1.3. (a) Machine à vapeur Boulton & Watt, 1788. (b) Pompe hydraulique pour une mine, par Salomon de Caus en 1615.

Est-ce qu'il existe une meilleure forme pour présenter les qualités de la machine à vapeur qu'en indiquant le nombre de chevaux qu'elle pouvait remplacer ? La seule question qui manquait était de trouver l'équivalence numérique pour atteindre cet objectif.

Watt a supposé qu'un « cheval » standard pouvait tirer 180 livres et il a déterminé qu'un cheval pouvait tourner une roue de moulin 144 fois par heure (ou 2,4 fois par minute). La roue avait un rayon de 12 pieds; par conséquent, le cheval a parcouru 2,4 × 2π × 12 pieds par minute. La puissance est calculée comme le produit de la force par la distance divisée par le temps.

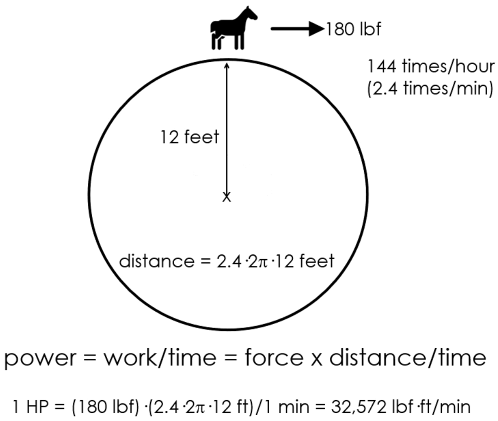


Figure 1.4. Définition du « cheval-vapeur » (*horsepower*, HP) par James Watt.

1 HP (Watt) = force x distance/temps = (180 lbf) x (2,4 x 2π x 12 ft) / 1 min = 32,572 ft·lbf/min)

Le résultat a été arrondi à 33.000 lbf·ft/min (pieds-livres par minute). La définition formelle du « cheval-vapeur » (*horsepower* en anglais) a été publiée en 1809 par James Watt.

L'idée était non seulement brillante, mais l'unité qui en résultait, le « cheval-vapeur », était profondément significative pour ses concitoyens. Watt a non seulement amélioré la machine à vapeur en tant qu'alternative technique pour l'industrie minière, mais l'a aussi rendu plus facile à comprendre pour le public général.

Les systèmes de mesure qui sont nés près de l'expérience des gens sont profondément significatifs, parce qu'à travers la mesure, ils établissent un dialogue entre l'homme et la nature. L'importance des mesures traditionnelles, comme le « cheval-vapeur », fait partie de ses vertus les plus remarquables.

2. James Watt a-t-il défini l'unité « watt » pour la puissance avec son propre nom ?

Nous avons l'habitude d'avoir chez nous à la maison de nombreux appareils électroménagers, qui nous aident à rendre notre vie plus facile. Faisons tourner ces appareils et nous trouverons une étiquette technique. Sur tous ces appareils, nous pouvons lire une ligne avec le symbole W, que nous appelons « watt ». Cela nous dit quelque chose sur la puissance de l'appareil. Alors, quelle est l'origine de ce nom ?

(a) (b)

Figure 2.1. (a) cafetière et (b) grille-pain, avec leurs étiquettes techniques.

Et Comme il est très célèbre dans le monde entier, beaucoup de gens pourraient associer ce nom à l'ingénieur écossais James Watt. Mais, est ce que c'est James Watt qui a défini l'unité de « watt » pour la puissance avec son propre nom ?

James Watt a défini le « cheval-vapeur » mais pas l'unité de puissance du Système International d'unités, le « watt » (W). Le « watt » comme unité de puissance a été proposé et défini par l'ingénieur électricien allemand Carl Wilhelm Siemens.

Sir Carl Wilhelm Siemens (1823 – 1883) était un ingénieur et homme d'affaires germano-britannique. Il est également connu sous le nom de Charles William Siemens car il est devenu un citoyen britannique naturalisé. C'était un brillant homme d'affaires et entrepreneur et, en même temps, un chercheur scientifique talentueux. Il a travaillé dans diverses activités industrielles et il a obtenu une reconnaissance internationale en tant que scientifique.

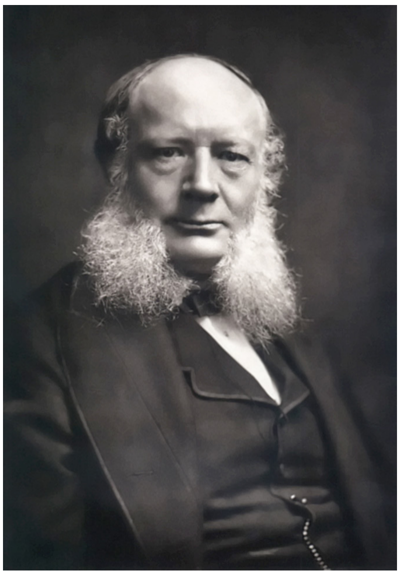
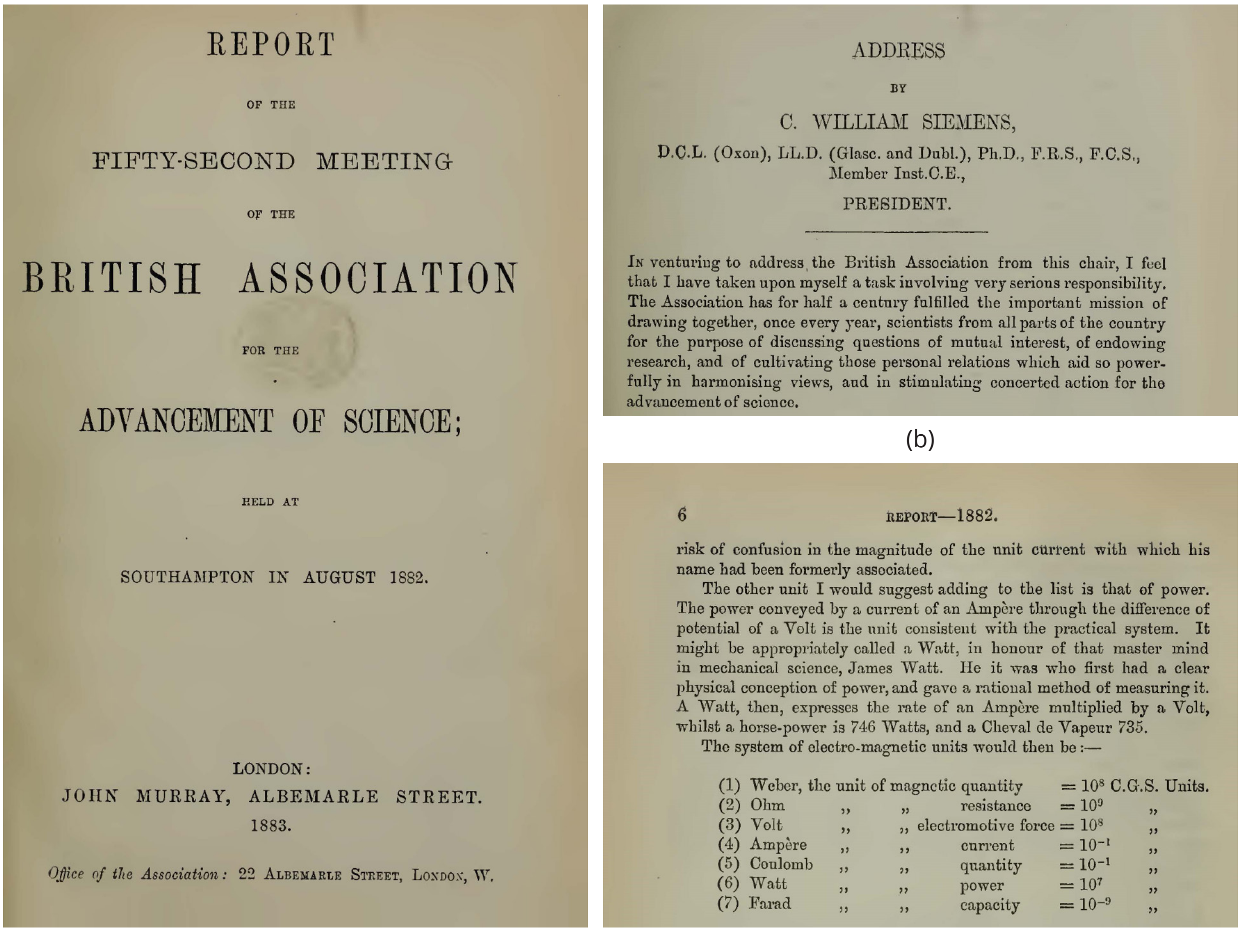


Figure 2.2. L'ingénieur germano-britannique Carl Wilhelm Siemens.

Au cours du 19ème siècle, l'utilisation des dynamos pour générer de l'électricité et celles des moteurs électriques pour transformer l'énergie électrique en mécanique se sont généralisées. Le besoin d'une unité de puissance liée aux grandeurs électriques (*volt, ampère, ohm*) augmentait au fil des années. En 1882, Carl Wilhelm Siemens, président de la British Association for the Advancement of Science, proposa l'adoption de l'unité « watt » dans son rapport à l'Association. L'unité de puissance proposée dans le système CGS a été nommée « watt » en l'honneur de l'ingénieur James Watt.



REPORT

OF THE

FIFTY-SECOND MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

HELD AT

SOUTHAMPTON IN AUGUST 1882.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1883.

Office of the Association: 22 ALBEMARLE STREET, LONDON, W.

(a)

ADDRESS

BY

C. WILLIAM SIEMENS,

D.C.L. (Oxon), LL.D. (Glasc. and Dubl.), Ph.D., F.R.S., F.C.S., Member Inst.C.E.,

PRESIDENT.

IN venturing to address the British Association from this chair, I feel that I have taken upon myself a task involving very serious responsibility. The Association has for half a century fulfilled the important mission of drawing together, once every year, scientists from all parts of the country for the purpose of discussing questions of mutual interest, of endowing research, and of cultivating those personal relations which aid so powerfully in harmonising views, and in stimulating concerted action for the advancement of science.

(b)

6 REPORT—1882.

risk of confusion in the magnitude of the unit current with which his name had been formerly associated.

The other unit I would suggest adding to the list is that of power. The power conveyed by a current of an Ampère through the difference of potential of a Volt is the unit consistent with the practical system. It might be appropriately called a Watt, in honour of that master mind in mechanical science, James Watt. He it was who first had a clear physical conception of power, and gave a rational method of measuring it. A Watt, then, expresses the rate of an Ampère multiplied by a Volt, whilst a horse-power is 746 Watts, and a Cheval de Vapeur 735.

The system of electro-magnetic units would then be :—

(1) Weber, the unit of	magnetic	quantity	$= 10^8$	C.G.S. Units.
(2) Ohm	,,	,,	resistance	$= 10^9$	,,
(3) Volt	,,	,,	electromotive force	$= 10^8$	,,
(4) Ampère	,,	,,	current	$= 10^{-1}$	,,
(5) Coulomb	,,	,,	quantity	$= 10^{-1}$	,,
(6) Watt	,,	,,	power	$= 10^7$	,,
(7) Farad	,,	,,	capacity	$= 10^{-9}$	,,

(c)

Figure 2.3. (a) Numéro d'août 1882 du British Association for the Advancement of Science. (b) communication du président de l'association, C. William Siemens, aux associés, (c) La proposition de C. William Siemens, entre autres, de l'unité de puissance « watt » en l'honneur de James Watt.

Le « watt » a été défini comme suit:

1 *watt* = 1 *ampere* x 1 *volt*

La reconnaissance internationale de cette unité a été obtenue avant la fin du 19ème siècle. Dans le même rapport de 1882, Siemens avait proposé le *joule* (J) comme unité d'énergie et de travail, qui fut définitivement adopté par la British Association en 1888. De 1908 à 1948, la définition du « watt » était encore liée aux unités électriques. A partir de 1948, la définition du « watt » est basée sur le *joule* de l'énergie:

1 watt = 1 joule/seconde

Il existe de nombreuses unités scientifiques portant le nom de personnes, dont la plupart ont reçu leur nom depuis longtemps. Une grande partie de la dénomination personnelle s'est produite dans les années 1860-70 pour le système CGS et 1870-1880 pour le système SI. Le cas le plus fréquent est que l'unité est nommée par quelqu'un d'autre pour honorer le découvreur ou parce que personne ne pourrait trouver un meilleur nom. Par convention, le nom de l'unité s'écrit correctement en minuscules, mais son abréviation est en majuscules.

3. Certaines températures sont mesurées en degrés Rankine. Qui était M. Rankine ?

Dans certains manuels américains de l'ingénierie qui traitent des concepts de température, on trouve la mention d'une température mesurée sur une échelle appelé Rankine. Très souvent, les relations entre cette échelle de température et celles de Celsius (°C), Fahrenheit (°F) et Kelvin (K) sont décrites par les facteurs de conversion respectifs:

$$K = (5/9)R = (5/9)(^{o}F + 459.67) = {^{o}C} + 273.15$$

Comme pour d'autres échelles de température bien connues, cette échelle semble porter le nom de M. Rankine. Qui était M. Rankine ?

L'échelle de Rankine a été nommée d'après l'ingénieur écossais William John Macquorn Rankine (1820 - 1872). William Rankine a travaillé comme ingénieur mécanicien et civil. A côté de son métier d'ingénieur professionnel et à partir de 1855, il est devenu professeur de génie civil et de mécanique à l'Université de Glasgow. Il a été l'un des grands contributeurs à la science de la thermodynamique. Beaucoup de ses études étaient axées sur l'efficacité des moteurs thermiques et la science de l'énergie.

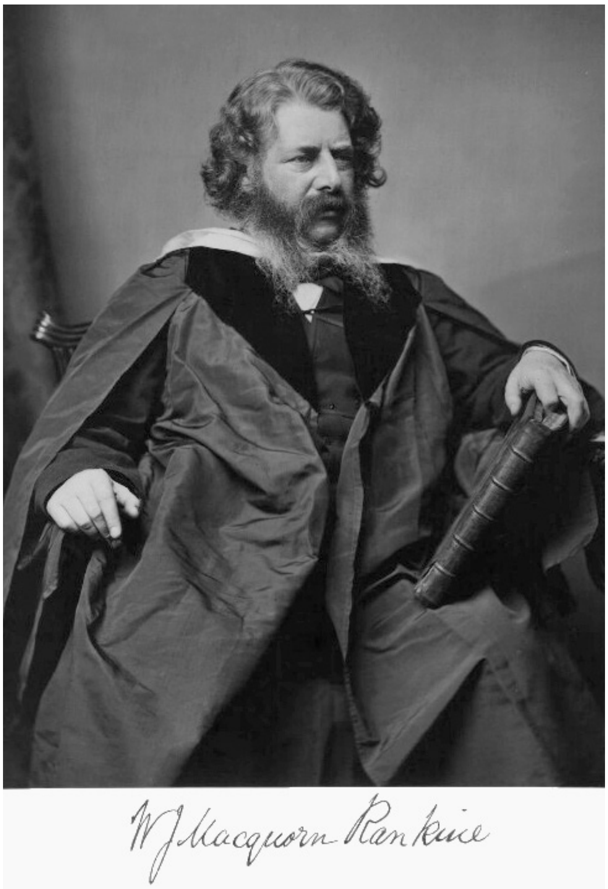
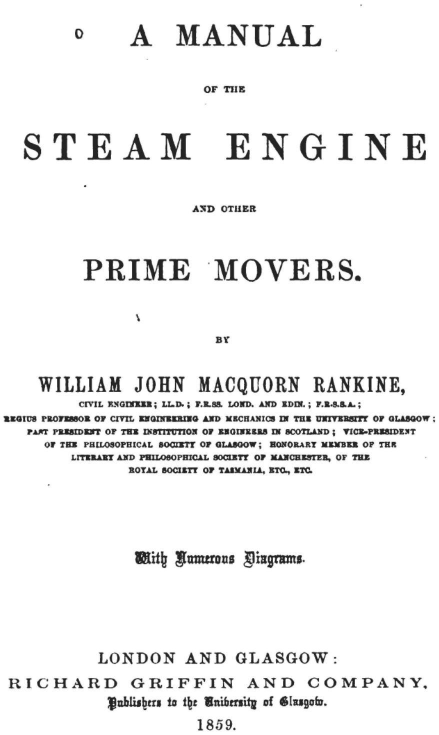


Figure 3.1. L'ingénieur écossais William John Macquorn Rankine.

Il a écrit plusieurs traités d'ingénierie, dont celui sur la machine à vapeur et des autres moteurs, qui est resté un manuel de référence pendant de nombreuses années au 19ème siècle. Il a obtenu une reconnaissance internationale et il est devenu membre des institutions prestigieuses comme The Royal Society of Edinburgh et The Royal Society of London.

William Rankine a publié en 1859 son Manual of the Steam Engine and other Prime Movers. Dans la troisième partie, Rankine décrit d'abord les fours et les chaudières qui fournissent de la chaleur à partir de la combustion d'un carburant, puis le moteur par lequel le fluide chauffé effectue un travail par un mécanisme d'entraînant. Auparavant, il a discuté des lois et des relations entre les phénomènes de chaleur et d'énergie mécanique, qui constituent les principes de la thermodynamique, sur lesquels dépendent le travail et l'efficacité des machines thermiques.


A MANUAL

OF THE

STEAM ENGINE

AND OTHER

PRIME MOVERS.

BY

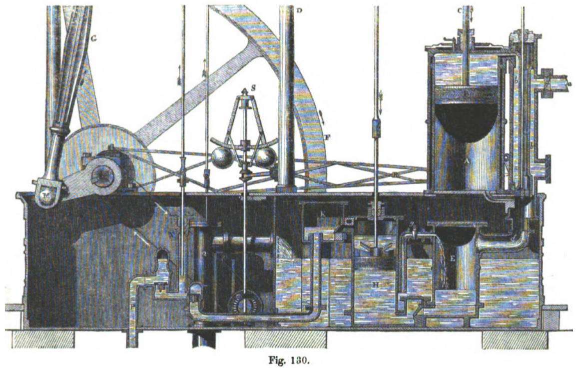
WILLIAM JOHN MACQUORN RANKINE,

CIVIL ENGINEER; LL.D.; F.R.SS. LOND. AND EDIN.; F.R.S.S.A.;
REGIUS PROFESSOR OF CIVIL ENGINEERING AND MECHANICS IN THE UNIVERSITY OF GLASGOW;
PAST PRESIDENT OF THE INSTITUTION OF ENGINEERS IN SCOTLAND; VICE-PRESIDENT
OF THE PHILOSOPHICAL SOCIETY OF GLASGOW; HONORARY MEMBER OF THE
LITERARY AND PHILOSOPHICAL SOCIETY OF MANCHESTER, OF THE
ROYAL SOCIETY OF TASMANIA, ETC., ETC.

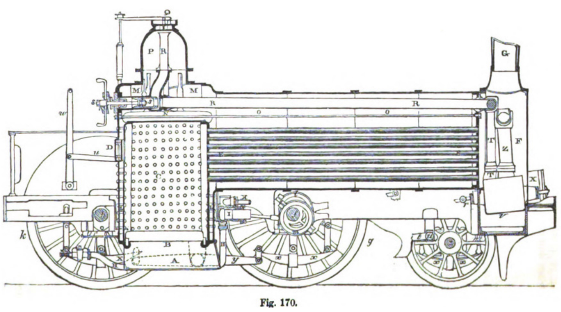
With Numerous Diagrams.

LONDON AND GLASGOW:
RICHARD GRIFFIN AND COMPANY.
Publishers to the University of Glasgow.
1859.

(a)



(b)



(c)

Figure 3.2. (a) Couverture de livre *Steam Engine and Other Prime Movers (1859)*. (b) coupe longitudinale d'une machine à vapeur rotative à double effet, par W. Rankine. (c) coupe longitudinale d'une locomotive à vapeur à six roues, par W. Rankine.

Lors de la présentation des concepts et des idées de température, Rankine introduit la définition des échelles de température absolue par rapport aux échelles ordinaires. Ainsi, en relation avec l'échelle Fahrenheit, il propose la Température Absolue respective où le zéro absolu correspond à - 461.2 ^{o}F. Cette échelle de température absolue sera nommée par la suite échelle de Rankine.

Concernant les données disponibles en 1859, les calculs de Rankine pour le zéro absolu de l'échelle Celsius ont conduit à la valeur de -274, très proche de -273,15 des calculs actuels. Cette échelle correspond à l'échelle Kelvin actuelle, proposée en 1848 par William Thomson (Lord Kelvin). Les calculs de Rankine pour le zéro absolu de l'échelle de Fahrenheit ont conduit à la valeur de - 461,2. La valeur actuelle est - 459,67.

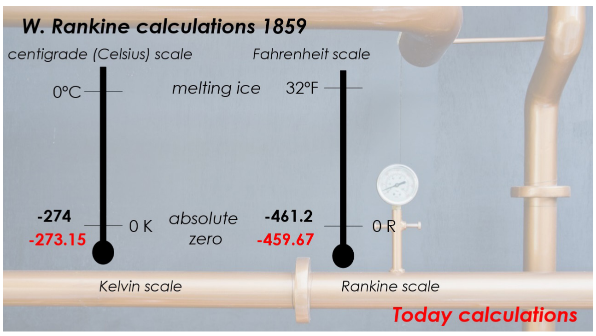


Figure 3.3. Comparaison des échelles de température Celsius, Fahrenheit, Kelvin et Rankine.

Cependant, l'échelle de Rankine est très peu utilisée. Il semble que durant la deuxième moitié de vingtième siècle, les Américains créaient des programmes informatiques et utilisaient des équations qui nécessitaient une température absolue, et ils utilisaient Rankine avant que Kelvin ne devienne dominant pour les calculs scientifiques. La raison pour laquelle il est encore utilisé dans l'industrie aérospatiale est qu'il y a beaucoup de programmes qui ont été développés à l'aide de Rankine, donc, pour être compatible avec ces anciens programmes, il est souvent plus simple de continuer à utiliser Rankine dans de nouveaux programmes aussi.

4. Existe-t-il une relation entre l'unité SI pour la conductance électrique, « siemens », et la société Siemens AG© ?

Dans le Système International d'Unités, il existe un ensemble d'unités dérivées. Parmi eux, il y en a un appelé « siemens », dont le symbole est la lettre S majuscule qui correspond à la propriété de conductance électrique.

SI derived units with special names and symbols[3]: 15

Name	Symbol	Quantity	In SI base units	In other SI units
radian[N 1]	rad	plane angle	m/m	1
steradian[N 1]	sr	solid angle	m^2/m^2	1
hertz	Hz	frequency	s^{-1}	
newton	N	force, weight	$kg{\cdot}m{\cdot}s^{-2}$	
pascal	Pa	pressure, stress	$kg{\cdot}m^{-1}{\cdot}s^{-2}$	N/m^2
joule	J	energy, work, heat	$kg{\cdot}m^2{\cdot}s^{-2}$	$N{\cdot}m = Pa{\cdot}m^3$
watt	W	power, radiant flux	$kg{\cdot}m^2{\cdot}s^{-3}$	J/s
coulomb	C	electric charge	$s{\cdot}A$	
volt	V	electrical potential difference (voltage), emf	$kg{\cdot}m^2{\cdot}s^{-3}{\cdot}A^{-1}$	W/A = J/C
farad	F	capacitance	$kg^{-1}{\cdot}m^{-2}{\cdot}s^4{\cdot}A^2$	$C/V = C^2/J$
ohm	Ω	resistance, impedance, reactance	$kg{\cdot}m^2{\cdot}s^{-3}{\cdot}A^{-2}$	$V/A = J{\cdot}s/C^2$
siemens	S	electrical conductance	$kg^{-1}{\cdot}m^{-2}{\cdot}s^3{\cdot}A^2$	Ω^{-1}
weber	Wb	magnetic flux	$kg{\cdot}m^2{\cdot}s^{-2}{\cdot}A^{-1}$	V·s
tesla	T	magnetic flux density	$kg{\cdot}s^{-2}{\cdot}A^{-1}$	Wb/m^2
henry	H	inductance	$kg{\cdot}m^2{\cdot}s^{-2}{\cdot}A^{-2}$	Wb/A
degree Celsius	°C	temperature relative to 273.15 K	K	
lumen	lm	luminous flux	cd·sr	cd·sr
lux	lx	illuminance	$cd{\cdot}sr{\cdot}m^{-2}$	lm/m^2
becquerel	Bq	activity referred to a radionuclide (decays per unit time)	s^{-1}	
gray	Gy	absorbed dose (of ionising radiation)	$m^2{\cdot}s^{-2}$	J/kg
sievert	Sv	equivalent dose (of ionising radiation)	$m^2{\cdot}s^{-2}$	J/kg
katal	kat	catalytic activity	$mol{\cdot}s^{-1}$	

Notes

1. ^ a b The radian and steradian are defined as dimensionless derived units.

Figure 4.1. Unités dérivées du système international.

En outre, nous pouvons trouver dans le monde entier le nom Siemens associé, par exemple, aux appareils ménagers, aux moteurs électriques, aux trains ou aux systèmes d'automatisation industrielle.

(a) (b) (c)

Figure 4.2. Produits de la société Siemens AG©. (a) moteurs électriques; (b) systèmes d'automatisation industrielle; (c) trains.

Existe-t-il une relation entre l'unité SI pour la conductance électrique, « siemens », et la société Siemens AG© ?

La 14e édition de la Conférence Générale des Poids et Mesures a approuvé l'ajout du « siemens » en tant qu'unité dérivée en 1971.

COMPTES RENDUS DES SÉANCES

DE LA

QUATORZIÈME CONFÉRENCE GÉNÉRALE

DES POIDS ET MESURES

PARIS, 4-8 OCTOBRE 1971

BUREAU INTERNATIONAL DES POIDS ET MESURES
Pavillon de Breteuil, F 92-Sèvres, France
Dépositaire : OFFILIB, 48 rue Gay-Lussac, F 75-Paris 5e

(a)

Tableau 4. Les 22 unités SI ayant un nom spécial et un symbole particulier

Grandeur dérivée	Nom spécial de l'unité	Expression de l'unité en unités de base (a)	Expression de l'unité en d'autres unités SI
angle plan	radian (b)	rad = m/m	
angle solide	stéradian (c)	sr = m^2/m^2	
fréquence	hertz (d)	Hz = s^{-1}	
force	newton	N = kg m s^{-2}	
pression, contrainte	pascal	Pa = kg m^{-1} s^{-2}	
énergie, travail, quantité de chaleur	joule	J = kg m^2 s^{-2}	N m
puissance, flux énergétique	watt	W = kg m^2 s^{-3}	J/s
charge électrique	coulomb	C = A s	
différence de potentiel électrique (e)	volt	V = kg m^2 s^{-3} A^{-1}	W/A
capacité électrique	farad	F = kg^{-1} m^{-2} s^4 A^2	C/V
résistance électrique	ohm	Ω = kg m^2 s^{-3} A^{-2}	V/A
conductance électrique	siemens	S = kg^{-1} m^{-2} s^3 A^2	A/V
flux d'induction magnétique	weber	Wb = kg m^2 s^{-2} A^{-1}	V s
induction magnétique	tesla	T = kg s^{-2} A^{-1}	Wb/m^2
inductance	henry	H = kg m^2 s^{-2} A^{-2}	Wb/A
température Celsius	degré Celsius (f)	°C = K	
flux lumineux	lumen	lm = cd sr (g)	cd sr
éclairement lumineux	lux	lx = cd sr m^{-2}	lm/m^2
activité d'un radionucléide (d, h)	becquerel	Bq = s^{-1}	
dose absorbée, kerma	gray	Gy = m^2 s^{-2}	J/kg
équivalent de dose	sievert (i)	Sv = m^2 s^{-2}	J/kg
activité catalytique	katal	kat = mol s^{-1}	

(b)

Figure 4.3. (a) Publication de la XIVe Conférence générale des poids et mesures, 4-8 octobre 1971; (b) Tableau 4, avec les unités dérivées du système international.

Le « siemens » (symbole: S) est l'unité dérivée de la conductance électrique. Dans les équations, la conductance est représentée par G. Un conducteur a une conductance de 1 *siemens* si une différence de potentiel électrique de 1 *volt* produit un courant de 1 *ampère*. C'est l'inverse de la résistance. Par conséquent, un « siemens » est égal à l'inverse d'un ohm (Ω^{-1}).

$$G = 1/R = I/V$$

Unité: *siemens;* [S] = [A/V] = [Ω^{-1}], Ω, *ohm;* A, *ampere;* V, *volt*

Il peut également être exprimé en termes d'unités de base du Système International uniquement. Le même mot « siemens » est utilisé à la fois pour le singulier et le pluriel. L'unité « siemens » a été nommée d'après l'ingénieur Ernst Werner von Siemens.

Figure 4.4. Werner von Siemens.

Werner von Siemens (1816 - 1892) était un brillant ingénieur électricien allemand, un homme d'affaires, un inventeur et un scientifique talentueux. En 1847, il a fondé la société Siemens and Halske, c'est une entreprise de construction télégraphique après l'invention du télégraphe à pointeur. En quelques décennies, l'entreprise est devenue l'un des principaux fabricants d'équipements électriques qui opère à l'échelle internationale. Cette société est l'actuel groupe international Siemens AG. De plus, Siemens a accordé toute son attention à la recherche scientifique. Il a découvert le principe dynamo-électrique et il a créé les bases de l›utilisation de l›énergie électrique comme source d›énergie. Tout au long de sa vie, l›ingénieur électricien révolutionnaire a reçu de nombreux prix en reconnaissance de ses contributions à la société et à la science.

En 1971, l'unité « siemens » n'était pas entièrement nouvelle. Depuis 1935, il a été utilisé par les ingénieurs électriciens comme unité de conductance électrique, lorsque la Commission internationale en électrotechnique a recommandé son utilisation lors de la réunion plénière à Scheveningen-Bruxelles. Il faut souligner que Werner von Siemens a largement contribué aux études techniques et scientifiques de la résistance électrique au cours du 19eme siècle.

12. Transmission Circuits for Telephonic Communication (a book), K. S. Johnson. D. Van Nostrand Company, Inc., 1927.
13. Transmission Networks and Wave Filters (a book), T. E. Shea. D. Van Nostrand Company, Inc., 1929.
14. Phase Distortion in Telephone Apparatus, C. E. Lane. *Bell System Tech. Jl.*, v. 9, July 1930, p. 493–521.
15. Harmonic Production in Ferromagnetic Materials, Eugene Peterson. *Bell System Tech. Jl.*, v. 7, Oct. 1928, p. 762–96.

I.E.C. Adopts MKS System of Units

At its plenary meeting of June 1935 at Scheveningen-Bruxelles, the International Electrotechnical Commission unanimously adopted the meter-kilogram-second (mks) or Giorgi system of units, 15 of the 25 constituent countries being represented. In this paper the principal historical antecedents of this action by the I.E.C. are outlined, and its principal import to electrical engineering is indicated. Since the preparation of this paper there have been further important developments in connection with the adoption of this system; reports of these developments, as translated from the original French texts, are given in appendixes I and II.

By ARTHUR E. KENNELLY
HONORARY MEMBER A.I.E.E.
Harvard University, Cambridge, Mass.

As is well known, the International Electrotechnical Commission is an international organization maintained by 25 countries. It was called into existence under the leadership of R. E. Crompton, in response to a recommendation of the International Electrical Congress of St. Louis (Mo.) in 1904. It was organized in 1906 with its secretariat in London, and C. LeMaistre has been its general secretary since that time. It comprises 24 advisory committees, each dealing with a particular electrotechnical subject, and it has held plenary meetings in London, Paris, Brussels, The Hague, Berlin, Cologne, Turin, Zurich, Bellagio-Rome, Geneva, Denmark, Scandinavia, and New York. It has accomplished much international electrotechnical work during its 29 years of activity.

At its plenary meeting, in June 1935, at Scheveningen-Bruxelles, the I.E.C. unanimously adopted the Giorgi System of meter-kilogram-second (mks) units, 15 countries being represented by the delegates present. Every electrical engineer should make himself acquainted with the significance of this decision. In effect, it replaces the 3 systems at present in use (namely, the absolute electromagnetic cgs system, the absolute electrostatic cgs system, and the practical series) by one practical system.

The fundamental units are so chosen that the present practical series or system becomes at once an absolute system. This brings about a great simplification in the teaching of units and in practical calculations.

For the present, the question of rationalization has been left for future consideration. As the permeability and permittivity of space are no longer unity, it would be an easy matter to fix their values so as to rationalize all calculations; that is to say, to arrange matters so that the multiplier 4π comes into those formulas only where it would be expected to enter.

Not since the International Congress of Electricians, at Paris[7] in 1881, has there been made a decision of similar international significance. It is the purpose of this paper to outline the principal historical antecedents of this I.E.C. action, to indicate its main import to electrical engineering, and to suggest a few of the implications it may involve. The account here given is, however, necessarily subsidiary to the official minutes of the meeting, which should be consulted by interested readers.

History of CGS and Practical Units

As early as 1848, resistance boxes had been produced in Germany, calibrated to correspond to the linear resistance of particular sizes of telegraph wire. Gauss and Weber, about 1850, showed how to make certain electric and magnetic measurements in absolute measure, adopting for this purpose the millimeter-milligram-second system (mms). In 1860, Werner Siemens introduced his mercury unit of resistance; i. e., a glass tube of one square millimeter cross sectional area and one meter long, filled with pure mercury, at zero degrees centigrade.

The British Association for the Advancement of Science (commonly abbreviated to B.A.), at its meeting in Manchester, of 1861, established a committee to report upon "standards of electrical resistance." This B.A. committee became famous for its pioneer work. It made annual reports[1] until 1867. It recommended the adoption of an absolute fundamental system of scientific units, and after trying the foot-grain-second system (fgs) advocated the meter-gram-second system (mgs). It computed theoretically, and worked out practically, approximate electric standards, especially that of electrical resistance, for which Latimer Clark suggested the name *ohm*. Because the mgs absolute electromag-

A paper recommended for publication by the A.I.E.E. committee on electrophysics, and scheduled for discussion at the A.I.E.E. winter convention, New York, N. Y., Jan. 28–31, 1936. Manuscript submitted Sept. 30, 1935; released for publication Nov. 1, 1935.
Scheduled for republication by the Institution of Electrical Engineers, London.
7. For all numbered references see list at end of paper.

December 1935 1373

(a)

Table I—Incomplete List of MKS Units and of Corresponding CGS Units

No.	Quantity	Symbol	MKS Unit	CGS Unit	CGS Units in One MKS Unit
Mechanical					
1	Length	L	meter	centimeter	10^2
2	Mass	M	kilogram	gram	10^3
3	Time	T	second	second	1
4	Area	S	square meter	square centimeter	10^4
5	Volume	V	cubic meter (stere)	cubic centimeter	10^6
6	Frequency	f	hertz (cycle per second)	cycle per second	1
7	Density	d	kilogram per meter	gram per cubic centimeter	10^{-3}
8	Specific gravity		numeric	numeric	1
9	Velocity	v	meter per second	centimeter per second	10^2
10	Slowness		second per meter	second per centimeter	10^{-2}
11	Acceleration	a	meter per second per second	centimeter per second per second	10^2
12	Force	F	— (joule per meter)	dyne	10^5
13	Pressure	p	— (joule per cubic meter)	dyne per square centimeter, barye	10
14	Angle	α, β	radian	radian	1
15	Angular velocity	ω	radian per second	radian per second	1
16	Torque	τ	— (joule per radian)	dyne ⊥ centimeter	10^7
17	Moment of inertia	J	kilogram-square meter	gram-square centimeter	10^7
Energetics					
18	Work or energy	W	joule	erg	10^7
19	Angular work, $\tau\alpha$	W	joule	erg	10^7
20	Volume energy	w	joule per cubic meter	erg per cubic centimeter	10
21	Active power	P	watt	erg per second	10^7
22	Reactive power	jQ	var	erg per second	10^7
23	Vector power, $P \pm jQ$		watt ∠	erg per second	10^7
Thermal					
24	Quantity of heat	Q	kilogram-calorie	gram-calorie	10^3
25	Temperature	θ	degree centigrade or Kelvin	degree centigrade or Kelvin	1
Luminous					
26	Intensity	I	candle	candle	1
27	Luminous flux	ψ	lumen	lumen	1
28	Illumination	E	lux	phot	10^{-4}
29	Brightness	b	candle per square meter	stilb	10^{-4}
30	Focal power		diopter		10^{-2}
Electrical					
31	Electromotive force	E	volt		10^8
32	Potential gradient	$\mathcal{E}$	volt per meter		10^6
33	Resistance	R	ohm		10^9
34	Resistivity	ρ	ohm-meter		10^{11}
35	Conductance	G	siemens, mho		10^{-9}
36	Conductivity	γ	siemens per meter, mho per meter		10^{-11}
37	Reactance	jX	ohm		10^9
38	Impedance, $R \pm jX$	Z	ohm ∠		10^9
39	Quantity	Q	coulomb		10^{-1}
40	Displacement	Q	coulomb		10^{-1}
41	Current	I	ampere		10^{-1}
42	Current density	i	ampere per square meter		10^{-5}
43	Capacitance	C	farad		10^{-9}
44	Specific inductive capacity	ϵ/ϵ_0	numeric	numeric	1
Magnetic					
45	Magnetic flux	Φ	weber	maxwell	10^8
46	Flux density	B	weber per square meter	gauss	10^4
47	Inductance	L	henry		10^9
48	Relative permeability	μ/μ_0	numeric	numeric	1

(b)

Figure 4.5. (a) Publication des accords de la Commission Électrotechnique Internationale de 1935; (b) Tableau I, avec les unités MKS (Kenelly, 1935).

Comme la conductance électrique est l'inverse de la résistance électrique, (Ω^{-1}), le premier nom proposé pour cette unité était « mho » avant qu'elle ne soit renommée « siemens » en 1971. Alors, puisqu'elle est l'inverse d'un *ohm*, « mho » est le mot ohm écrit à l'envers et qui avait été suggéré par M. William Thomson (Lord Kelvin) en 1883. Thomson a utilement ajouté que la prononciation correcte de «mho» pouvait être obtenue en prenant un phonographe et en le renversant dans le sens de la hauteur. Son symbole est une lettre grecque majuscule inversée qui est oméga.

THOMSON ON ELECTRICAL UNITS OF MEASUREMENT. 149

3 May, 1883.

JAMES BRUNLEES, F.R.S.E, President, in the Chair.

Electrical Units of Measurement.

By Sir William Thomson, F.R.S., M. Inst. C.E.

In physical science a first essential step in the direction of learning any subject, is to find principles of numerical reckoning, and methods for practicably measuring, some quality connected with it.

(a)

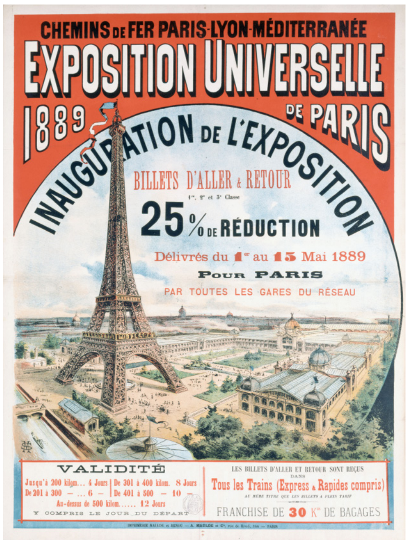
in series. For the reciprocal of an ohm in the measurement of resisting power—for the unit reckoning of conductivity which will agree with the ohm—it is suggested to take a phonograph and turn it backwards, and see what it will make of the word "ohm." I admire the suggestion, and I wish some one would take the responsibility of adopting it; we should then have *mho* boxes of coils at once in general use. With respect to electric light,

(b)

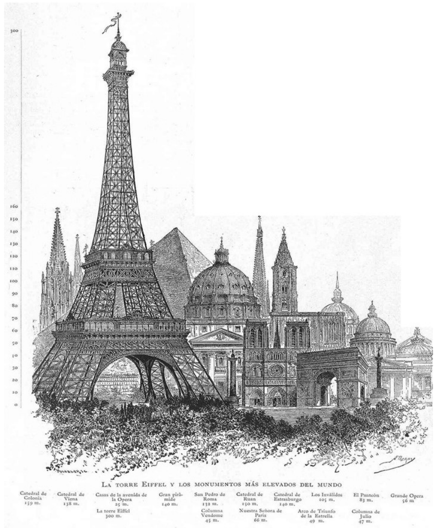
Figure 4.6. (a) La proposition de William Thomson (Lord Kelvin) sur les unités électriques, 1883; (b) Proposition pour le nom de l'unité de conductance électrique.

5. Qui a donné son nom à la Tour Eiffel ?

Vous avez probablement entendu parler de la Tour Eiffel, la célèbre tour de Paris, en France. C'est une tour en treillis de fer, et c'était la pièce maîtresse de l'Exposition universelle de 1889. La tour mesure 330 mètres de hauteur, soit à peu près la même hauteur qu'un bâtiment de 81 étages. C'était la plus haute structure artificielle du monde jusqu'en 1930. La tour a été reconnue par l›UNESCO comme site du patrimoine mondial en 1991.



(a)

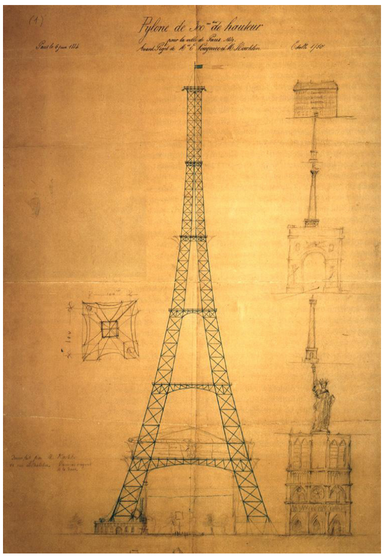


(b)

Figure 5.1. (a) Affiche de l'Exposition Universelle de Paris, 1889; (b) Comparaison des hauteurs de bâtiments connus, dans la publication La Ilustración Artística, 1889, 367, pp.3.

La conception de la tour est attribuée à Maurice Koechlin et Émile Nouguier, deux ingénieurs, et à Stephen Sauvestre, un architecte. Il a été conçu comme « un grand pylône, composé de quatre poutres en treillis se tenant et qui s'élèvent obliquement pour se rejoindre au sommet, reliées entre elles par des plates-formes métalliques à intervalles réguliers », selon les mots de Koechlin. Notez la pile de bâtiments esquissée, avec Notre-Dame en bas, indiquant l'échelle de la tour proposée.

Le brevet a été déposé en 1884. La tour a été construite de 1887 à 1889.



(a)

(b)

Figure 5.2. (a) Croquis de Maurice Koechlin et Émile Nouguier et comparaison de l'empilement de bâtiments connus; (b) Tour Eiffel, site du patrimoine mondial de l'UNESCO en 1991.

Les concepteurs ont travaillé pour la Compagnie des Établissements Eiffel, l'entreprise de l'ingénieur Gustave Eiffel. La Tour Eiffel a été nommée d'après Alexandre Gustave Eiffel (1832 - 1923), un ingénieur civil Français.

Figure 5.3. Gustave Eiffel, 1890.

Diplômé de l'École Centrale des Arts et Manufactures de Paris, il s'est fait connaître comme ingénieur de divers ponts pour le Réseau ferroviaire français. En 1868, il est co-fondateur de la société Eiffel and Company et commence à travailler dans d'autres pays d'Europe et à l'étranger.

(a)

(b)

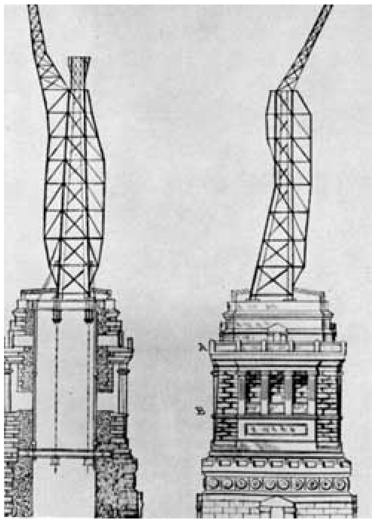
(c)

(d)

Figure 5.4. (a) Pont de Bordeaux, France, 1861; (b) Gare de Budapest, 1877; (c) Pont Maria Pia à Porto (Portugal), 1877; (d) Pont de Belvárosi à Szeged, Hongrie, 1881.

En 1881, Eiffel conçoit une structure composée d'un pylône à quatre pieds pour soutenir les tôles en cuivre qui forment le corps de la Statue de la Liberté à New York. La statue entière a été érigée dans l'usine d'Eiffel à Paris avant d'être démontée et expédiée aux États-Unis.

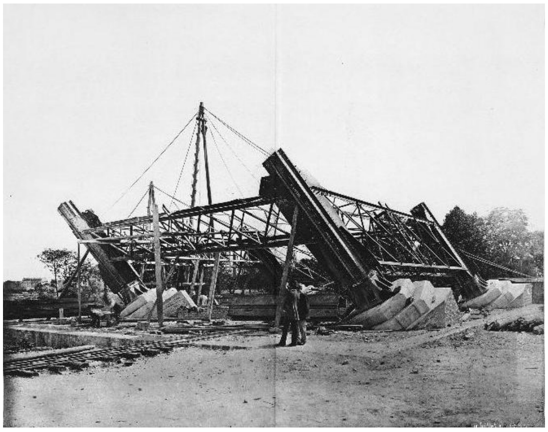
(a)



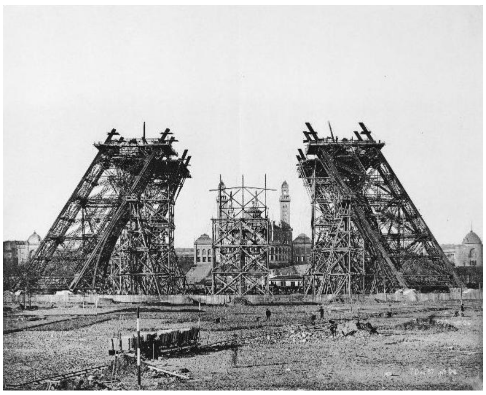
(b)

Figure 5.5. (a) La Statue de la Liberté, New York; (b) Structure interne de la Statue de la Liberté.

La Tour Eiffel est l'œuvre la plus célèbre de Gustave Eiffel. Le brevet 164 364 a été déposé le 18 septembre 1884. La tour a été construite de 1887 à 1889. Les principaux travaux de gros œuvre sont achevés à la fin du mois de mars 1889 et, le 31 mars, Eiffel a célébré son achèvement en emmenant un groupe de personnes officielles du gouvernement et de représentants de la presse au sommet de la tour. Comme les ascenseurs n'étaient pas encore en fonction, l'ascension s'est faite à pied et a duré plus d'une heure.



(a)



(b)

(c)

(d)

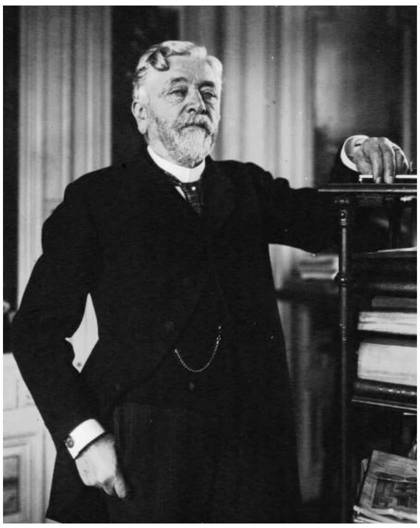
(e)

(f)

(g)

Figure 5.6. Construction de la Tour Eiffel (a) 1er juillet 1887; (b) le 2 décembre 1887; (c) le 3 mars 1888; (d) le 4 mai 1888; (e) le 5 août 1888; (f) 6 décembre 1888; (g) 7 mars 1889.

En 1893, Eiffel démissionne de la direction de la Compagnie des Établissements Eiffel et son nom disparaît du nom de la société. Il a ensuite commencé une carrière de chercheur en aérodynamique et sa contribution dans ce domaine est susceptible d'être aussi importante que son travail d'ingénieur, mais qui sont considérablement moins connues. À cette époque, il a plus de 70 ans. Une nouvelle carrière de scientifique commence pour lui et qui va durer vingt ans.

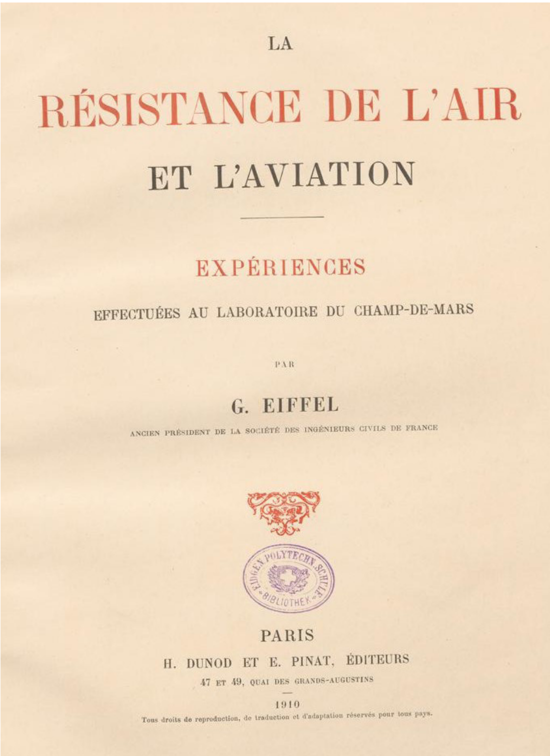


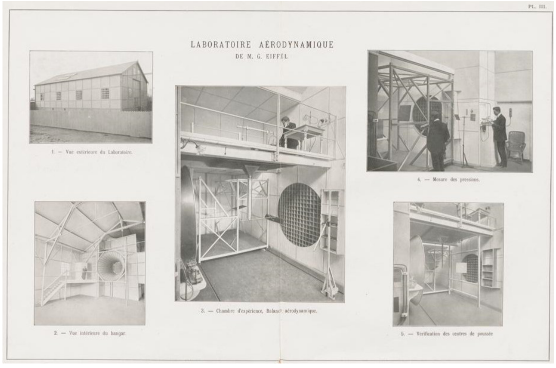
(a)

(b)

Figure 5.7. (a) Gustave Eiffel, 1910; (b) Eiffel avec une maquette d'avion.

En 1909, Eiffel construit sa première soufflerie au pied de la Tour Eiffel sur le Champ de Mars. Cette installation a été opérationnelle jusqu'en 1911 pour étudier l'aérodynamique. Au début de 1912, il installe dans le quartier d'Auteuil une nouvelle soufflerie aux performances accrues. Réussissant sa première série d'essais, la soufflerie d'Eiffel est alors à la disposition des pionniers dans leur conquête de l'air: Farman, Blériot, Voisin, Bréguet.





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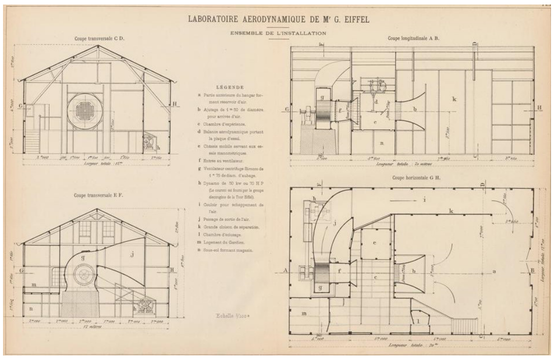


(a) (c)

Figure 5.8. (a) Couverture du livre d'Eiffel sur l'aérodynamique, 1910; (b) Photographie du laboratoire d'Eiffel; (c) Plan du laboratoire

L'une des principales innovations d'Eiffel a été l'ajout d'un diffuseur à la soufflerie. Il a fait l'objet d'un brevet daté du 28 novembre 1911. Cette invention a eu de nombreux avantages, car elle a permis à Eiffel de réduire drastiquement la puissance électrique requise pour une telle installation. Depuis cette date, toutes les souffleries sont équipées d'un diffuseur.

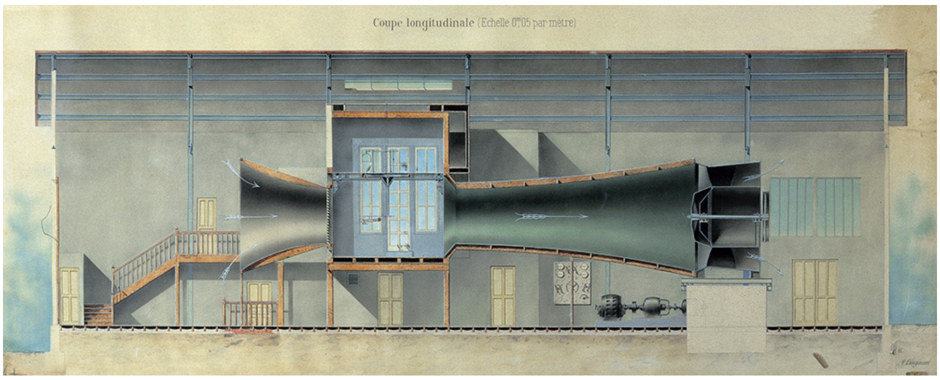


Figure 5.9. Soufflerie de Eiffel.

Ses études sur les performances des avions ont été publiées dans plusieurs livres et revues. En 1917, il a déposé même un brevet pour un avion de chasse à grande vitesse.

La contribution d'Eiffel à cette science émergente de l'aérodynamique a été reconnue aux États-Unis, où il a reçu la médaille d'or de Langley en 1913, qui n'avait auparavant été décernée qu'à Wilbur et Orville Wright.

6. Qui a donné son nom aux prix Nobel ?

Les prix Nobel, qui sont connus dans le monde entier, sont cinq prix décernés à ceux qui ont apporté le plus grand bénéfice à l'humanité. Les prix Nobel sont décernés dans les domaines de la physique, de la chimie, de la physiologie ou de la médecine, de la littérature et de la paix depuis 1901. Le Prix en sciences économiques a été ajouté en 1969. Les prix Nobel sont largement considérés comme les prix les plus prestigieux disponibles dans leurs domaines respectifs.

Entre 1901 et 2017, les prix Nobel ont été décernés 585 fois à 923 personnes et organisations. Le prix Nobel n'a pas été décerné entre 1940 et 1942 en raison du déclenchement de la Seconde Guerre mondiale. Chaque lauréat reçoit une médaille d'or, un diplôme et une récompense monétaire.

(a) (b)

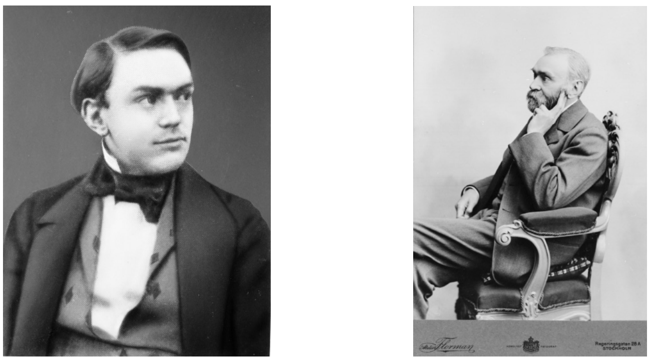
Figure 6.1. (a) Médaille du prix Nobel; (b) Diplôme du prix Nobel.

Parmi les Lauréats, il y a quelques curiosités.

Six lauréats ont reçu plus d'un prix. Le Comité international de la Croix-Rouge a reçu trois fois le prix Nobel de la paix, plus que tout autre. Le Haut-Commissariat des Nations Unies pour les réfugiés (HCR) a reçu le prix Nobel de la paix à deux reprises. En physique, il a été décerné à John Bardeen à deux reprises. Idem en Chimie pour Frederick Sanger. Deux lauréats ont été récompensés deux fois mais pas dans le même domaine: Marie Curie (Physique et Chimie) et Linus Pauling (Chimie et Paix). Parmi les 892 lauréats du prix Nobel, 48 étaient des femmes. (Jusqu'à 2021). Six lauréats du prix Nobel n'ont pas été autorisés à accepter le prix Nobel par leurs gouvernements: quatre Allemands (1936-1939), un Chinois (2010) et un Russe (1958). Deux lauréats du prix Nobel ont refusé le prix, qui sont Jean-Paul Sartre (Littérature, 1964) et Lê Đức Thọ (Paix, 1973).

Qui a donné son nom aux prix Nobel ?

Les prix Nobel ont été nommés par son créateur, Alfred Bernhard Nobel (1833 - 1896). Nobel était un chimiste, ingénieur, inventeur, homme d'affaires et philanthrope suédois. Il est né à Stockholm, où il a vécu sa petite enfance. En 1842, il déménage avec sa famille à Saint-Pétersbourg, où la famille possède une entreprise de fabrication de machines-outils et d'explosifs. Alfred Nobel a hérité de son père son intérêt pour la technologie et l'ingénierie

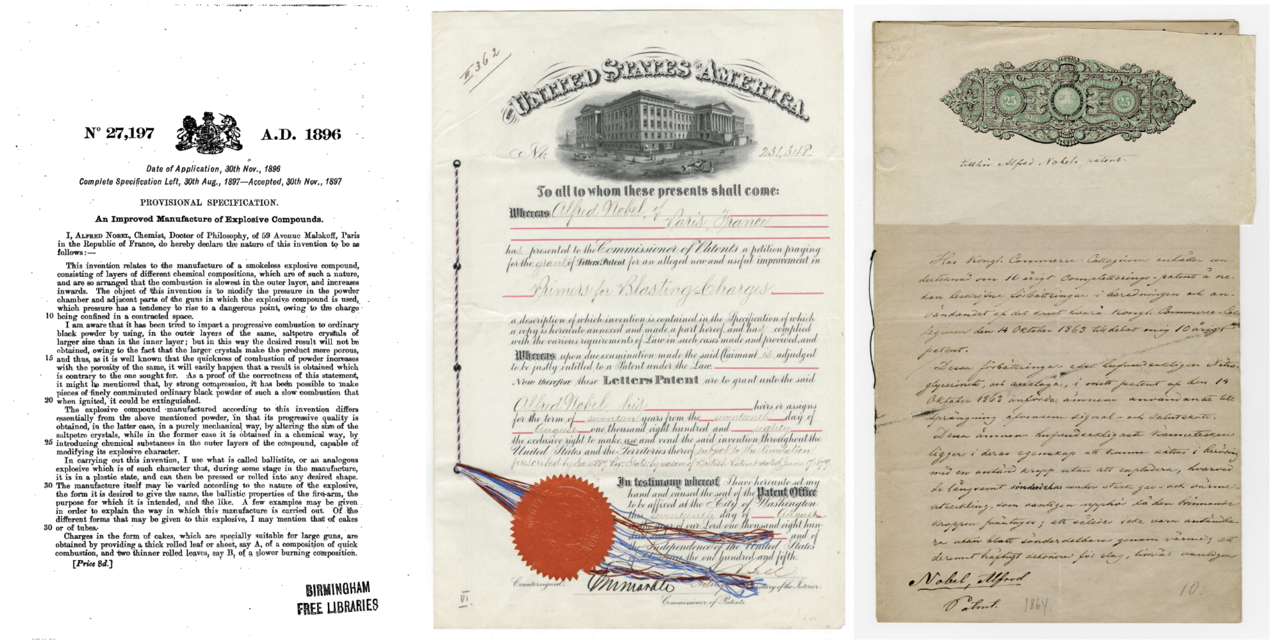


(a) (b)

Figure 6.2. (a) Alfred Nobel, jeune (b) Alfred Nobel, adulte.

Nobel est devenu un excellent inventeur et ingénieur. Il a déposé son premier brevet pour un compteur de gaz en 1857. Durant sa vie, Nobel a remporté 355 brevets à l'échelle internationale.

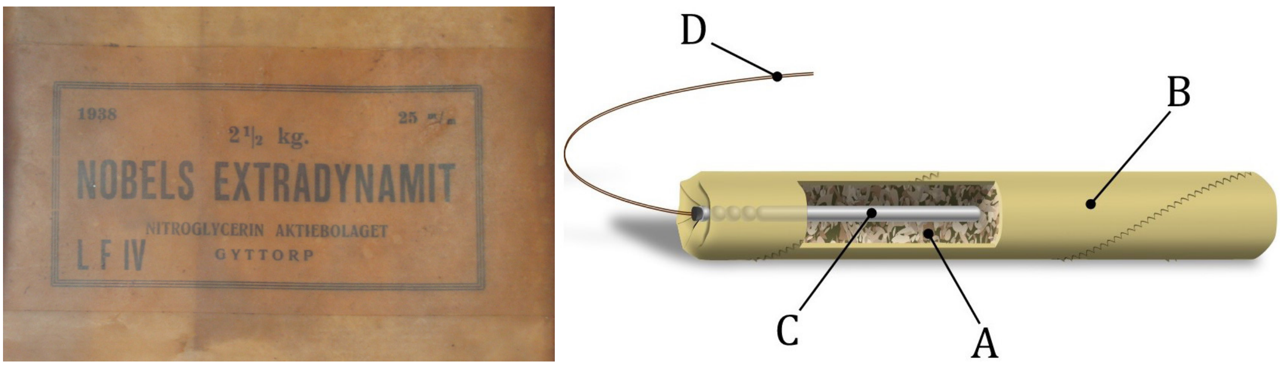
De retour en Suède en 1859, Nobel se consacre à l'étude des explosifs et invente un détonateur en 1863 et la dynamite en 1867, cette dernière est une substance plus facile et plus sûre à manipuler que la nitroglycérine qui est tellement instable. La dynamite a été brevetée aux États-Unis et au Royaume-Uni et elle a été largement utilisée dans l'exploitation minière et la construction de réseaux de transport à l'échelle internationale.



(a) (b) (d)

Figure 6.3. Les brevets d'Alfred Nobel sur les explosifs (a) Grande-Bretagne; (b) États-Unis d'Amérique; (c) Suède.

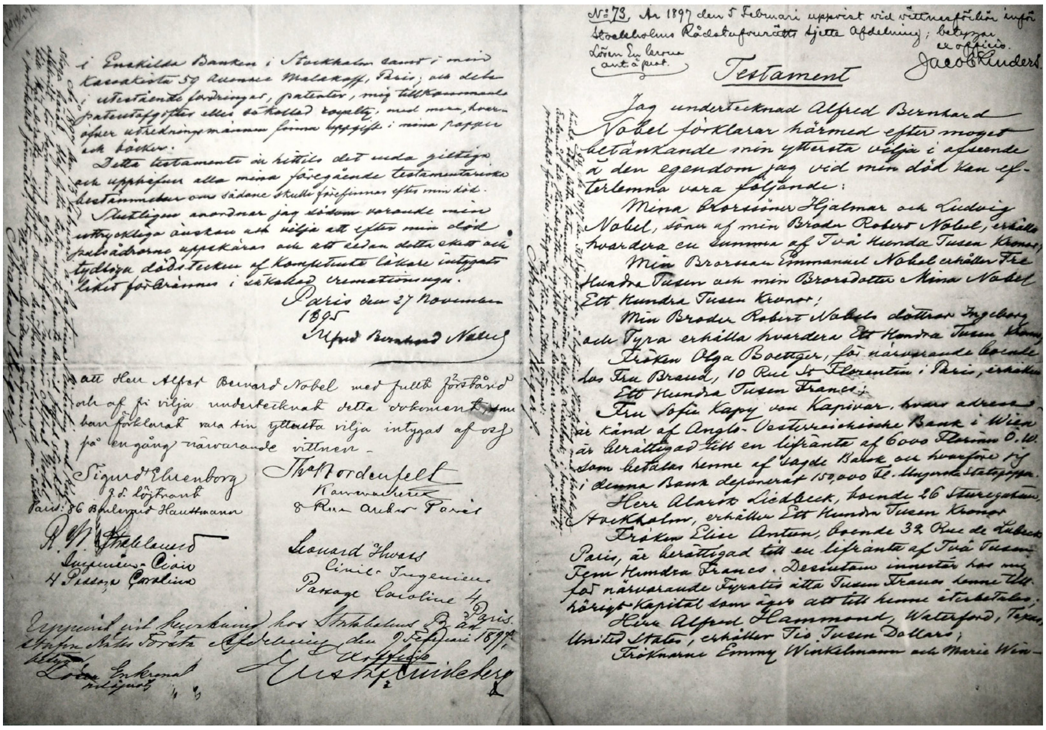
Afin d'améliorer l'image de son entreprise par rapport aux controverses antérieures associées aux explosifs dangereux et à la guerre, Nobel avait également envisagé de nommer la substance très puissante « Nobel's Safety Powder », mais s'est plutôt contenté de Dynamite, se référant au mot grec pour "puissance" (δύναμις). À la fin de sa vie, son entreprise avait établi plus de 90 usines d'armement, malgré son caractère apparemment pacifiste.



(a) (b)

Figure 6.4. (a) Boîte de dynamite Nobel (b) Cartouche de dynamite: [A] Terre de diatomées (ou tout autre type de matériau absorbant) imbibée de nitroglycérine, [B] Revêtement protecteur entourant la matière explosive, [C] Détonateur, [D] Fil connecté au détonateur.

À la fin de sa vie, Nobel a décidé de faire don de la majorité de sa richesse pour fonder le prix Nobel comme son meilleur héritage. En 1895, il signa son dernier testament et mit de côté la majeure partie de sa succession pour établir les prix Nobel, qui seront décernés chaque année sans distinction de nationalité.



i Enskilda Banken i Stockholm samt i mina Kassakistor 59 Avenue Malakoff, Paris; och dels i utestående fordringar, patenter, mig tillkommande patentafgifter eller så kallad royalty, med mera, hvarefter utredningsmännen finna upplysning i mina papper och böcker.
Detta testamente är hittils det enda gällande och upphäfver alla mina föregående testamentariska bestämmelser om sådane skulle förefinnas efter min död.
Slutligen anordnar jag såsom varande min uttryckliga önskan och vilja att efter min död pulsådrorna uppskäras och att sedan detta skett och tydliga dödstecken af kompetente läkare intygats liket förbrännes i sekaled crematorium.
Paris den 27 November 1895
Alfred Bernhard Nobel

Att Herr Alfred Bernhard Nobel med fullt förstånd och af fri vilja undertecknat detta dokument som han förklarat vara sin yttersta vilja intyga af oss på en gång närvarande vittnen –
Sigurd Ehrenborg, f.d. Löjtnant, Paris: 84 Boulevard Haussmann
R. W. Strehlenert, Civilingeniör, 4 Passage Caroline
Thos Nordenfelt, Konstruktör, 8 Rue Auber Paris
Leonard Hwass, Civilingeniör, 4 Passage Caroline

Testament

Jag undertecknad Alfred Bernhard Nobel förklarar härmed efter moget betänkande min yttersta vilja i afseende å den egendom jag vid min död kan efterlemna vara följande:
Mina Brorsöner Hjalmar och Ludvig Nobel, söner af min Broder Robert Nobel, erhålla hvardera en Summa af Två Hundra Tusen Kronor;
Min Brorson Emmanuel Nobel erhåller Tre Hundra Tusen och min Brorsdotter Mina Nobel Ett Hundra Tusen Kronor;
Min Broder Robert Nobels döttrar Ingeborg och Tyra erhålla hvardera Ett Hundra Tusen Kronor;
Fröken Olga Boettger, för närvarande boende hos Fru Brand, 10 Rue St Florentin i Paris, erhåller Ett Hundra Tusen Francs;
Fru Sofie Kapy von Kapivar, hvars adress är känd af Anglo-Oesterreichische Bank i Wien, är berättigad till en lifränta af 6000 Florins Ö.W. som betalas henne af sagde Bank och hvarför jag i denna Bank deponerat 150,000 Fl. i Ungerska Statspapper.
Herr Alarik Liedbeck, boende 26 Sturegatan Stockholm, erhåller Ett Hundra Tusen Kronor;
Fröken Elise Antun, boende 32 Rue de Lubeck, Paris, är berättigad till en lifränta af Två Tusen Fem Hundra Francs. Dessutom innestår hos mig för närvarande Fyrtioåtta Tusen Francs henne tillhöriga Kapital som skall återbetalas.
Herr Alfred Hammond, Waterford, Texas, United States, erhåller Tio Tusen Dollars;
Fröknarne Emmy Winkelmann och Marie Win-

Figure 6.5. Testament d'Alfred Nobel, 1895.

Nobel a été élu membre de l'Académie royale des sciences de Suède en 1884, la même institution qui sélectionnera plus tard les lauréats pour deux des prix Nobel, et il a reçu un doctorat honorifique de l'Université d'Uppsala en 1893. L'élément chimique Nobelium, avec le symbole No et le numéro atomique 102, a été nommé en l'honneur d'Alfred Nobel. Comme tous les éléments de numéro atomique supérieur à 100, le nobélium ne peut être produit que dans des accélérateurs de particules.

Nobel était aussi un poète et un dramaturge avec un goût pour la mélodramatique, bien que la plupart de ses écrits soient restés inédits. Nobel a écrit le dramaturge Nemesis dans la dernière année de sa vie et le scénario a reçu une publication limitée après sa mort en 1896. Après un siècle, la première, et jusqu'à présent, la seule production a eu lieu au théâtre Intima de Strindberg à Stockholm en 2005.

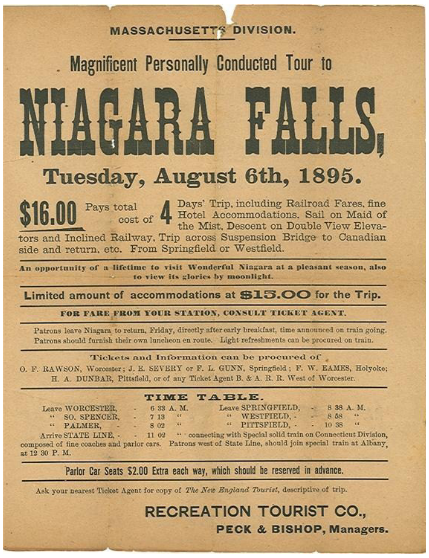
(a) (b)

Figure 6.6. (a) Intima Theater de Strindberg à Estocolmo; (b) Bibliothèque privée d'Alfred Nobel à Björkborn Manor, Karlskoga, Sweden.

L'énorme intérêt d'Alfred Nobel pour la littérature et l'écriture se reflète dans ses collections de livres. Après sa mort, il a laissé une bibliothèque privée de plus de 1500 volumes, principalement des fictions dans la langue originale, des œuvres des grands écrivains du 19ème siècle, mais aussi des classiques et des œuvres de philosophes, théologiens, historiens et autres scientifiques.

7. Qui était le concepteur du « Aero Car » aux chutes du Niagara ?

Les chutes du Niagara comptent parmi les plus grandes, les plus belles et les plus célèbres cascades au monde. Il se compose d'un groupe de trois chutes d'eau à l'extrémité sud de la gorge du Niagara, enjambant la frontière entre la province canadienne de l'Ontario et l'Etat américain du New York. Les chutes sont situées sur la rivière du Niagara et qui relie le lac Érié au lac Ontario. En plus de sa beauté naturelle, les chutes du Niagara sont également une source importante d'énergie hydroélectrique. L'équilibre entre les utilisations récréatives, commerciales et industrielles a été un défi pour les intendants des chutes depuis le 19e siècle.



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Patrons leave Niagara to return, Friday, directly after early breakfast, time announced on train going. Patrons should furnish their own luncheon en route. Light refreshments can be procured on train.

Tickets and Information can be procured of
O. F. RAWSON, Worcester; J. E. SEVERY or F. L. GUNN, Springfield; F. W. EAMES, Holyoke; H. A. DUNBAR, Pittsfield, or of any Ticket Agent B. & A. R. R. West of Worcester.

TIME TABLE.

Leave WORCESTER,	6 33 A. M.	Leave SPRINGFIELD,	8 38 A. M.
" SO. SPENCER,	7 13 "	" WESTFIELD,	8 58 "
" PALMER,	8 02 "	" PITTSFIELD,	10 38 "
Arrive STATE LINE,	11 02 "		

connecting with Special solid train on Connecticut Division, composed of fine coaches and parlor cars. Patrons west of State Line, should join special train at Albany, at 12 30 P. M.

Parlor Car Seats $2.00 Extra each way, which should be reserved in advance.

Ask your nearest Ticket Agent for copy of *The New England Tourist*, descriptive of trip.

RECREATION TOURIST CO.,
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(a)

(b)

Figure 7.1. (a) Annonce des chutes du Niagara 1895; (b) Vue panoramique des chutes du Niagara.

L'une des principales attractions touristiques des chutes du Niagara est la voiture Aero-Car, une balade inoubliable sur les eaux vibrantes de la rivière Niagara offre aux passagers des vues spectaculaires sur le tourbillon du Niagara et les rapides de la rivière.

(a)

(b)

Figure 7.2. (a) Vue panoramique de l'Aero-Car; (b) Voiture Aero-Car.

En 1913, Le Parc du Niagara a été approché par un groupe d'hommes d'affaires espagnols qui étaient intéressés par la construction d'un nouveau téléphérique pour transporter les visiteurs à travers le tourbillon du Niagara. L'objectif était de fournir une perspective entièrement nouvelle de la gorge et d'offrir une vue imprenable sur ce phénomène naturel.

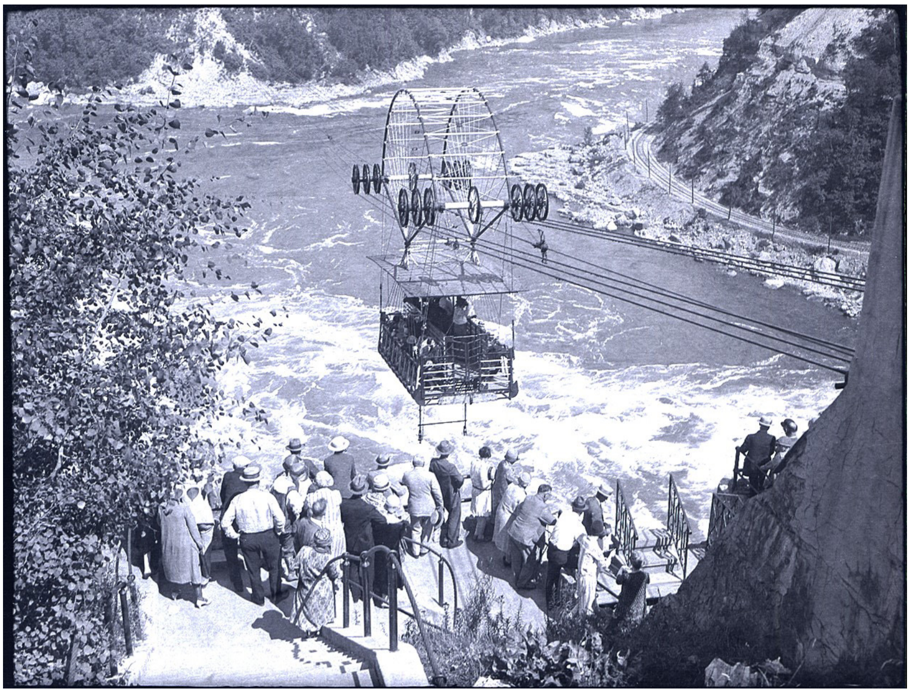
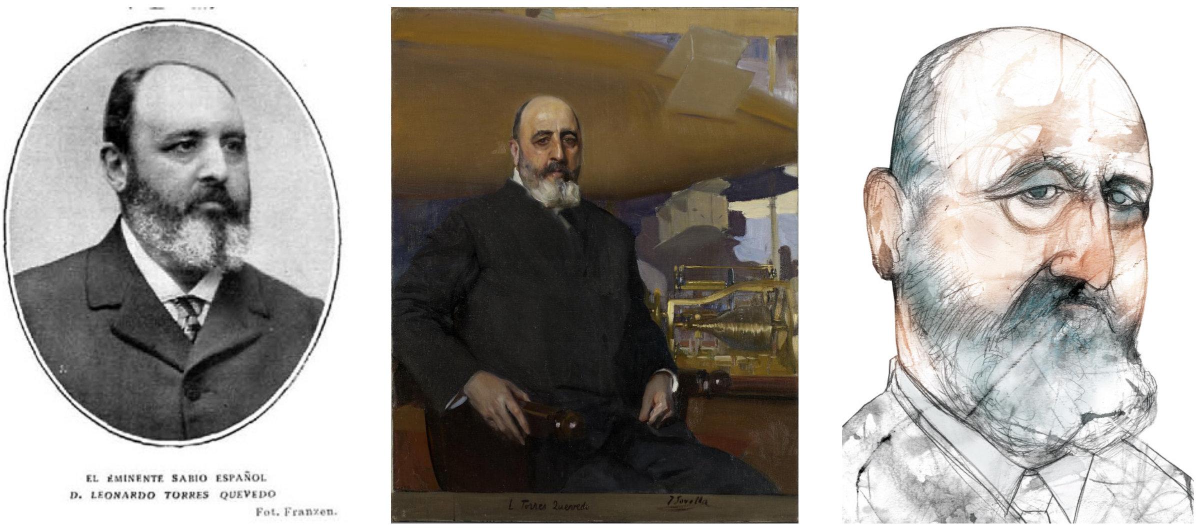


Figure 7.3. Aero-Car en 1926.

Qui était le concepteur du « Aero Car » aux chutes du Niagara ?

Le concepteur était Leonardo Torres Quevedo (1852 – 1936), un ingénieur civil et mathématicien espagnol de la fin du 19e et du début du 20e siècle. Torres a été un pionnier dans le développement des machines de radiocommande et de calculs automatisés, aussi il est connu pour ses travaux sur les principes de fonctionnement à distance sans fil. Il a également été un concepteur novateur de dirigeables aérostatiques et de téléphériques, comme la voiture Aero-Car située aux chutes du Niagara. Il est l'auteur d'un grand nombre de brevets dans le monde entier.

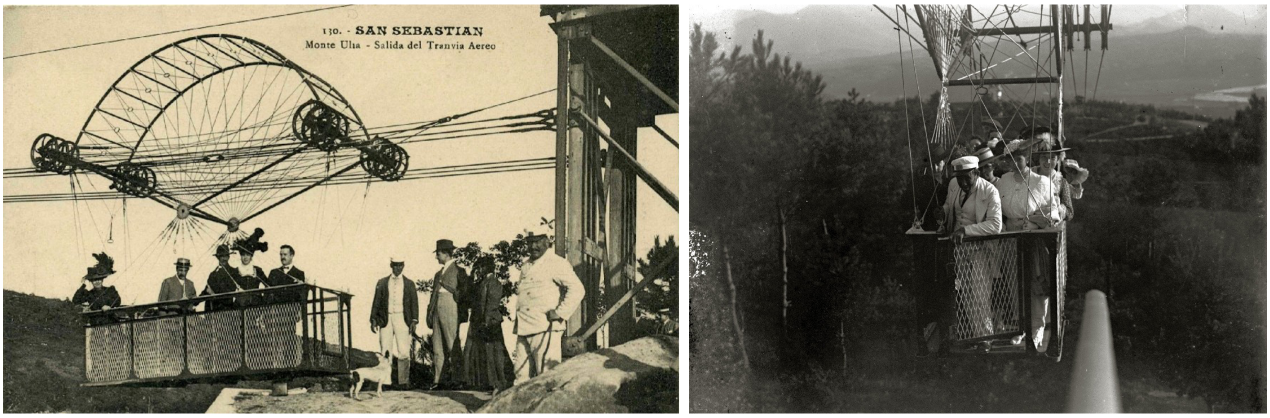


(a) (b) (c)

Figure 7.4. Leonardo Torres Quevedo. (a) Photographie par C. Franzen, 1916 (b) Portrait par J. Sorolla, 1917; (c) Portrait par E. Merle, FECYT, 2011.

En plus de ses réalisations techniques, Torres Quevedo a également été honoré pour ses contributions à la science et à la société. En 1910, Il a été élu président de l'Académie Royale des Sciences Exactes, Physiques et Naturelles de Madrid, et en 1920, il a été admis à l'Académie Royale Espagnole et à l'Académie Française des Sciences. Il a également reçu un doctorat honoris causa de la Sorbonne à Paris en 1922.

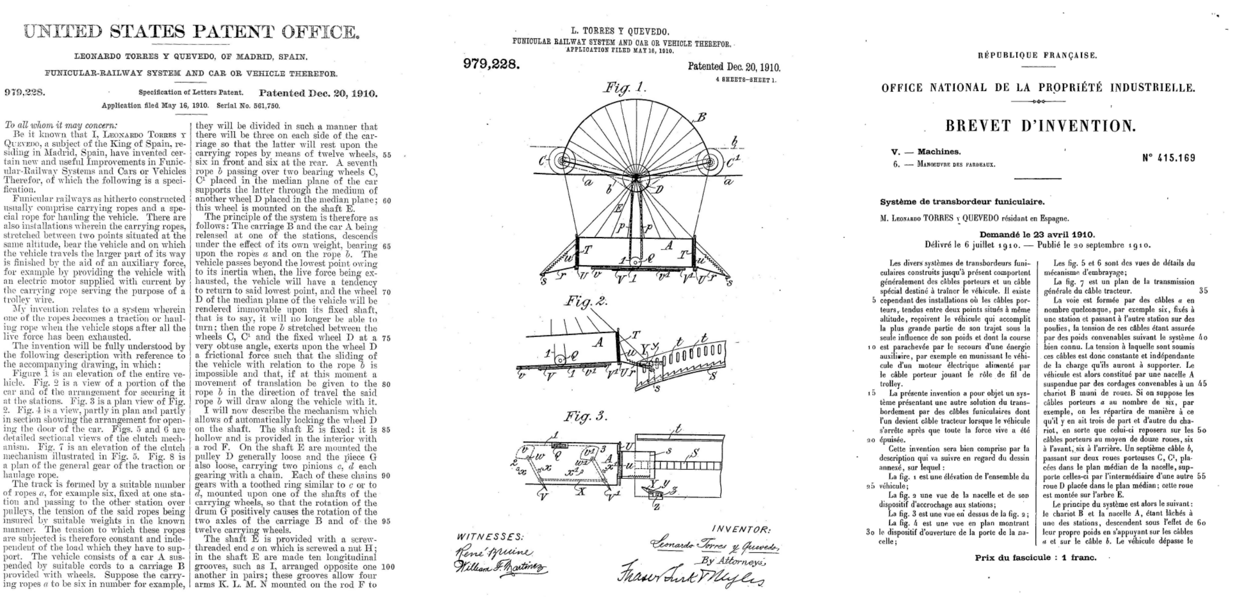
L'expérimentation de Torres dans le domaine des téléphériques a commencé dès 1887. En 1907, Torres a construit le premier téléphérique aérien adapté au transport public de personnes, dans le mont Ulía à Saint-Sébastien en Espagne. Le problème de la sécurité a été résolu au moyen d'un ingénieux système de câbles de support multiples. Cette conception a était très solide et résistait parfaitement à la rupture de l'un des câbles de support.



(a) (b)

Figure 7.5. Téléphérique du Monte Ulía, San Sebastián. (a)1907; (b) 1916.

Le téléphérique Aero-Car conçue et brevetée par l'ingénieur espagnol survole la gorge du Niagara depuis 1916. Il a conçu cette attraction suivant les principes de l'installation similaire à Saint-Sébastien.



UNITED STATES PATENT OFFICE.

LEONARDO TORRES Y QUEVEDO, OF MADRID, SPAIN.

FUNICULAR-RAILWAY SYSTEM AND CAR OR VEHICLE THEREFOR.

979,228. Specification of Letters Patent. Patented Dec. 20, 1910.

Application filed May 16, 1910. Serial No. 561,750.

To all whom it may concern:

Be it known that I, Leonardo Torres y Quevedo, a subject of the King of Spain, residing in Madrid, Spain, have invented certain new and useful Improvements in Funicular-Railway Systems and Cars or Vehicles Therefor, of which the following is a specification.

Funicular railways as hitherto constructed usually comprise carrying ropes and a special rope for hauling the vehicle. There are also installations wherein the carrying ropes, stretched between two points situated at the same altitude, bear the vehicle and on which the vehicle travels the larger part of its way is finished by the aid of an auxiliary force, for example by providing the vehicle with an electric motor supplied with current by the carrying rope serving the purpose of a trolley wire.

My invention relates to a system wherein one of the ropes becomes a traction or hauling rope when the vehicle stops after all the live force has been exhausted.

The invention will be fully understood by the following description with reference to the accompanying drawing, in which:

Figure 1 is an elevation of the entire vehicle. Fig. 2 is a view of a portion of the car and of the arrangement for securing it at the stations. Fig. 3 is a plan view of Fig. 2. Fig. 4 is a view, partly in plan and partly in section showing the arrangement for opening the door of the car. Figs. 5 and 6 are detailed sectional views of the clutch mechanism. Fig. 7 is an elevation of the clutch mechanism illustrated in Fig. 5. Fig. 8 is a plan of the general gear of the traction or haulage rope.

The track is formed by a suitable number of ropes *a*, for example six, fixed at one station and passing to the other station over pulleys, the tension of the said ropes being insured by suitable weights in the known manner. The tension to which these ropes are subjected is therefore constant and independent of the load which they have to support. The vehicle consists of a car A suspended by suitable cords to a carriage B provided with wheels. Suppose the carrying ropes *a* to be six in number for example, they will be divided in such a manner that there will be three on each side of the carriage so that the latter will rest upon the carrying ropes by means of twelve wheels, six in front and six at the rear. A seventh rope *b* passing over two bearing wheels C, C^1 placed in the median plane of the car supports the latter through the medium of another wheel D placed in the median plane; this wheel is mounted on the shaft E.

The principle of the system is therefore as follows: The carriage B and the car A being released at one of the stations, descends under the effect of its own weight, bearing upon the ropes *a* and on the rope *b*. The vehicle passes beyond the lowest point owing to its inertia when, the live force being exhausted, the vehicle will have a tendency to return to said lowest point, and the wheel D of the median plane of the vehicle will be rendered immovable upon its fixed shaft, that is to say, it will no longer be able to turn; then the rope *b* stretched between the wheels C, C^1 and the fixed wheel D at a very obtuse angle, exerts upon the wheel D a frictional force such that the sliding of the vehicle with relation to the rope *b* is impossible and that, if at this moment a movement of translation be given to the rope *b* in the direction of travel the said rope *b* will draw along the vehicle with it.

I will now describe the mechanism which allows of automatically locking the wheel D on the shaft. The shaft E is fixed: it is hollow and is provided in the interior with a rod F. On the shaft E are mounted the pulley D generally loose and the piece G also loose, carrying two pinions *c*, *d* each gearing with a chain. Each of these chains gears with a toothed ring similar to *c* or to *d*, mounted upon one of the shafts of the carrying wheels, so that the rotation of the drum G positively causes the rotation of the two axles of the carriage B and of the twelve carrying wheels.

The shaft E is provided with a screw-threaded end *e* on which is screwed a nut H; in the shaft E are made ten longitudinal grooves, such as I, arranged opposite one another in pairs; these grooves allow four arms K. L. M. N mounted on the rod F to

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BREVET D'INVENTION.

V. — Machines.
6. — Manœuvre des fardeaux.

N° 415.169

Système de transbordeur funiculaire.

M. Leonardo TORRES y QUEVEDO résidant en Espagne.

Demandé le 23 avril 1910.
Délivré le 6 juillet 1910. — Publié le 20 septembre 1910.

Les divers systèmes de transbordeurs funiculaires construits jusqu'à présent comportent généralement des câbles porteurs et un câble spécial destiné à traîner le véhicule. Il existe cependant des installations où les câbles porteurs, tendus entre deux points situés à même altitude, reçoivent le véhicule qui accomplit la plus grande partie de son trajet sous la seule influence de son poids et dont la course est parachevée par le secours d'une énergie auxiliaire, par exemple en munissant le véhicule d'un moteur électrique alimenté par le câble porteur jouant le rôle de fil de trolley.

La présente invention a pour objet un système présentant une autre solution du transbordement par des câbles funiculaires dont l'un devient câble tracteur lorsque le véhicule s'arrête après que toute la force vive a été épuisée.

Cette invention sera bien comprise par la description qui va suivre en regard du dessin annexé, sur lequel :

La fig. 1 est une élévation de l'ensemble du véhicule;

La fig. 2 une vue de la nacelle et de son dispositif d'accrochage aux stations;

La fig. 3 est une vue en dessus de la fig. 2;

La fig. 4 est une vue en plan montrant le dispositif d'ouverture de la porte de la nacelle;

Les fig. 5 et 6 sont des vues de détails du mécanisme d'embrayage;

La fig. 7 est un plan de la transmission générale du câble tracteur.

La voie est formée par des câbles *a* en nombre quelconque, par exemple six, fixés à une station et passant à l'autre station sur des poulies, la tension de ces câbles étant assurée par des poids convenables suivant le système bien connu. La tension à laquelle sont soumis ces câbles est donc constante et indépendante de la charge qu'ils auront à supporter. Le véhicule est alors constitué par une nacelle A suspendue par des cordages convenables à un chariot B muni de roues. Si on suppose les câbles porteurs *a* au nombre de six, par exemple, on les répartira de manière à ce qu'il y en ait trois de part et d'autre du chariot, en sorte que celui-ci reposera sur les câbles porteurs au moyen de douze roues, six à l'avant, six à l'arrière. Un septième câble *b*, passant sur deux roues portantes C, C^1 placées dans le plan médian de la nacelle, supporte celles-ci par l'intermédiaire d'une autre roue D placée dans le plan médian; cette roue est montée sur l'arbre E.

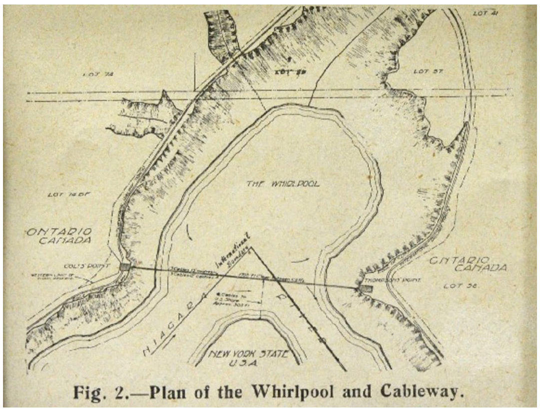
Le principe du système est alors le suivant : le chariot B et la nacelle A, étant lâchés à une des stations, descendent sous l'effet de leur propre poids en s'appuyant sur les câbles *a* et sur le câble *b*. Le véhicule dépasse le

Prix du fascicule : 1 franc.

(a) (b) (c)

Figure 7.6. Brevets pour le téléphérique de Torres Quevedo, 1910. (a) Brevet US979228A (b) Brevet US979228A, schéma; (c) Brevet FR415169A.

Bien qu'il voyage entre deux points sur la rive canadienne, les passagers de ce téléphérique antique traversent dans chaque voyage quatre fois la frontière entre le Canada et les États-Unis, en raison de la courbure de la rivière Niagara. La voiture aérienne pouvait accueillir jusqu'à 40 passagers à la fois et était suspendue à 76 mètres au-dessus de l'eau par une série de câbles en acier. La tension des lignes de câbles devait être maintenue par un contrepoids de 10 tonnes logé à son extrémité de Pointe Thompson. La voiture est propulsée par un moteur électrique de 37 kW et se déplace à une vitesse d'environ 7 km/h.



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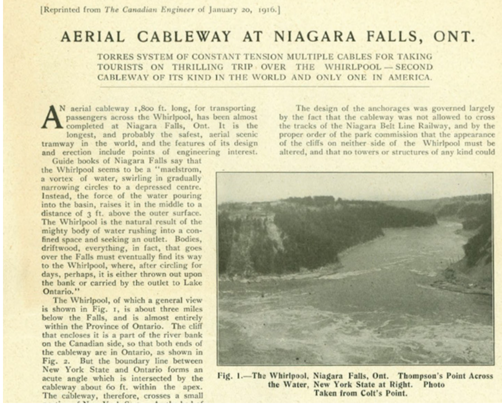


[Reprinted from *The Canadian Engineer* of January 20, 1916.]

AERIAL CABLEWAY AT NIAGARA FALLS, ONT.

TORRES SYSTEM OF CONSTANT TENSION MULTIPLE CABLES FOR TAKING TOURISTS ON THRILLING TRIP OVER THE WHIRLPOOL — SECOND CABLEWAY OF ITS KIND IN THE WORLD AND ONLY ONE IN AMERICA.

AN aerial cableway 1,800 ft. long, for transporting passengers across the Whirlpool, has been almost completed at Niagara Falls, Ont. It is the longest, and probably the safest, aerial scenic tramway in the world, and the features of its design and erection include points of engineering interest.

Guide books of Niagara Falls say that the Whirlpool seems to be a "maelstrom, a vortex of water, swirling in gradually narrowing circles to a depressed centre. Instead, the force of the water pouring into the basin, raises it in the middle to a distance of 3 ft. above the outer surface. The Whirlpool is the natural result of the mighty body of water rushing into a confined space and seeking an outlet. Bodies, driftwood, everything, in fact, that goes over the Falls must eventually find its way to the Whirlpool, where, after circling for days, perhaps, it is either thrown out upon the bank or carried by the outlet to Lake Ontario."

The Whirlpool, of which a general view is shown in Fig. 1, is about three miles below the Falls, and is almost entirely within the Province of Ontario. The cliff that encloses it is a part of the river bank on the Canadian side, so that both ends of the cableway are in Ontario, as shown in Fig. 2. But the boundary line between New York State and Ontario forms an acute angle which is intersected by the cableway about 60 ft. within the apex. The cableway, therefore, crosses a small

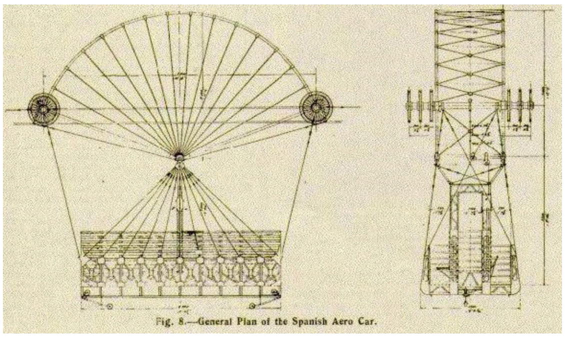
The design of the anchorages was governed largely by the fact that the cableway was not allowed to cross the tracks of the Niagara Belt Line Railway, and by the proper order of the park commission that the appearance of the cliffs on neither side of the Whirlpool must be altered, and that no towers or structures of any kind could

Fig. 1.—The Whirlpool, Niagara Falls, Ont. Thompson's Point Across the Water, New York State at Right. Photo Taken from Colt's Point.

(b)

Figure 7.7. (a) Plan des itinéraires Aero-Car entre le Canada et les États-Unis; (b) Actualités de l'Aero-Car sur *The Canadian Engineer*, 1916.

La construction a été commencée en 1915 et elle a été inaugurée le 8 août 1916. Les premiers passagers étaient des dignitaires espagnols, et la voiture était décorée avec des drapeaux de quatre nations différentes, le Canada, l'Espagne, les États-Unis et la France. En 1984, l'attraction a subi d'importantes améliorations pour moderniser ses composants mécaniques mais la voiture n'a pas été modifiée pour préserver son intégrité historique. Malgré plus de 100 ans d'existence, l'Aero Car n'a connu aucun accident digne de mention et les passagers peuvent ainsi profiter en toute sécurité des vues spectaculaires sur le tourbillon et les rapides d'eau vive de la rivière Niagara.



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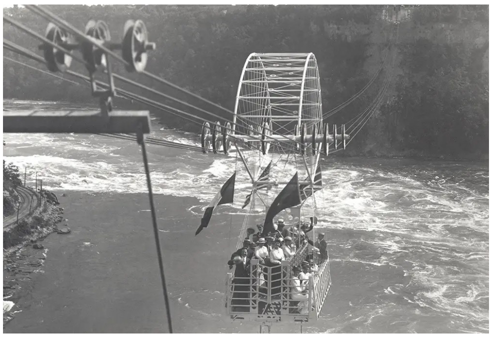
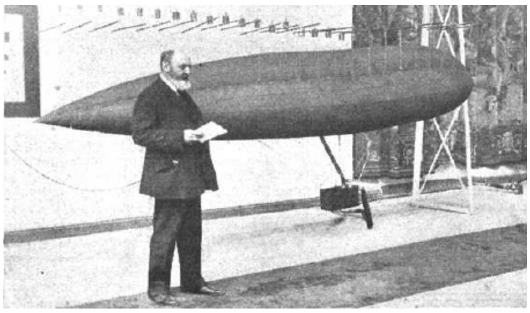


(b)

Figure 7.8. (a) Plan de l'Aero-Car por Torres Quevedo; (b) Inauguration de l'Aero-Car.

Leonardo Torres Quevedo a également travaillé sur la conception et la construction de dirigeables aérostatiques. Depuis 1902, il a développé un nouveau type de dirigeable avec un cadre interne de câbles flexibles qui donneraient au dirigeable une rigidité par le biais de la pression intérieure. En 1905, il a construit le premier dirigeable espagnol pour l'armée et, depuis 1911, la collaboration a été commencée entre Torres et la société Astra France. Les dirigeables Astra-Torres ont été largement utilisés pendant la Première Guerre mondiale, principalement pour la protection navale et l'inspection.



(a)

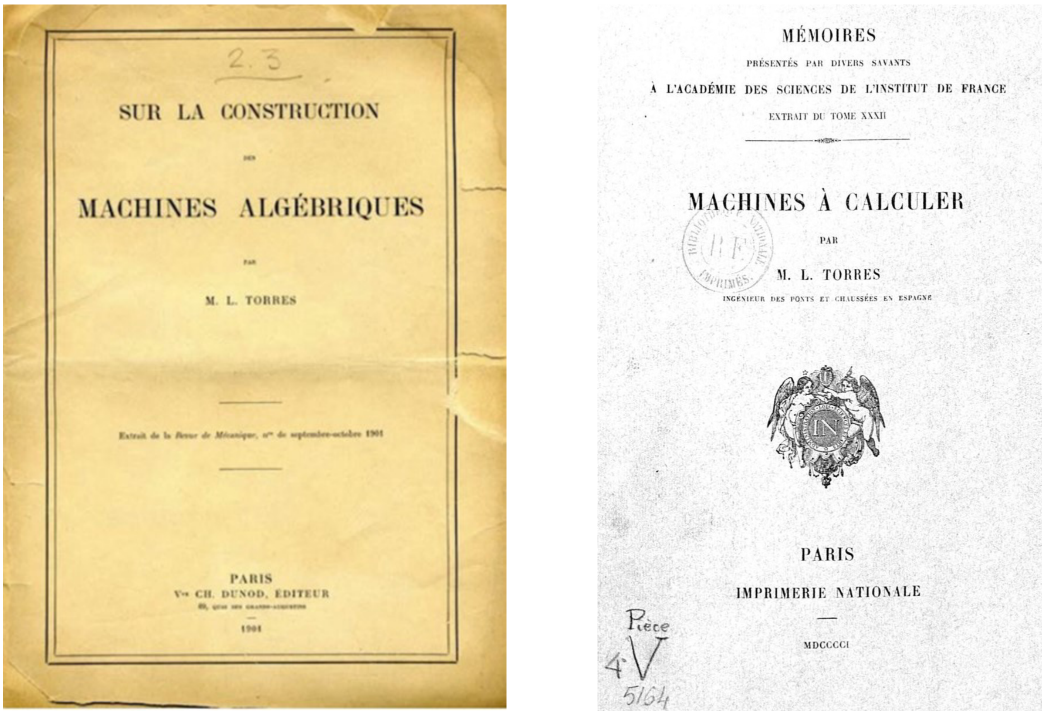
(b)

Figure 7.9. (a) Torres Quevedo et son dirigeable; (b) Dirigeable Astra-Torres, 1911.

Torres a également été un pionnier dans le domaine de la télécommande. En 1903, il a présenté le Telekino à l'Académie Française des Sciences. Le Telekino consistait en un robot qui exécutait des commandes transmises par des ondes électromagnétiques. Il a été breveté en France, en Espagne, en Grande-Bretagne et aux États-Unis. En 2007, le prestigieux Institut d'ingénieurs en électricité et électronique (IEEE) a consacré un jalon en génie électrique et informatique au Telekino.

Figure 7.10. Plaque commémorative de l'IEEE.

Finalement, de tout le travail effectué par Torres Quevedo tout au long de sa vie, sa renommée la plus universelle est probablement due à son travail en « automatique ». Il a apporté d'importantes contributions aux machines algébriques – les prédécesseurs des ordinateurs analogiques – et aux machines arithmétiques – les prédécesseurs des ordinateurs numériques modernes.



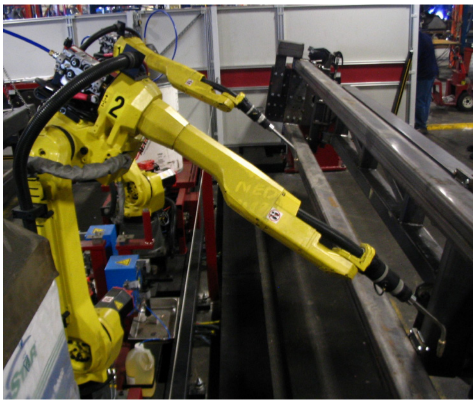
(a) (b)

Figure 7.11. Publications de Torres Quevedo (a) Machines Algébriques, 1901; (b) Machines à calculer, 1901.

En 1900, il a présenté à l'Académie Française des sciences un rapport avec une solution théorique générale et complète pour ces machines. Il a également construit des appareils électromécaniques capables de faire des calculs mathématiques.

8. Qui est considéré comme le « père de la robotique » ?

La robotique est une branche interdisciplinaire de l'informatique et de l'ingénierie. Elle implique la conception, la construction, l'exploitation et l'utilisation de robots capables d'aider et d'assister les humains. Les robots peuvent être employés dans de multiples contextes et à des fins variées, que ce soit dans les processus de fabrication, l'exploration spatiale, les prothèses pour les humains ou encore la chirurgie assistée par robot. De plus, certains de ces robots sont même conçus pour présenter une apparence similaire à celle des êtres humains.



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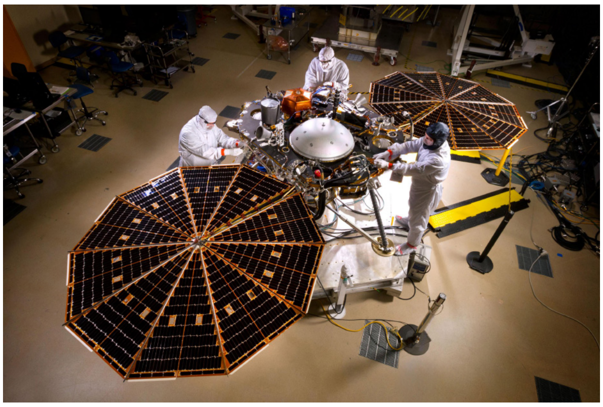

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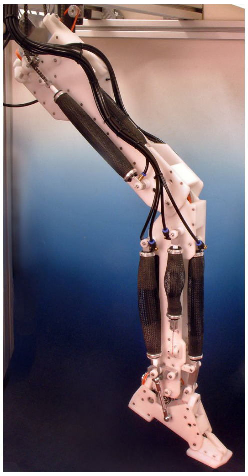

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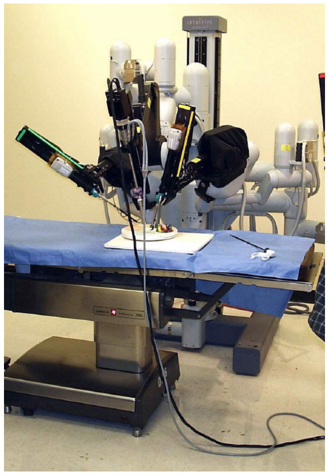

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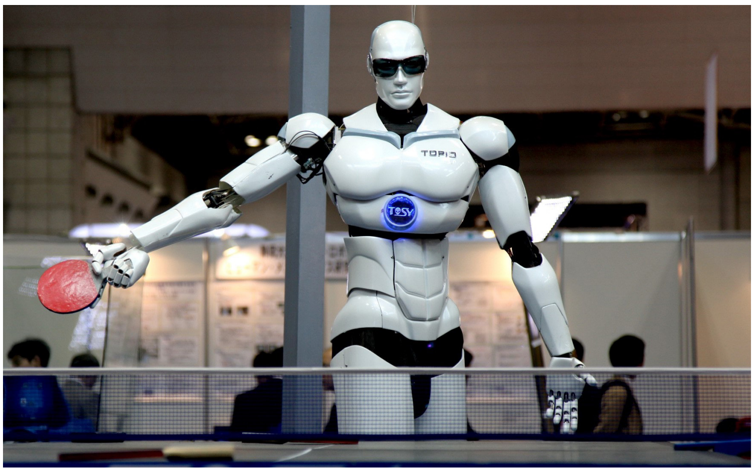
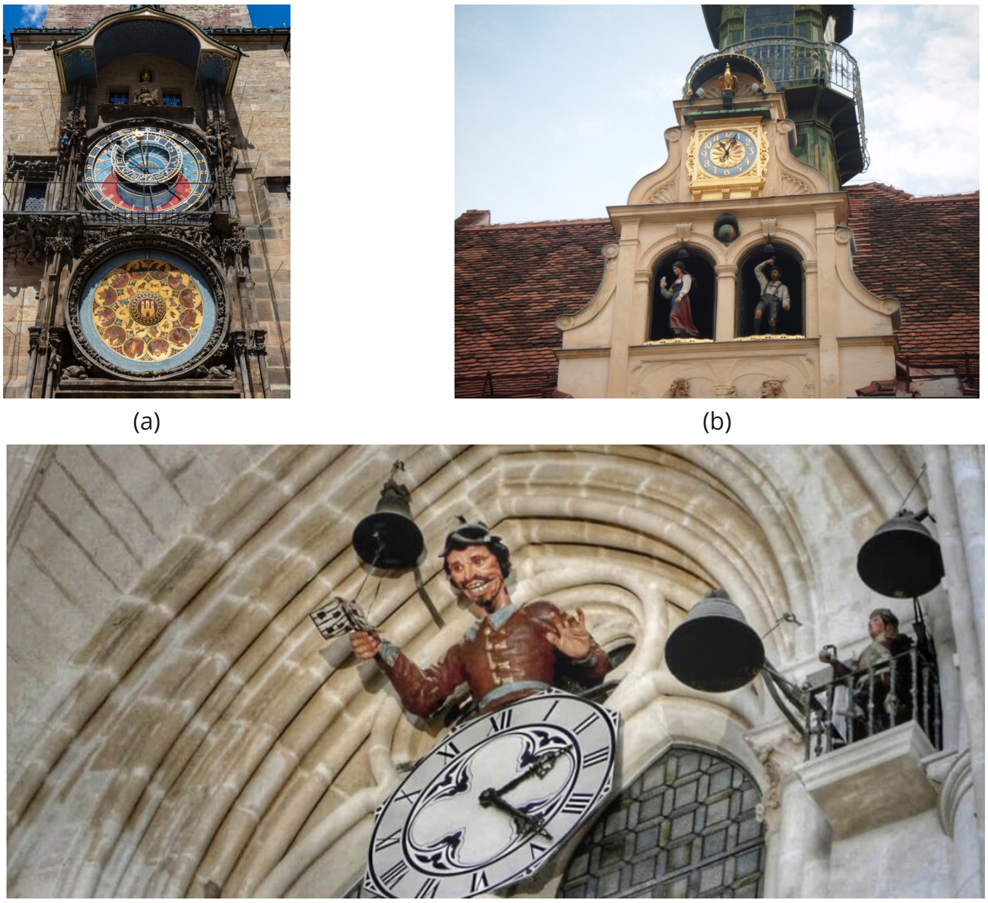


(e)

Figure 8.1. (a) robot de soudage; (b) robot d'exploration spatiale; (c) prothèses robotisées; (d) la chirurgie assistée par robot; (e) robot humanoïde.

Dès le Moyen Âge en Europe, on trouve de nombreux exemples d'automates, qui sont les prédécesseurs des robots. Parmi ces exemples, on peut citer les horloges astronomiques mécaniques avec des figurines automates qui ont commencé à être développées au 14ème siècle. L'un des automates les plus célèbres est l'horloge astronomique de Prague, qui est située à l'ancien hôtel de ville de Prague, la capitale de la République tchèque. Cette horloge a été installée pour la première fois en 1410, ce qui en fait la troisième plus ancienne horloge astronomique du monde et la plus ancienne encore en fonctionnement. Un autre exemple se trouve dans la Cathédrale de Santa María à Burgos, en Espagne. Il s'agit du Papamoscas, un automate articulé qui ouvre la bouche pour indiquer les heures en sonnant.



(a) (b)

(c)

Figure 8.2. (a) Horloge astronomique de Prague, République tchèque; (b) Veille au Glockenspiel à Graz (Autriche); (c) Horloge Papamoscas, cathédrale de Burgos, Espagne.

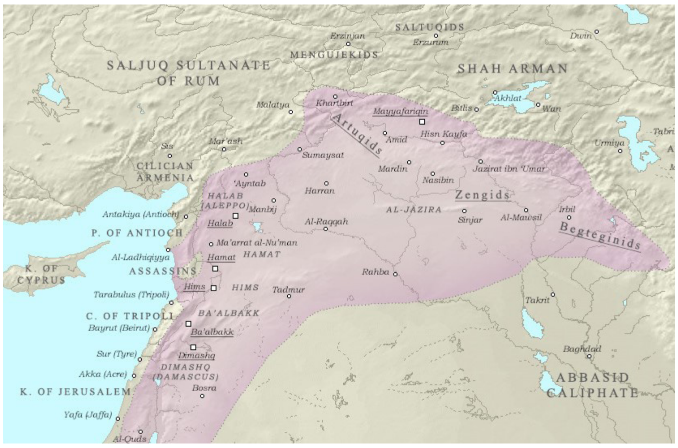
Mais est-ce que ces automates, précurseurs des robots modernes, étaient les premiers de l'histoire ?

L'idée des automates prend racine dans les mythologies de nombreuses cultures à travers le monde. Des ingénieurs et inventeurs des anciennes civilisations, notamment en Chine, en Grèce, en Inde, en Perse et en Égypte, ont tenté de construire des machines auto-fonctionnantes, certaines ressemblant à des animaux et à des humains. La plupart d'entre elles étaient conçues comme des illusions ou des jouets destinés à divertir les rois et les empereurs.

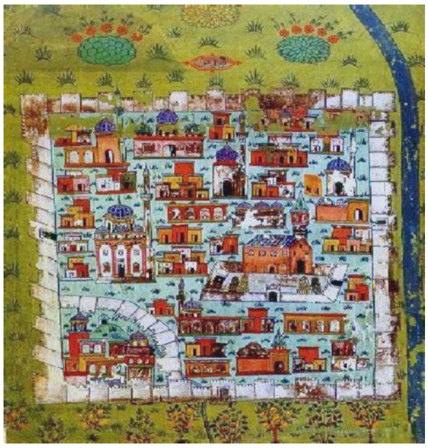
Mais, au 13ème siècle, des ingénieurs arabes ont produit des automates pour manipuler l'environnement dans le but d'améliorer le confort humain. Leur contribution la plus significative a été de développer des applications pratiques, en s'appuyant sur les travaux des Grecs.

Aujourd'hui, l'un de ces ingénieurs arabes est considéré comme le « père de la robotique ».

Ismail Al Jazari (1136 - 1206) était un polymathe arabe qui excella dans divers domaines, notamment en tant qu'érudit, inventeur, ingénieur en mécanique, artisan, artiste et mathématicien. Il est né dans la région de la Haute Mésopotamie et il a occupé le poste d'ingénieur en chef de la dynastie des Artuqides, un royaume régional, pour lequel il a conçu plus d'une centaine de dispositifs ingénieux. Il a passé près de 25 ans à Diyarbakir, une ville située sur les rives du fleuve Tigre.



(a)



(b)

Figure 8.3. (a) Carte du royaume régional d' Artuqides au sein du sultanat Ayyoubide, vers 1193; (b) Carte de Diyarbakir, 16ème siècle.

En 1206, il a dévoilé au monde un catalogue de ses machines incomparables, connu aujourd'hui sous le nom de « Livre de la connaissance des dispositifs mécaniques ingénieux ». Al-Jazari poursuit en décrivant les améliorations qu'il a apportées aux travaux de ses prédécesseurs, et il présente un certain nombre de dispositifs techniques et composants qui sont des innovations originales qui n'apparaissent pas dans les travaux précédents. Il ne décrit que les dispositifs qu'il a lui-même construits. Le style du livre ressemble à celui d'un livre moderne de « faites-le vous-même ».

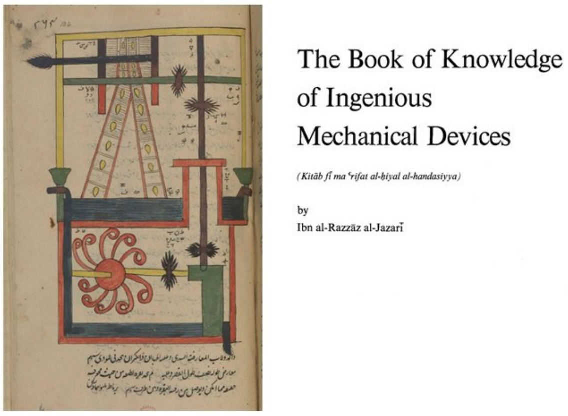


Figure 8.4. The Book of Knowledge of Ingenious Mechanical Devices.

Sa conception d'un bateau avec quatre musiciens - une harpiste, une flûtiste et deux batteurs - destiné à jouer des chansons est considérée par beaucoup comme le premier robot programmable de l'histoire. Le robot comprend une machine à tambour programmable avec des cames qui heurtent de petits leviers pour actionner la percussion. Le batteur peut être programmé pour jouer différents rythmes et motifs de batterie en déplaçant les cames.

(a)

(b)

(c)

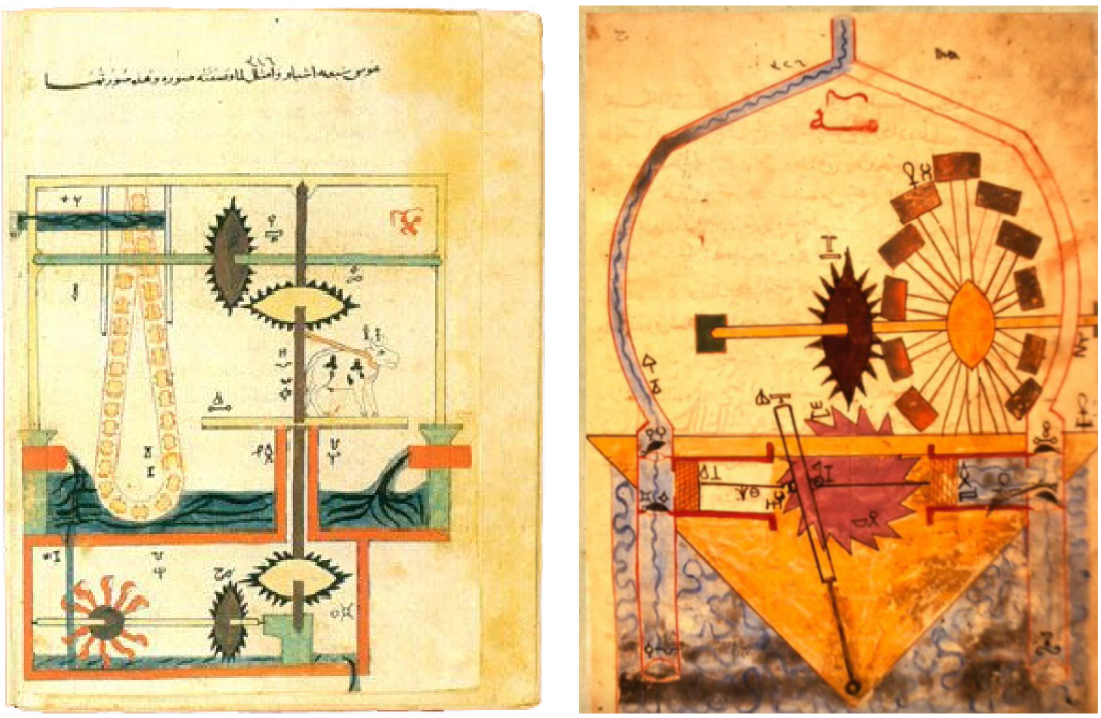
Figure 8.5. Automates Al Jazari. (a) Automate musical; (b) Automate musical avec mécanisme; (c) Mécanisme à came.

Parmi les autres automates, on trouve une horloge à eau avec des batteurs, un automate de lavage des mains avec un mécanisme de rinçage, et une fontaine de paon avec des serviteurs automatisés.

(a) (b) (c)

Figure 8.6. Automates Al Jazari. (a) Horloge à eau pour percussionnistes; (b) Automate pour le lavage des mains; (c) Fontaine du paon.

Al-Jazari a inventé cinq machines pour l'élévation de l'eau, ainsi que des moulins à eau et des roues à eau dotées de cames sur leur axe, utilisées pour faire fonctionner les automates. C'est dans ces machines d'élévation d'eau qu'il a introduit ses idées les plus importantes et les composants des nouveaux mécanismes.



(a) (b)

Figure 8.7. Automates Al Jazari. (a) Saqiya (chaîne de pots); (b) Pompe d'aspiration à double effet avec soupapes et mouvement du piston alternatif.

Il a également inventé divers types d'horloges, notamment l'horloge à bougie, l'horloge à éléphant et l'horloge de château.

(a) (b) (c)

Figure 8.8. Automates Al Jazari. (a) Horloge à bougies; (b) Horloge à éléphant; (c) Horloge du château.

En plus de ses remarquables réalisations en tant qu'inventeur et ingénieur, Al-Jazari était également un artiste talentueux. Dans son ouvrage intitulé « Livre de la connaissance des dispositifs mécaniques ingénieux », il a non seulement décrit ses inventions en détail, mais il a illustré ses inventions avec de belles peintures miniatures, un style artistique typique de l'art islamique médiéval.

Sa renommée repose principalement sur son livre, mais ses réalisations en tant qu'inventeur ont également joué un rôle clé dans la vie civique pendant de nombreuses années. La plupart de ses inventions étaient en avance de plusieurs siècles par rapport aux avancées de la science européenne de son époque. De nombreux historiens de la technologie soulignent que deux siècles plus tard, le célèbre inventeur de la Renaissance italienne, Léonard de Vinci, aurait pu être influencé par les automates classiques d'Al-Jazari lorsqu'il concevait ses propres automates.

Figure 8.9. Modèle de robot de Léonard de Vinci avec fonctionnement interne. Peut-être construit par Léonard de Vinci vers 1495.

Les machines automatiques inventées par Al-Jazari ont joué un rôle essentiel dans l'évolution des sciences mécaniques et cybernétiques d'aujourd'hui. Al-Jazari a réalisé des avancées majeures dans la technologie moderne en utilisant la science et la technologie de manière extraordinaire, en tenant compte des conditions de son époque, posant ainsi les fondements de la science moderne de contrôle automatique.

9. Qui est l'inventeur de l'autocuiseur ?

Nous avons probablement dans notre cuisine un autocuiseur (appelé aussi marmite à pression). Il s'agit d'un récipient hermétique qui augmente la vitesse de cuisson de certains aliments, ce qui réduit le temps de préparation nécessaire et économise considérablement de l'énergie. La cuisson sous pression est le processus de cuisson des aliments à la vapeur et à l'eau sous haute pression, ou dans un liquide de cuisson à base d'eau. L'autocuiseur nécessite généralement quelques minutes pour atteindre les conditions de cuisson souhaitées. Pour certaines marques, le régulateur de pression commence à s'élever au-dessus de sa buse, permettant ainsi à l'excès de vapeur de s'échapper.

(a) (b)

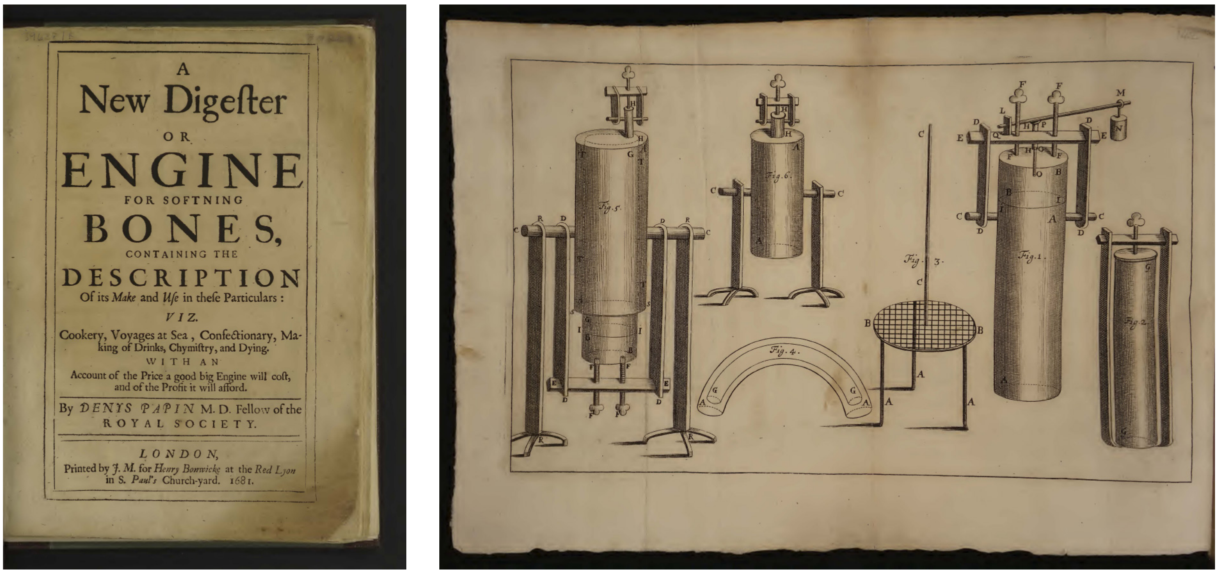
Figure 9.1. Cocotte-minute. (a) les composants: récipient, couvercle et soupape; (b) Ensemble.

Qui est l'inventeur de l'autocuiseur ?

L'inventeur de l'autocuiseur était Denis Papin (1647 - 1713), un physicien, mathématicien, ingénieur et inventeur français. En 1669, même il a obtenu un diplôme de médecine de l'université d'Angers, il n'a jamais exercé cette profession. Au lieu de cela, il s'est consacré à l'étude de la physique et des machines. Il a vécu en France, en Angleterre et en Allemagne, devenant ainsi un scientifique et un inventeur de premier plan de son époque.

Figure 9.2. Denis Papin, 1689.

En 1680, Papin présenta son invention du digesteur à vapeur à Royal Society de Londres dans le cadre d'une étude scientifique. Par la suite, il a été élu membre de la Société. En 1681, un premier document fut publié à Londres pour décrire la première série d'expériences menées avec cette machine. Il s'intitulait *A New Digester or Machine for Softening Bones* et comprenait une description détaillée de sa fabrication et de son utilisation dans ces contextes spécifiques. Il fonctionne en expulsant l'air du récipient et en piégeant la vapeur produite par le liquide bouillant.



(a) (b)

Figure 9.3. (a) Page de titre de l'édition anglaise de 1681, *Steam Digester*; (b) Dessins du *Steam Digester*.

Sous pression atmosphérique standard, l'eau bout à 100 °C. Lorsqu'on chauffe des aliments contenant de l'eau à cette température, l'excès de chaleur entraîne la conversion efficace d'une partie de l'eau en vapeur, maintenant ainsi la température des aliments à 100 °C.

Dans un autocuiseur hermétique, lorsque l'eau bout, la vapeur est emprisonnée dans la marmite, ce qui augmente la pression. Il est cependant essentiel de noter que la température d'ébullition de l'eau augmente avec la pression. Dans un autocuiseur hermétique, le volume et la quantité de vapeur sont fixes, de sorte que la température peut être contrôlée directement en ajustant la pression, avec une soupape de surpression. Par exemple, si la pression atteint 2 bars ou 200 kPa, l'eau aura atteint une température d'environ 120°C, ce qui permet une cuisson beaucoup plus rapide des aliments.

Pressions et températures de l'autocuiseur

Pression totale	Pression manométrique par rapport à l'atmosphère	Température	Temps de cuisson approximatif par rapport à l'ébullition
1.0 bar	**0.0 bar**	**100°C (212°F)**	**100%**
1.1 bar	0.1 bar	103°C (217°F)	80%
1.2 bar	0.2 bar	105°C (221°F)	70%
1.3 bar	0.3 bar	107°C (225°F)	61%
1.4 bar	0.4 bar	110°C (230°F)	50%
1.5 bar	0.5 bar	112°C (234°F)	43%
1.6 bar	0.6 bar	114°C (237°F)	38%
1.7 bar	0.7 bar	116°C (241°F)	33%
1.8 bar	0.8 bar	117°C (243°F)	31%
1.9 bar	0.9 bar	119°C (246°F)	27%
2.0 bar	**1.0 bar**	**121°C (250°F)**	**23%**

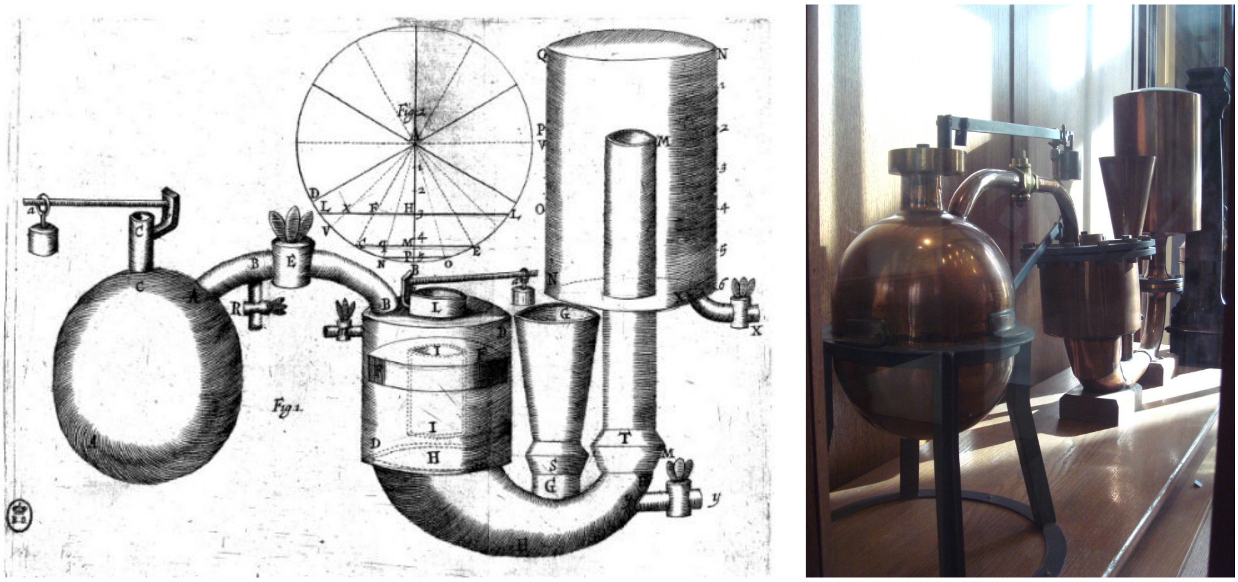
Figure 9.4. Evolution de la température d'ébullition de l'eau avec la pression.

Même si, à l'époque, il n'y avait aucune possibilité de transformer cette invention en un produit d'usage général, sa conception a été la base des premiers autocuiseurs qui, au début du XXe siècle, ont commencé à devenir des équipements couramment utilisés dans nos cuisines .

(a) (b) (c)

Figure 9.5. (a) Autocuiseur, fin XVIIIe siècle; (b) Autocuiseur, vers 1864; (c) Super Cocotte, 1973.

Au cours de sa carrière, Papin a inventé bien d'autres appareils, parmi lesquels: une machine à élever l'eau, une machine à incendie, le premier système de cylindre à piston à vapeur, une maquette de sous-marin à vapeur et une machine à vapeur pour pomper l'eau. Ce moteur est contemporain des premières machines à vapeur britanniques opérationnelles du début du XVIIIe siècle.



(a) (b)

Figure 9.6. Machine à vapeur de Papin. (a) Schéma, vers 1705; (b) Reconstruction.

Durant sa carrière, Denis Papin a collaboré avec d'autres grands scientifiques de son époque, parmi lesquels figuraient Christiaan Huygens, Gottfried Leibniz et Robert Boyle.

10. Plus lourd que l’air: premier vol pionnier en Europe.

De nombreuses histoires de l’Antiquité évoquent le désir de voler, comme la légende grecque d’Icare et de Dédale, et le Vimana dans les anciennes épopées indiennes. Parmi les premières tentatives enregistrées avec des planeurs figurent celles d’Abbas ibn Firnas, poète andalou et arabophone du IXe siècle et d’Eilmer de Malmesbury, moine anglais du XIe siècle. Léonard de Vinci a fait des recherches sur la conception des ailes des oiseaux et a conçu un avion à propulsion humaine.

Figure 10.1. (a) care et Dédale, Musée des Beaux-Arts et de la Dentelle d’Alençon; (b) Le char céleste Vimana, illustration du Ramayana; (c) Statue d’Ibn Firnas à l’aéroport de Bagdad; (d) Moine Eilmer, Malmesbury Abbey; (e) Léonard de Vinci, machine volante.

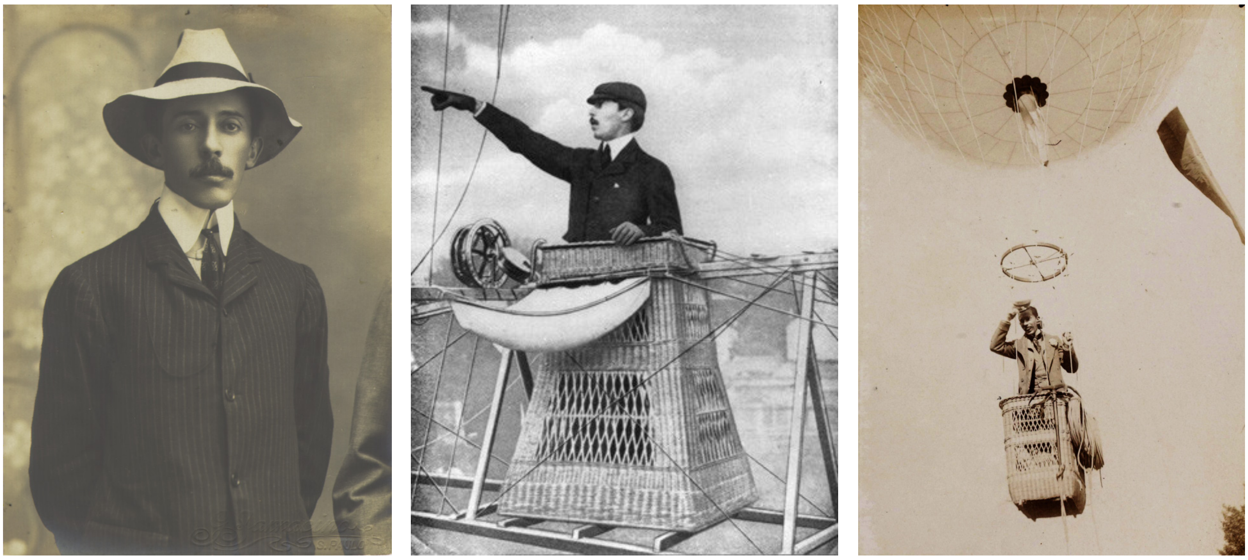
Depuis lors, de nombreux pionniers de l’aviation ont contribué au développement d’avions pratiques. Les avions modernes sont des machines volantes à ailes fixe avec des systèmes distincts pour la portance, la propulsion et le contrôle.

Les frères Wright, Orville et Wilbur Wright, étaient des pionniers de l’aviation américaine généralement crédités d’avoir inventé, construit et piloté le premier avion réussi au monde. L’invention révolutionnaire des frères a été la création d’un système de contrôle à trois axes, qui a permis au pilote de diriger efficacement l’avion et de maintenir son équilibre. Le premier vol d’Orville Wright, de 37 mètres en 12 secondes, a marqué le premier vol contrôlé et motorisé d’un avion plus lourd que l’air à Kitty Hawk, en Caroline du Nord, le 17 décembre 1903. Lors de leurs premiers vols, les frères Wright ont utilisé des rails de guidage et une catapulte pour le faire décoller.

Figure 10.2. Le premier vol des frères Wright à Kitty Hawk, en Caroline du Nord, le 17 décembre 1903.

En 1906, le Brésilien Alberto Santos-Dumont (1873-1932) a effectué ce qui a été prétendu être le premier vol d'avion, décollant sans l'aide d'un système de lancement externe. Il établit le premier record du monde reconnu par l'Aéro-Club de France et par la Fédération Aéronautique Internationale en volant 220 mètres en moins de 22 secondes.

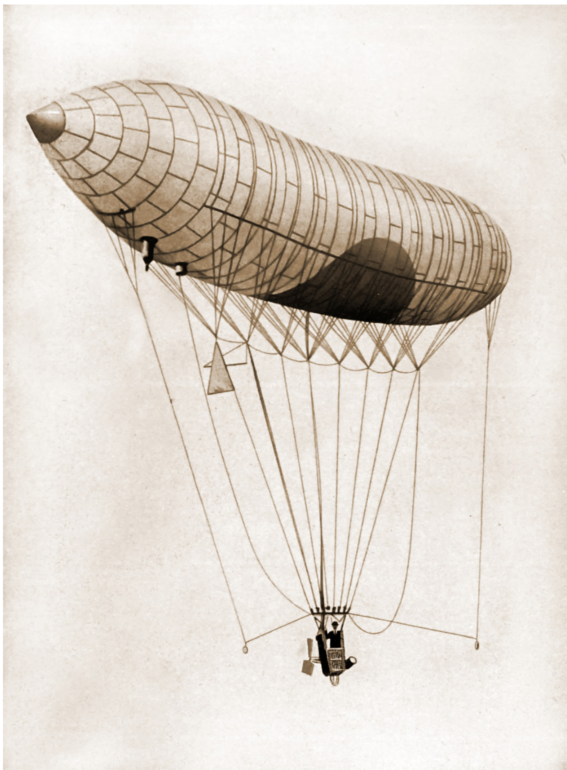
Alberto Santos-Dumont était un aéronaute, sportif et inventeur brésilien. Bien qu'il n'ait jamais obtenu de diplôme, il a suivi quelques cours d'ingénieur et a développé un talent pratique et mécanique admirable, ainsi qu'un génie inventif. Très jeune, il s'est distingué comme alpiniste et sportif automobile. À l'âge de 24 ans, Santos-Dumont est parti pour la France, où il a passé la majeure partie de sa vie d'adulte. C'est là qu'il est devenu aéronaute professionnel.



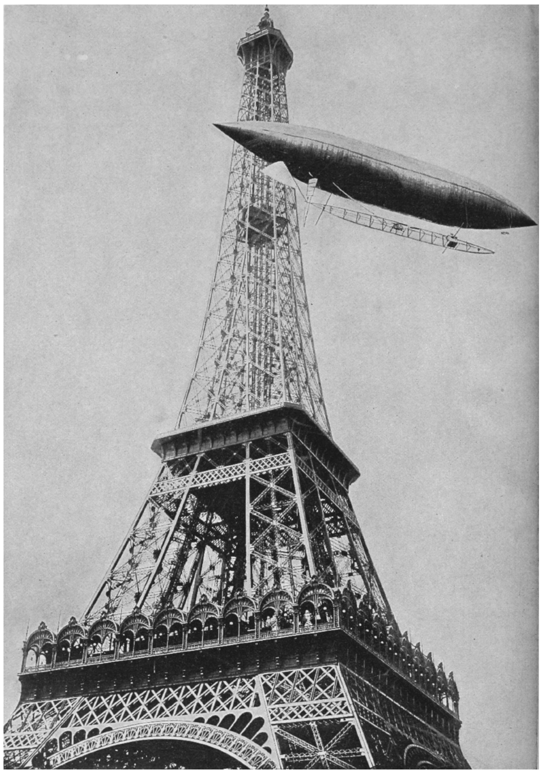
(a) (b) (c)

Figure 10.3. Alberto Santos Dumont (a) Portrait, 1903; (b) À bord d'une montgolfière; (c) Décollage le 4 juillet 1898 au Brésil.

De 1898 à 1903, il a construit jusqu'à 13 dirigeables, plus légers que l'air, propulsés par des moteurs à combustion interne. Il a survolé la tour Eiffel à plusieurs reprises avec ses dirigeables, dans le cadre de compétitions de dirigeables.



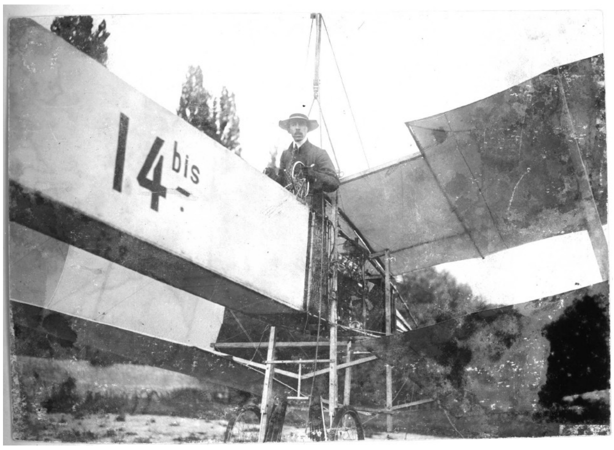
(a)



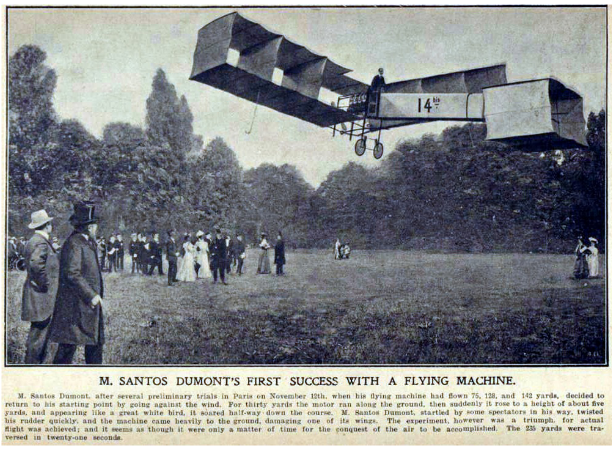
(b)

Figure 10.4. (a) Dirigeable Santos-Dumont Nº1, 1898; (b) Vol Santos-Dumont autour de la Tour Eiffel.

En 1904, plusieurs prix d'aviation sont créés en France pour stimuler le développement d'avions plus lourds que l'air. Le décollage, le contrôle et l'atterrissage étaient les grandes préoccupations. La Fédération Aéronautique Internationale, créée en 1905, est chargée d'enregistrer les manifestations officielles. Après avoir développé plusieurs prototypes, Santos-Dumont a présenté l'avion 14-bis, un biplan avec deux surfaces octogonales insérées comme ailerons pour améliorer le contrôle, et le gouvernail à l'avant, comme la configuration des frères Wright. Le 12 novembre 1906, il a réussi à voler 220 mètres, pendant 21 secondes à une vitesse moyenne de 37,4 km/h.



(a)


M. SANTOS DUMONT'S FIRST SUCCESS WITH A FLYING MACHINE.

M. Santos Dumont, after several preliminary trials in Paris on November 12th, when his flying machine had flown 75, 128, and 142 yards, decided to return to his starting point by going against the wind. For thirty yards the motor ran along the ground, then suddenly it rose to a height of about five yards, and appearing like a great white bird, it soared half-way down the course. M. Santos Dumont, startled by some spectators in his way, twisted his rudder quickly, and the machine came heavily to the ground, damaging one of its wings. The experiment, however was a triumph, for actual flight was achieved; and it seems as though it were only a matter of time for the conquest of the air to be accomplished. The 235 yards were traversed in twenty-one seconds.

(b)

Figure 10.5. (a) Santos-Dumont dans le 14-bis; (b) Actualités du vol du 14-bis.

Santos-Dumont a continué à développer des avions, comme la *Demoiselle*. Cet avion a été conçu pour les compétitions sportives, capable de voler jusqu'à 2 kilomètres et d'atteindre 96 km/h. Plus tard, il a été utilisé pour l'entraînement des pilotes pendant la Première Guerre mondiale.

(a) (b)

Figure 10.6. (a) Santos-Dumont à la *Demoiselle;* (b) Plaque d'Alberto Santos-Dumont en Avenue des Champs-Élysées, Paris.

Le 19 octobre 1906, Santos-Dumont a remporté une compétition de vol au-dessus de Paris avec son dirigeable numéro 6. Le prix lui a été remis lors d'un dîner au célèbre restaurant Maxim's. C'est là qu'il rencontre le joaillier Louis Cartier. Le bijoutier a appris que le pilote ne pouvait pas consulter sa montre de poche pendant le vol parce qu'il avait besoin de ses deux mains pour piloter l'avion. Cartier a alors conçu et offert à Santos-Dumont une nouvelle montre en or, carrée et plate, attachée au poignet grâce à un bracelet et une boucle. Il venait de créer la première montre-bracelet pour homme. Santos-Dumont l'utilisait comme chronomètre lors de ses vols suivants. Cette montre, appelée Cartier-Santos, est toujours fabriquée aujourd'hui.

(a) (b)

Figure 10.7. (a) Santos-Dumont, 1916; (b) Horloge Cartier-Santos.

11. Qui a construit le pont de Brooklyn ?

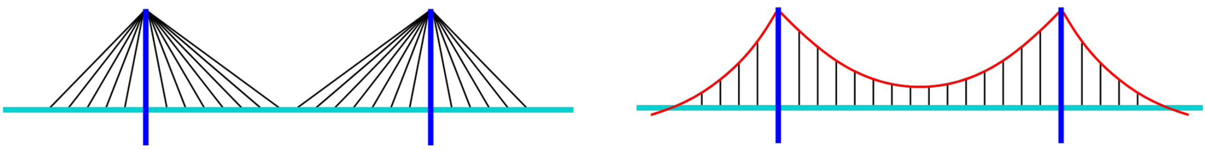
Le pont de Brooklyn est une icône de la ville de New York.

Il relie Manhattan à Brooklyn en enjambant l'East River. Le pont de Brooklyn a été ouvert le 24 mai 1883 et était le premier pont fixe au-dessus de l'East River. À cette époque, c'était le pont suspendu le plus long du monde, avec une travée principale de 486 mètres et un tablier à 38 mètres au-dessus de l'eau. Le pont s'appelait à l'origine le pont de New York et Brooklyn ou le pont de l'East River, mais a été officiellement renommé pont de Brooklyn en 1915.

(a) (b)

Figure 11.1. (a), (b) Pont de Brooklyn à New York, entre Manhattan et Brooklyn.

Le pont de Brooklyn est un emblème de l'ingénierie du XIXe siècle en raison de l'innovation de l'utilisation de l'acier comme matériau de construction à grande échelle à l'époque. Il utilise une conception hybride de pont à haubans et de pont suspendu, avec des câbles de suspension verticaux et diagonaux. C'était le premier pont suspendu par des câbles d'acier. Ses tours en pierre présentent un style néo-gothique caractérisé par des arcs brisés.



(a) (b)

Figure 11.2. (a) Un pont à haubans comporte une ou plusieurs pylônes, à partir desquels les câbles soutiennent le tablier du pont; (b) Un pont suspendu a un tablier qui pendait sous des câbles de suspension entre les tours, avec des câbles de suspente verticaux.

À l'origine, le pont avait été planifié pour inclure deux chaussées à double voie, des voies pour la cavalerie aux extrémités, deux voies de tramway au centre et une plate-forme piétonne surélevée. Actuellement, il comporte six voies pour les voitures, trois dans chaque direction.

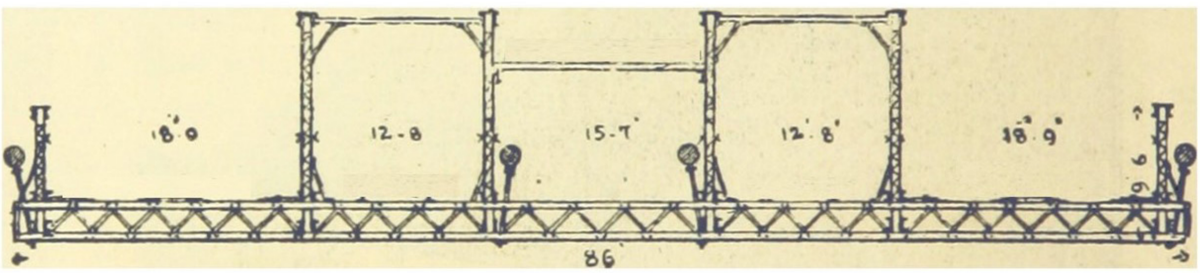
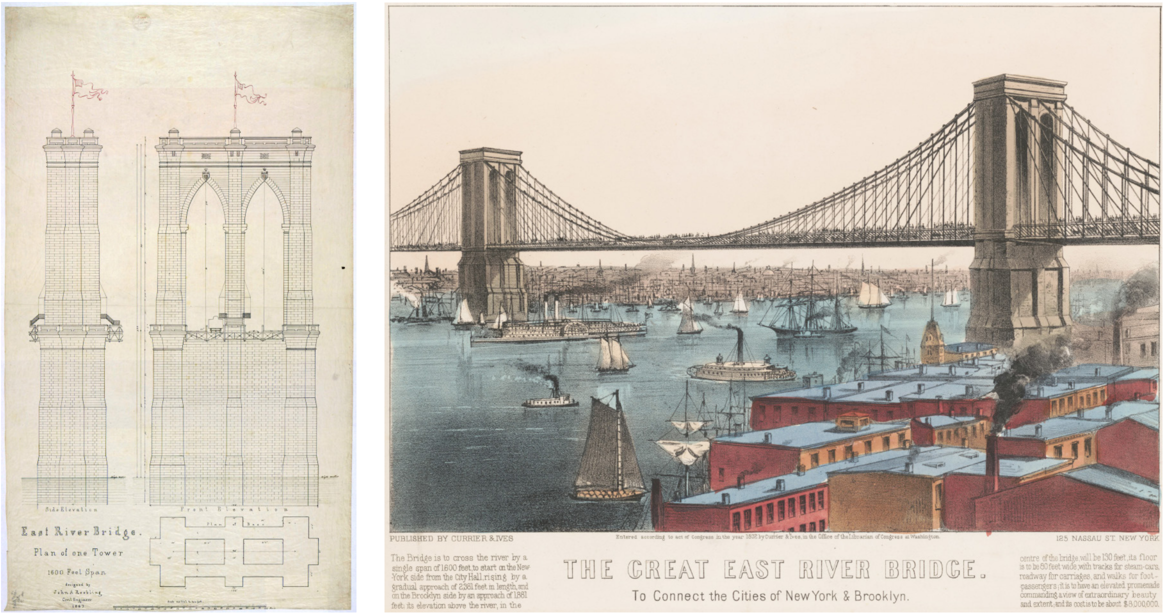


Figura 11.3. Conception initiale du pont de Brooklyn.

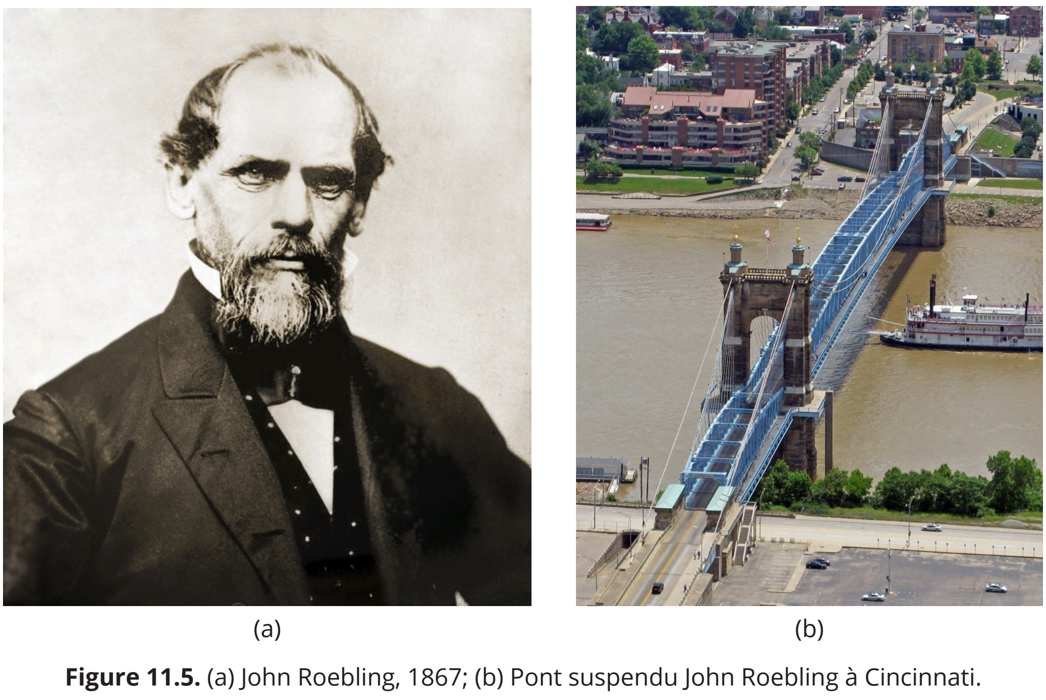
Les premières propositions pour un pont reliant Manhattan et Brooklyn ont été faites au début du XIXe siècle. À cette époque, le seul moyen de transport entre les deux villes était assuré par quelques lignes de ferry. En février 1867, le Sénat de l'État de New York a adopté un projet de loi autorisant la construction d'un pont suspendu entre Brooklyn et Manhattan. En avril 1867, les villes de New York et de Brooklyn ont été autorisées à souscrire à un capital-actions de 5 millions de dollars pour financer la construction du pont par la New York and Brooklyn Bridge Company. Le pont a été construit entre 1870 et 1883.



(a) (b)

Figure 11.4. (a) Plan de la tour du pont de Brooklyn, 1867; (b) Image attendue du pont.

L'ingénieur principal désigné en 1867 pour construire le pont de Brooklyn était John Roebling (1806–1869), un ingénieur civil américain d'origine allemande. Il était renommé pour son expertise dans les ponts suspendus à câbles, ayant conçu ceux de Pittsburgh, Niagara ou Cincinnati. Malheureusement, il est décédé en 1869, juste avant le début des travaux.

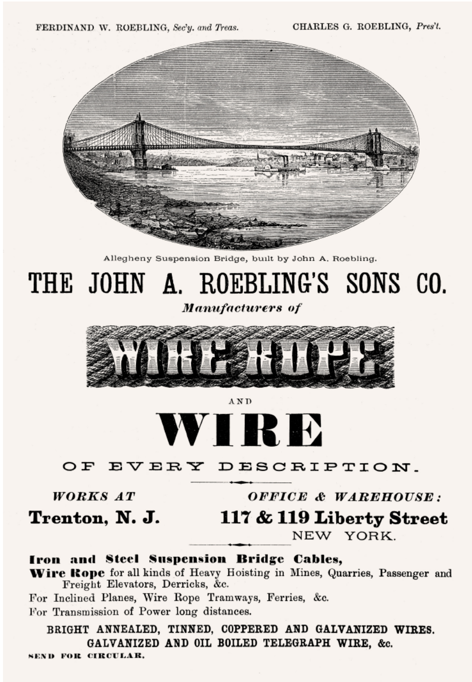


(a) (b)

Figure 11.5. (a) John Roebling, 1867; (b) Pont suspendu John Roebling à Cincinnati.

Washington Roebling (1837–1926), le fils de John Roebling, âgé de 32 ans, a ensuite été embauché pour remplir le rôle de son père. Il avait étudié l'ingénierie au Rensselaer Polytechnic Institute de Troy, à New York, et avait travaillé avec son père sur plusieurs ponts suspendus. En 1868, Washington est devenu ingénieur adjoint sur le pont de Brooklyn et a été nommé ingénieur en chef après le décès de son père au milieu de l'année 1869.

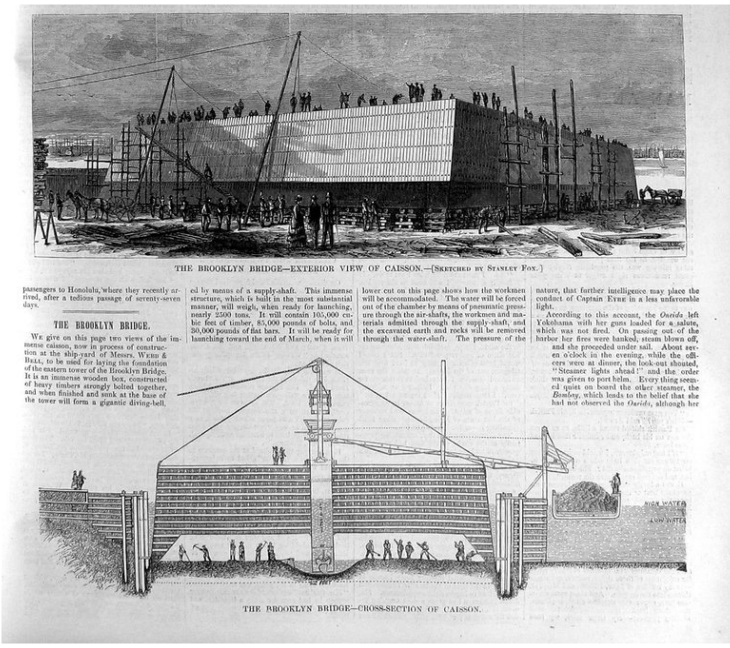
(a)



(b)

Figure 11.6. (a) Washington Roebling, 1854; (b) Publicité Roebling's & Sons, 1879.

Mais, très tôt au début des travaux, en 1870, il a contracté une maladie de décompression alors qu'il travaillait dans les caissons des piles du pont, profondément sous la surface de la rivière. Cette maladie l'a tellement affecté qu'il a dû rester alité. C'est ainsi que sa femme, Emily Warren Roebling, a pris le relais et est devenue une figure clé de l'ingénierie.



THE BROOKLYN BRIDGE—EXTERIOR VIEW OF CAISSON.—[Sketched by Stanley Fox.]

passengers to Honolulu, where they recently arrived, after a tedious passage of seventy-seven days.

THE BROOKLYN BRIDGE.

We give on this page two views of the immense caisson, now in process of construction at the ship-yard of Messrs. Webb & Bell, to be used for laying the foundation of the eastern tower of the Brooklyn Bridge. It is an immense wooden box, constructed of heavy timbers strongly bolted together, and when finished and sunk at the base of the tower will form a gigantic diving-bell,

ed by means of a supply-shaft. This immense structure, which is built in the most substantial manner, will weigh, when ready for launching, nearly 2500 tons. It will contain 105,000 cubic feet of timber, 85,000 pounds of bolts, and 30,000 pounds of flat bars. It will be ready for launching toward the end of March, when it will

lower cut on this page shows how the workmen will be accommodated. The water will be forced out of the chamber by means of pneumatic pressure through the air-shafts, the workmen and materials admitted through the supply-shaft, and the excavated earth and rocks will be removed through the water-shaft. The pressure of the

nature, that further intelligence may place the conduct of Captain Eyre in a less unfavorable light.

According to this account, the *Oneida* left Yokohama with her guns loaded for a salute, which was not fired. On passing out of the harbor her fires were banked, steam blown off, and she proceeded under sail. About seven o'clock in the evening, while the officers were at dinner, the look-out shouted, "Steamer lights ahead!" and the order was given to port helm. Every thing seemed quiet on board the other steamer, the *Bombay*, which leads to the belief that she had not observed the *Oneida*, although her

THE BROOKLYN BRIDGE—CROSS-SECTION OF CAISSON.

Figure 11.7. Caissons pressurisés des piles du pont de Brooklyn.

Emily Warren Roebling (1843–1903) est célèbre pour ses contributions pendant plus de 10 ans à la réalisation du pont de Brooklyn. Elle avait étudié les mathématiques et les sciences, et elle a commencé à prendre de nombreuses notes sur les tâches restant à accomplir pour le pont, comme son mari le lui avait indiqué. Elle a également commencé à étudier ses propres questions techniques, notamment la résistance des matériaux, l'analyse des contraintes, la construction des câbles et le calcul des courbes de caténaire. Elle a assumé une grande partie des responsabilités de l'ingénieur en chef, supervisant quotidiennement le projet et en assurant la gestion.

(a) (b)

Figure 11.8. (a) Emily Roebling, 1896; (b) Pont de Brooklyn en construction.

Pendant la décennie suivant l'incapacité de Washington due à sa maladie, Emily Roebling s'est consacrée à achever le pont de Brooklyn. Emily et son mari ont planifié ensemble la poursuite de la construction du pont. Elle a géré les interactions avec les politiciens, les ingénieurs concurrents et tous les autres impliqués dans le projet au point que beaucoup pensaient qu'elle avait conçu le pont elle-même. Emily Roebling a été la première à traverser le pont en calèche lors de la cérémonie d'ouverture en 1883.

Les excellents travaux d'Emily Warren Roebling en tant qu'ingénieur ont été reconnus par l'American Society of Civil Engineers. En 1951, le Brooklyn Engineers Club a installé une plaque sur le pont de Brooklyn pour célébrer le rôle d'Emily Warren Roebling dans l'achèvement de sa construction.

Figure 11.9. Plaque commémorative, 1951.

Après avoir terminé son travail sur le pont de Brooklyn, Roebling s'est mise à soutenir plusieurs causes féminines. Elle a également écrit plusieurs essais, défendu l'égalité des droits et critiqué les discriminations envers les femmes. À l'âge de 56 ans, en 1899, elle a repris ses études et a obtenu un diplôme en droit à l'Université de New York.

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Figuras. Créditos / Figures. Credits / Gráficos. Créditos / Figures. Crédits

FIGURAS. CRÉDITOS.

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1. ¿Quién definió el *caballo de vapor* como unidad de potencia?

Who defined the horsepower as the unit of power? /
Quem definiu o cavalo-vapor como unidade de potência? /
Qui a défini le cheval-vapeur comme l'unité de puissance ?

Figura	
1.1(a)	Wikimedia https://commons.wikimedia.org/w/index.php?curid=26009
1.1(b)	Wikimedia https://commons.wikimedia.org/w/index.php?curid=49836
1.1(c)	El autor, E. Montero.
1.2	Wikimedia https://commons.wikimedia.org/w/index.php?curid=64603979
1.3(a)	Science Museum Group. https://collection.sciencemuseumgroup.org.uk/objects/co50948/ rotative-steam-engine-by-boulton-and-watt-1788-beam-engine-steam-engine.
1.3(b)	Internet Archive https://archive.org/details/raisonsdesforce00Caus/page/n37/mode/2up
1.4	El autor, E. Montero.

2. ¿Definió James Watt la unidad de potencia *watt* con su propio nombre?

Did James Watt define the watt unit for power with his own name? /
James Watt definiu a unidade watt com o seu próprio nome? /
James Watt a-t-il défini l'unité watt pour la puissance avec son propre nom ?

Figura	
2.1(a)	El autor, E. Montero.
2.1(b)	El autor, E. Montero.
2.2	Wikimedia https://commons.wikimedia.org/w/index.php?curid=139398
2.3(a)	Biodiversity Heritage Library https://www.biodiversitylibrary.org/item/95237#page/5/mode/1up
2.3(b)	Biodiversity Heritage Library https://www.biodiversitylibrary.org/item/95237#page/85/mode/1up
2.3(c)	Biodiversity Heritage Library https://www.biodiversitylibrary.org/item/95237#page/89/mode/1up

3. Algunas temperaturas se miden en grados Rankine. ¿Quién era el Sr. Rankine?

Some temperatures are measured in degrees Rankine. Who was Mr. Rankine? /
Algumas temperaturas são medidas em graus Rankine. Quem era o Sr. Rankine? /
Certaines températures sont mesurées en degrés Rankine. Qui était M. Rankine ?

Figura	
3.1	Wikimedia https://commons.wikimedia.org/w/index.php?curid=133401731

Figura	
3.2a, b, c	Internet Archive https://archive.org/details/amanualsteameng03rankgoog/page/n5/mode/2up
3.3	El autor, E. Montero.

4. La unidad de conductancia eléctrica, siemens, ¿tiene algo que ver con la empresa Siemens AG©?

Does the SI unit for the electrical conductance, siemens, has some relation with the Siemens AG© company? /
A unidade SI para a condutância elétrica, siemens, tem alguma relação com a empresa Siemens AG©? /
Existe-t-il une relation entre l'unité SI pour la conductance électrique, siemens, et la société Siemens AG© ?

Figura	
4.1	Wikipedia https://en.wikipedia.org/wiki/International_System_of_Units
4.2a, b, c	With permission of the The Siemens AG company https://www.siemens.com
4.3a, b	Bureau International des Poids et Mesures https://www.bipm.org
4.4	With permission of the Siemens Historical Institute 0001-werner-von-siemens-1872-eb-iv-49-300.jpg (2002×2833)
4.5a, b	IEEE Explore https://ieeexplore.ieee.org/document/6538821
4.6a, b	Internet Archive https://archive.org/details/practicalapplic00bramgoog/page/n160/mode/2up?q=mho https://archive.org/details/practicalapplic00bramgoog/page/n182/mode/2up?q=mho

5. ¿Quién dio a la Torre Eiffel su nombre?

Who gave the Eiffel Tower its name? /
Quem deu o nome à Torre Eiffel? /
Qui a donné son nom à la Tour Eiffel ?

Figura	
5.1a	Wikimedia https://commons.wikimedia.org/wiki/File:Paris_1889_plakat.jpg
5.1b	La Ilustración Artística, 1889, 367, pp.3 Ministerio de Cultura, España https://prensahistorica.mcu.es
5.2a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=406407
5.2b	Wikimedia https://commons.wikimedia.org/wiki/File:Tour_Eiffel_Wikimedia_Commons.jpg
5.3	Wikimedia https://commons.wikimedia.org/w/index.php?curid=41304911
5.4a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=3852318
5.4b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=718131
5.4c	Wikimedia https://commons.wikimedia.org/w/index.php?curid=3127206

Figura	
5.4d	Wikimedia https://commons.wikimedia.org/w/index.php?curid=173395
5.5a	El autor. E. Montero
5.5b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=524337
5.6a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=598705
5.6b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=598710
5.6c	Wikimedia https://commons.wikimedia.org/w/index.php?curid=598712
5.6d	Wikimedia https://commons.wikimedia.org/w/index.php?curid=598715
5.6e	Wikimedia https://commons.wikimedia.org/w/index.php?curid=598723
5.6f	Wikimedia https://commons.wikimedia.org/w/index.php?curid=598728
5.6g	Wikimedia https://commons.wikimedia.org/w/index.php?curid=598732
5.7a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=18323802
5.7b	Aerodynamic Eiffel https://www.aerodynamiqueeiffel.fr/a-propos/histoire-du-laboratoire/
5.8a	Internet Archive https://archive.org/details/EiffelLaRsistanceDeLairEtLaviation1910/page/n7/mode/2up
5.8b	Internet Archive https://archive.org/details/EiffelLaRsistanceDeLairEtLaviation1910/page/n179/mode/2up
5.8c	Internet Archive https://archive.org/details/EiffelLaRsistanceDeLairEtLaviation1910/page/n173/mode/2up
5.9	Aerodynamic Eiffel https://www.aerodynamiqueeiffel.fr/a-propos/histoire-du-laboratoire/

6. ¿Quién dio su nombre a los Premios Nobel?

Who gave its name to the Nobel Prizes? /
Quem deu o nome aos prêmios Nobel? /
Qui a donné son nom aux Prix Nobel ?

Figura	
6.1a	Internet Archive https://archive.org/details/arkivkopia.se-digmus-tek-TEKA0018305
6.1b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=6923011
6.2a	Internet Archive https://archive.org/details/arkivkopia.se-digmus-tek-TEKA0018304

Figura	
6.2b	Internet Archive https://archive.org/details/arkivkopia.se-digmus-tek-TEKA0018301
6.3a, b	Espacenet https://worldwide.espacenet.com/
6.3c	Wikimedia https://commons.wikimedia.org/w/index.php?curid=4109235
6.4a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=10283567
6.4b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=74472594
6.5	Wikimedia https://commons.wikimedia.org/wiki/File:Alfred_Nobels_will-November_25th,_1895.jpg
6.6a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=9917537
6.6b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=3091246

7. ¿Quién fue el diseñador del “Aero Car” en las Cataratas del Niágara?

Who was the designer of the “Aero Car” in Niagara Falls? /
Quem foi o designer do “Aero Car” nas Cataratas do Niágara? /
Qui était le concepteur du « Aero Car » aux chutes du Niagara ?

Figura	
7.1a	Wikimedia https://commons.wikimedia.org/wiki/File:AdvertisementTripNiagaraFalls6August1895.jpg
7.1b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=54981000
7.2a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=53913976
7.2b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=37436184
7.3	Wikimedia https://commons.wikimedia.org/w/index.php?curid=97055312
7.4a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=37017247
7.4b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=37017247
7.4c	Wikimedia https://commons.wikimedia.org/w/index.php?curid=37026915
7.5a	Google Arts & Culture, fondo fotográfico de Francisco González Redondo https://artsandculture.google.com/asset/cable-car-of-the-monte-ula-lower-station/YAHioR7_YxFxqw
7.5b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=56194935

Figura	
7.6a, b, c	Espacenet https://worldwide.espacenet.com/
7.7a	Google Arts & Culture https://artsandculture.google.com/asset/drawing-of-the-whirlpool-and-cableway/aAEkWRXMHbSeQw
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7.8a	Google Arts & Culture https://artsandculture.google.com/asset/aerial-cable-car-no-5-cable-car/pAGquuvAOD5C4w?hl=en
7.8b	With permission of Niagara Parks https://www.niagaraparks.com/things-to-do/history-of-the-aero-car
7.9a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=5671912
7.9b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=5671912
7.10	Wikimedia https://en.wikipedia.org/w/index.php?curid=18502725
7.11a	Google Arts & Culture https://artsandculture.google.com/asset/ensayo-sobre-la-construccin-de-las-mquinas-algbricas-de-leonardo-torres-quevedo/zAECamqKA_1v4A
7.11b	Bibliothèque Nationale de France https://gallica.bnf.fr/ark:/12148/bpt6k840139b

8. ¿Quién es considerado el "padre de la robótica"?

Who is considered the "father of robotics"? /
Quem é considerado o "pai da robótica"? /
Qui est considéré comme le « père de la robotique » ?

Figura	
8.1a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=79553342
8.1b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=40512710
8.1c	Wikimedia https://commons.wikimedia.org/w/index.php?curid=2107342
8.1d	Wikimedia https://commons.wikimedia.org/w/index.php?curid=3158337
8.1e	Wikimedia https://commons.wikimedia.org/w/index.php?curid=18947366
8.2a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=123336264
8.2b	El autor. E. Montero

Figura	
8.2c	Guías Turísticos de Burgos https://www.guiasturisticosburgos.com/blog/el-papamoscas-catedral-de-burgos.htm
8.3a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=39153303
8.3b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=21967186
8.4	Internet Archive https://archive.org/details/cover_20200113_2057/page/n1/mode/2up
8.5a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=8669792
8.5b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=635055
8.5c	Wikimedia https://commons.wikimedia.org/wiki/File:Nockenwelle_ani.gif
8.6a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=69773607
8.6b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=635058
8.6c	Wikimedia https://commons.wikimedia.org/w/index.php?curid=77357372
8.7a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=407668
8.7b	YouTube https://www.youtube.com/watch?v=LyHGU_mJhqE
8.8a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=635048
8.8b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=4173094
8.8c	Wikimedia https://commons.wikimedia.org/w/index.php?curid=8950810
8.9	Wikimedia https://commons.wikimedia.org/w/index.php?curid=395321

9. ¿Quién fue el inventor de la olla a presión?

Who was the inventor of the pressure cooker? /
Quem foi o inventor da panela de pressão? /
Qui est l'inventeur de l'autocuiseur ?

Figura	
9.1a	El autor, E. Montero
9.1b	El autor, E. Montero
9.2	Wikimedia https://commons.wikimedia.org/w/index.php?curid=135410
9.3a	Internet Archive https://archive.org/details/b30330245/page/n11/mode/2up?ref=ol&view=theater

Figura	
9.3b	Internet Archive https://archive.org/details/b30330245/page/n19/mode/2up?ref=ol&view=theater
9.4	El autor, E. Montero
9.5a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=53724004
9.5b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=18168727
9.5c	Wikimedia https://commons.wikimedia.org/w/index.php?curid=15511587
9.6a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=6680398
9.6b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=8780757

10. Más pesado que el aire: primer vuelo pionero en Europa.

Heavier than air: first pioneer flight in Europe. /
Mais pesado que o ar: primeiro voo pioneiro na Europa. /
Plus lourd que l'air: premier vol pionnier en Europe.

Figura	
10.1a	Wikipedia https://commons.wikimedia.org/w/index.php?curid=139969
10.1b	Wikipedia https://commons.wikimedia.org/w/index.php?curid=38310502
10.1c	Wikipedia https://commons.wikimedia.org/w/index.php?curid=88881891
10.1d	Wikipedia https://commons.wikimedia.org/w/index.php?curid=332630
10.1e	Wikipedia https://commons.wikimedia.org/w/index.php?curid=11228469
10.2	Wikimedia https://commons.wikimedia.org/w/index.php?curid=75148383
10.3a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=92836303
10.3b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=658559
10.3c	Wikimedia https://commons.wikimedia.org/w/index.php?curid=44834718
10.4b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=277761
10.4b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=41696493
10.5a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=110858576

Figura	
10.5b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=3674702
10.6a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=1626221
10.6b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=116416212
10.7a	Wikimedia https://commons.wikimedia.org/w/index.php?curid=2959342
10.7b	Wikimedia https://commons.wikimedia.org/w/index.php?curid=21001772

11. ¿Quién construyó el puente de Brooklyn?

Who built the Brooklyn Bridge? /
Quem construiu a Ponte do Brooklyn? /
Qui a construit le pont de Brooklyn ?

Figura	
11.1a	Wikipedia https://commons.wikimedia.org/w/index.php?curid=77925095
11.1b	Wikipedia https://commons.wikimedia.org/w/index.php?curid=93491801
11.2a	Wikipedia https://commons.wikimedia.org/w/index.php?curid=2659374
11.2b	Wikipedia https://commons.wikimedia.org/w/index.php?curid=2659364
11.3	Wikipedia https://commons.wikimedia.org/wiki/File:New_York_and_Brooklyn_Bridge_(1883)_-_p22.jpg
11.4a	Wikipedia https://commons.wikimedia.org/w/index.php?curid=7896896
11.4b	Wikipedia https://commons.wikimedia.org/w/index.php?curid=112869258
11.5a	Wikipedia https://commons.wikimedia.org/w/index.php?curid=10967039
11.5b	Wikipedia https://commons.wikimedia.org/w/index.php?curid=6958691
11.6a	Wikipedia https://commons.wikimedia.org/w/index.php?curid=15725762
11.6b	Wikipedia https://commons.wikimedia.org/w/index.php?curid=47213913
11.7	Wikipedia https://commons.wikimedia.org/wiki/File:ExteriorViewOfBrooklynBridgeCaisson_ HarpersWeekly_1870.jpg
11.8a	Wikipedia https://commons.wikimedia.org/w/index.php?curid=10956614

Figura	
11.8b	Wikipedia https://commons.wikimedia.org/wiki/File:Manhattan_Bridge_Construction_1909_Edit.jpg
11.9	Wikipedia https://commons.wikimedia.org/wiki/File:2008-10-26_Brooklyn_Bridge_NY_21.jpg

QR Cuestionarios de autoevaluación / Self-assessment questionnaires / Questionários de autoavaliação / Questionnaires d’auto-évaluation

QR CUESTIONARIOS DE AUTOEVALUACIÓN.

Self-assessment questionnaires / Questionários de autoavaliação / Questionnaires d'auto-évaluation

1. **¿Quién definió el *caballo de vapor* como unidad de potencia?**

   Who defined the horsepower as the unit of power? /
   Quem definiu o cavalo-vapor como unidade de potência? /
   Qui a défini le cheval-vapeur comme l'unité de puissance ?

ES EN PT FR

2. **¿Definió James Watt la unidad de potencia *watt* con su propio nombre?**

   Did James Watt define the watt unit for power with his own name? /
   James Watt definiu a unidade watt com o seu próprio nome? /
   James Watt a-t-il défini l'unité watt pour la puissance avec son propre nom ?

ES EN PT FR

3. **Algunas temperaturas se miden en grados Rankine. ¿Quién era el Sr. Rankine?**

   Some temperatures are measured in degrees Rankine. Who was Mr. Rankine? /
   Algumas temperaturas são medidas em graus Rankine. Quem era o Sr. Rankine? /
   Certaines températures sont mesurées en degrés Rankine. Qui était M. Rankine ?

ES EN PT FR

4. **La unidad de conductancia eléctrica, siemens, ¿tiene algo que ver con la empresa Siemens AG©?**

   Does the SI unit for the electrical conductance, siemens, has some relation with the Siemens AG© company? /
   A unidade SI para a condutância elétrica, siemens, tem alguma relação com a empresa Siemens AG©? /
   Existe-t-il une relation entre l'unité SI pour la conductance électrique, siemens, et la société Siemens AG© ?

ES EN PT FR

5. ¿Quién dio a la Torre Eiffel su nombre?

Who gave the Eiffel Tower its name? /
Quem deu o nome à Torre Eiffel? /
Qui a donné son nom à la Tour Eiffel ?

ES EN PT FR

6. ¿Quién dio su nombre a los Premios Nobel?

Who gave its name to the Nobel Prizes? /
Quem deu o nome aos prêmios Nobel? /
Qui a donné son nom aux Prix Nobel ?

ES EN PT FR

7. ¿Quién fue el diseñador del "Aero Car" en las Cataratas del Niágara?

Who was the designer of the "Aero Car" in Niagara Falls? /
Quem foi o designer do "Aero Car" nas Cataratas do Niágara? /
Qui était le concepteur du « Aero Car » aux chutes du Niagara ?

ES EN PT FR

8. ¿Quién es considerado el "padre de la robótica"?

Who is considered the "father of robotics"? /
Quem é considerado o "pai da robótica"? /
Qui est considéré comme le « père de la robotique » ?

ES EN PT FR

9. ¿Quién fue el inventor de la olla a presión?

Who was the inventor of the pressure cooker? /
Quem foi o inventor da panela de pressão? /
Qui est l'inventeur de l'autocuiseur ?

ES EN PT FR

10. Más pesado que el aire: primer vuelo pionero en Europa.

Heavier than air: first pioneer flight in Europe. /
Mais pesado que o ar: primeiro voo pioneiro na Europa. /
Plus lourd que l'air: premier vol pionnier en Europe.

ES EN PT FR

11. ¿Quién construyó el puente de Brooklyn?

Who built the Brooklyn Bridge? /
Quem construiu a Ponte do Brooklyn? /
Qui a construit le pont de Brooklyn ?

ES EN PT FR

ISBN 978-84-18465-96-3

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