A passive dynamic walker, Edward Muybridge photosequence

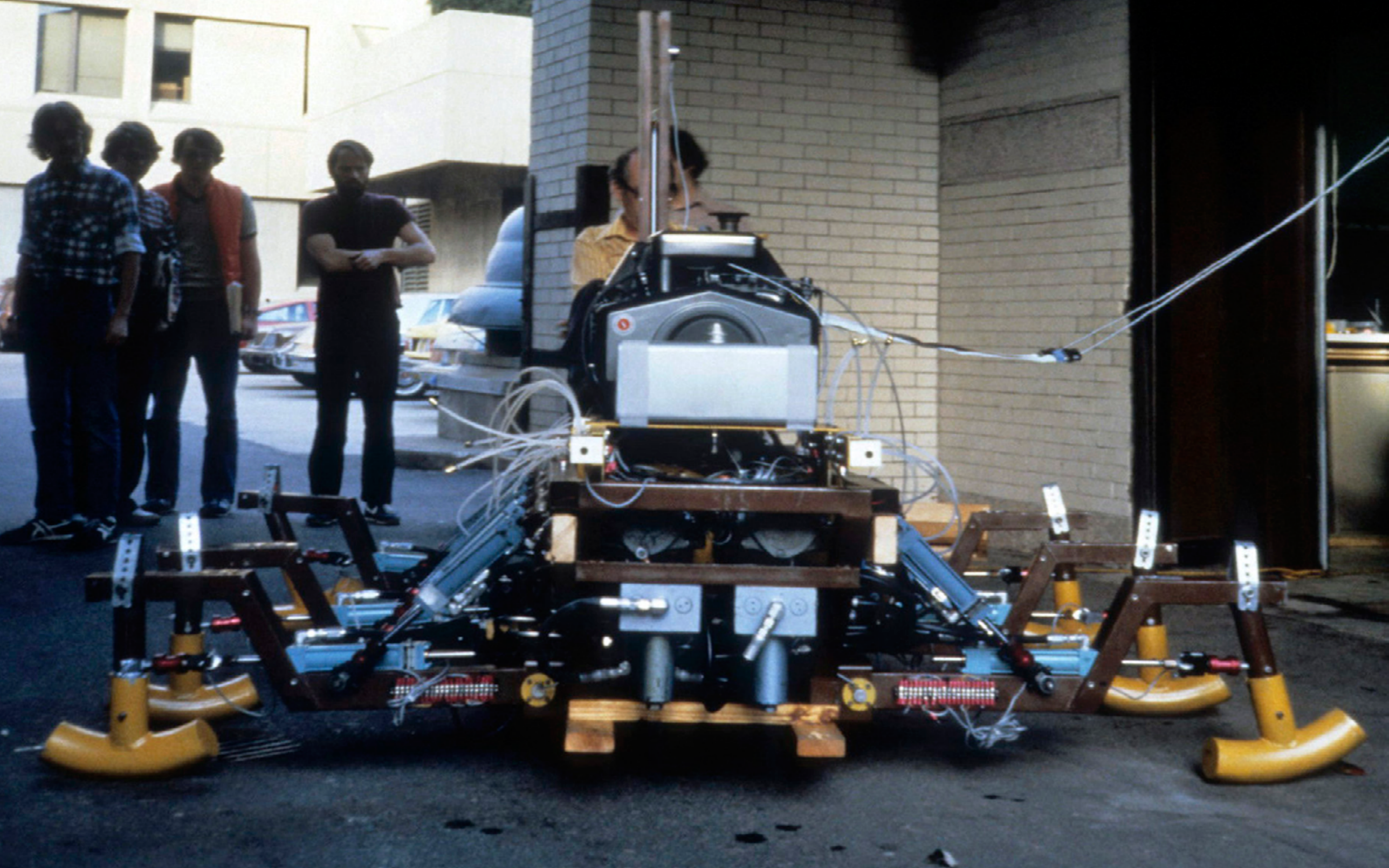
In 1981, Ivan published “A Six-Legged Walking Machine”, a detailed analysis of the hexapod. The version you see on display is the second printing, published in 1983, titled “A Walking Robot”. Frederick H. Carlson drew the illustrations and Eddie Frank typeset the pages.

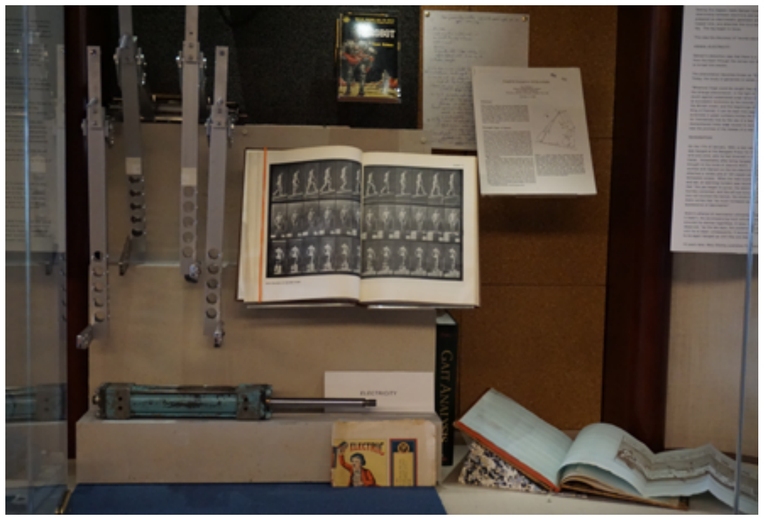
In retrospect, Ivan looks back and takes account of some of the mistakes in the Trojan Cockroach’s design. Mistakes lead to discovery though, and many things were learned in the process. The scale of the machine did not fit the six legged design, as nature is prone to making hexapods with different proportions in mind. Balance would prove to be key in developing walking machines. Ivan and Marc co-published an article seen here in “Scientific American” which sketches out their different approaches to machines that walk. This was only the beginning.

PASSIVE DYNAMIC WALKING

In the late 1980’s, Tad McGreer at Cornell perfected “passive dynamic walking”. Tad, inspired by gliders, was interested in finding ways for robots to move without motors, sensors, or brains.

McGreer created a simple planar mechanism with two legs that could walk down a slight slope without any other energy source or control. The swing leg is a pendulum, and the stance leg is an inverted pendulum. The pendulums are tied together at the hip.





Display case from Posner Center Exhibition

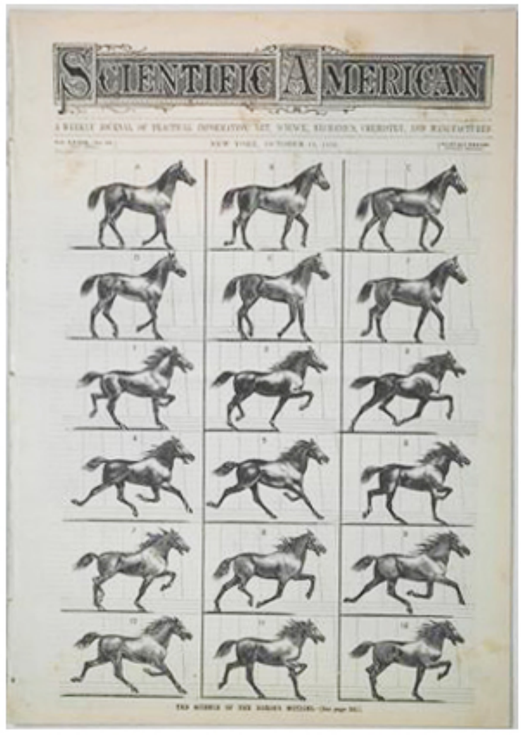
There is something altogether unsettling about watching this mechanism walk. Life for a moment becomes movement, as the movement of the legs is blinding to the eye, the precision seemingly human, automatic and natural.

EDWARD MUYBRIDGE

In 1860, Edward Muybridge left San Francisco on a trip to England to purchase antiquarian books. He mistakenly missed his boat, and was forced to travel by stagecoach across the country, intending to board a ship to England from New York.

En route through Texas, Muybridge's stagecoach lost control, crashing violently and injured everyone on board. Muybridge was violently thrown from the vehicle, suffering severe head injuries. He never fully recovered.

Psychologists have since speculated that Muybridge sustained substantial injuries to the orbitofrontal cortex, a part of the brain directly above the eyes. During his time recovering from this accident, Muybridge became interested in the burgeoning field of photography. He began taking photos.



Scientific American - New York, October 19, 1878

HORSES

In 1872, nearly a decade later, Leland Stanford was racing horses. Stanford was considered by some to be a “robber baron”. Stanford hired Muybridge to settle a debate- were all four feet of a horse off of the ground when they gallup?

It was traditionally thought that horses trot with one foot always against the ground, and that all feet are off the ground at a point mid-full gallop. Stanford believed in ”unsupported transit”, claiming that in both trot and gallup, there was a moment when all feet were off the ground.

To test this claim, Muybridge arranged a number of large glass plate cameras in a line along the edge of a racetrack. He set them each to be triggered by a snapping thread as each horse passed.

This study, titled Sallie Gardner at a Gallop or The Horse in Motion shows images of a horse with all feet off the ground during a trot. The illustrators had gotten it wrong. Between 1883 and 1886, Muybridge took over 100,000 images. In 1887, his major collected work was published, comprising 20,000 of the photographs, a groundbreaking work titled Animal Locomotion: an Electro-Photographic Investigation of Connective Phases of Animal Movements.

First edition of *R.U.R.* Rossum's Universal Robots

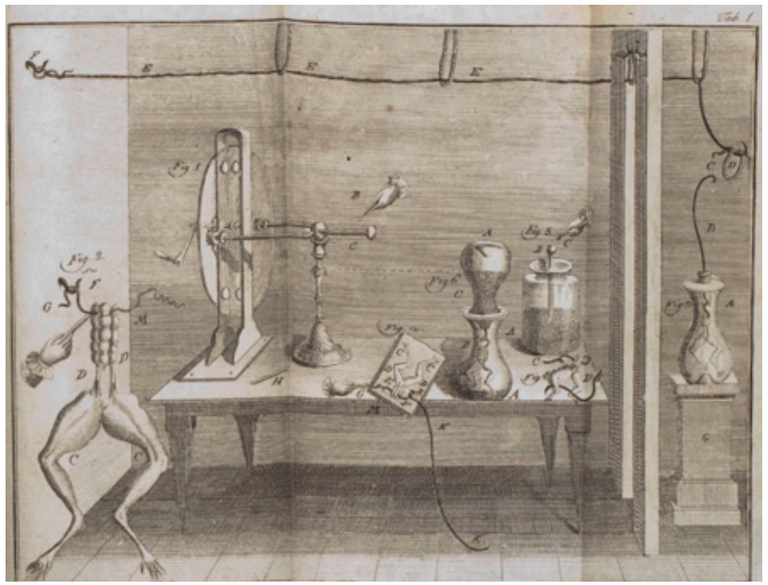
HISTORY OF "ROBOT"

The etymology of the word "Robot" is rooted both in the history of theater and class politics. In Czechian, a "robotnik" was a peasant or a serf in the 19th century. The word "Robot" itself first appears in a theatrical play, entitled "R.U.R.", a science fiction play by Czech writer Karel Capek. R.U.R. is an acronym which stands for Rossum's Universal Robots.

It premiered on January 21, 1921, and introduced the word "Robot" to the world. R.U.R. takes place in a factory that makes artificial people out of synthetic organic matter. It details the uprising of a hostile robot revolution, ultimately resulting in the extinction of the human race.

ROSSUM'S ELECTRIC ANIMALS

The story starts with a scientist named Rossum, who, while researching marine biology, discovered a chemical that acted like a protoplasmic agent, similar to the living content of a human cell. Rossum began to try to make his own animals, initially failing to fully form a living copy of a dog and a man. His intention, beyond defying God, was to nullify God's existence all together. His nephew came to visit him, and seeing a different potential for the protoplasm, locked Rossum in his lab and hijacked his research.



Prints from Galvani's treatise on the physio electrical effects of animal electricity

The outcome of the younger Rossum's work results in a world filled with an inexpensive, popular and widespread "robotic" workforce. The play goes on to detail the outcomes of this new work force - a decline in human births, a new, world-wide robot economy, and the gradual development of ever more advanced, fully formed versions of Rossum's Universal Robots.

ELECTRIC FROG LEGS

Luigi Galvani was born in 1737 in Bologna, Italy.

On January 26th, 1781, he discovered frog electricity.

Galvani was slowly skinning a frog on a table sometime in the middle of the 18th century. The table had been used for conducting experiments with static electricity. He was rubbing the skins of frogs.

His assistant, by accident, touched an exposed sciatic nerve of the frog with a metal scalpel that had been charged with static electricity. They looked down and saw sparks, and the dead frogs legs started kicking. Seeing this happen made Galvani investigate the relationship between electricity and animation. Galvani prepared an electrostatic generator with a connection to a copper wire, and attached this to a nerve above a frogs leg. The leg began to move.

This was the discovery of "animal electricity".

Luigi Galvani

ANIMAL ELECTRICITY

Galvani's deduction was that there is a fluid that flows from the brain through the nerves into the muscles where it is turned into motion.

The phenomenon becomes known as "Galvanism". Today, the study of galvanism is called electrophysiology.

"Wherever frogs could be caught they were used to repeat the strange phenomenon. In the light of the struggle and revolt against established order which marked the period (a successful revolution by the colonial Americans against the British crown, and the beginnings of revolt against the King of France), it can be seen how eagerly laymen and scientists in great numbers hunted the hapless frog to see for themselves how by the use of a few pieces of metal, dismembered limbs were caused to revive. Here, indeed, was the promise of the release of a new vital force."[2]

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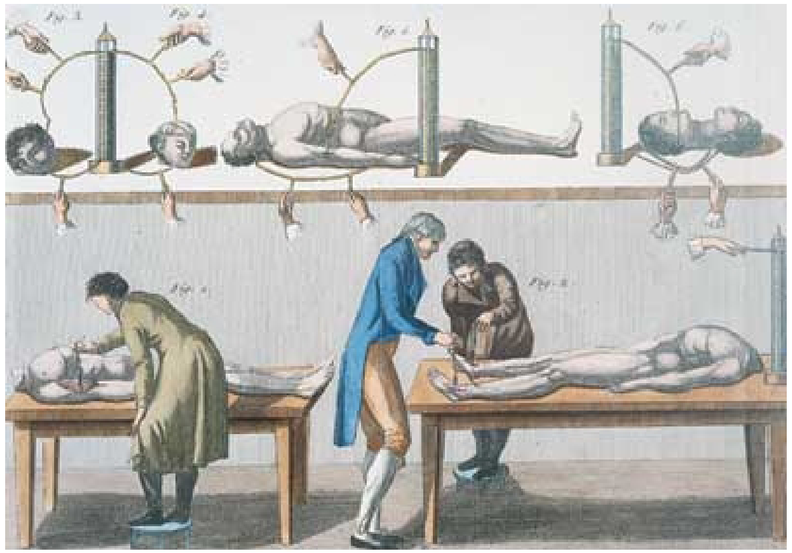

Drawing of the Galvani laboratory attempting to reanimate a deceased person

REANIMATION

On the 17th of January, 1803, a man named George Foster was hanged at the Newgate Prison for the murder of his wife and child, who he had drowned in the Paddington Canal. Immediately after being hanged, his body was brought to the home of Joannis Aldini. Aldini, who had worked with Galvani on the bio-electricity experiments, attached a voltaic pile of 120 copper and zinc discs to the beheaded corpse. When the rods touched Foster's mouth and ear, an alarming incident was recorded, as Aldini wrote that "the jaw began to quiver, the adjoining muscles were horribly contorted, and the left eye actually opened." When one rod touched the rectum, the whole body convulsed- Aldini writes that "so much increased as almost to give an appearance of reanimation".

Aldini's attempt at reanimation ultimately failed- though, if it hadn't, the accompanying court officials would have ensured his demise regardless. A news report at the time observed, "as the law says, the condemned shall hang until he is dead; consequently, if recovered, they are liable to be again hanged up until they are dead."[3]

15 years later, Mary Shelley published Frankenstein.

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