

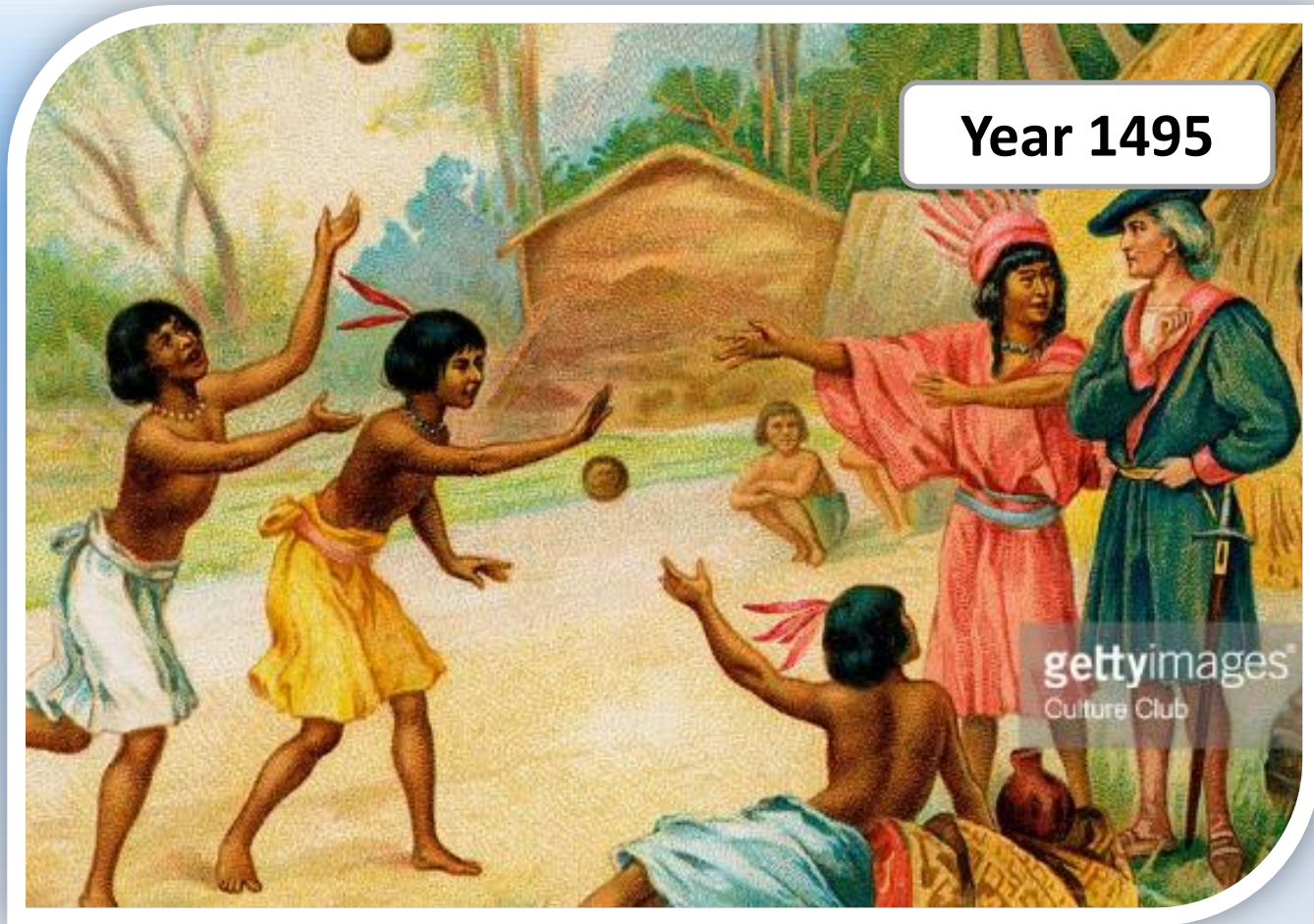
# From Columbus playing Indians to the space materials of today



Annual meeting 2016 04 13

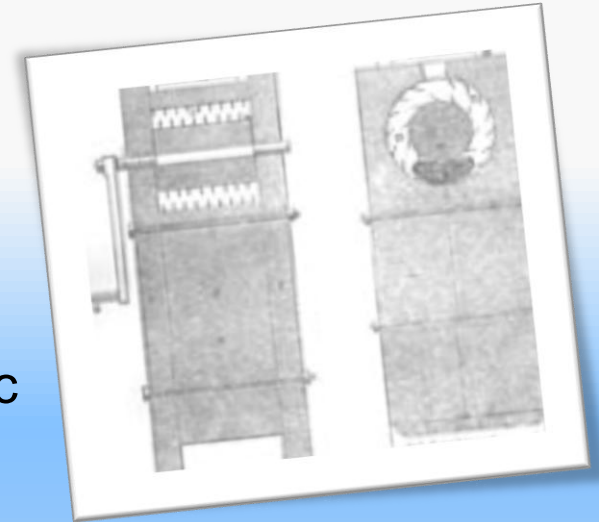


# The start of over five hundred years technology



## Early use of Natural Rubber

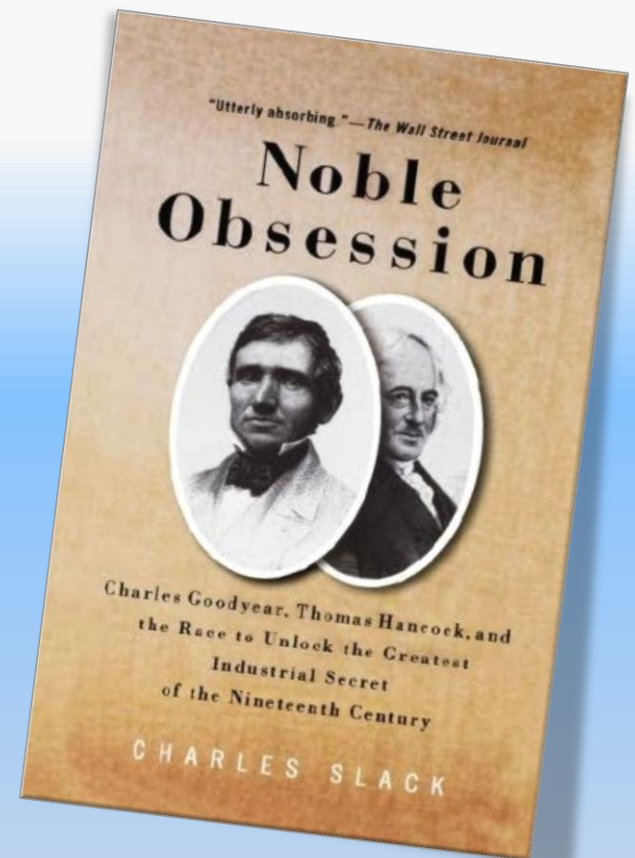
- In 1756 Charles Marie de La Condamine describe the properties in the first scientific paper and named the material caoutchouc
- Eraser manufacturing in England 1770 and the word Rubber was born
- In 1791 Samuel Peal made waterproofing leather by desolving rubber in turpentine and impregnating the leather
- In 1819 Thomas Hancock design the masticator
- In 1823 Charles Macintosh patented a method for making waterproof garments



## The revolution of curing

In 1839 Charles Goodyear found that:  
Adding sulphur to natural rubber and  
heating it up changed the material from a  
plastic to an elastic state.

Totally new properties was received and  
this opened a new world of possibilities



# The start of one of today's most important means of transportation -vehicles

- John B.Dunlop patented the pneumatic tire 1888
- Karl Benz built 1886 the first car with combustion engine
- The first users of pneumatic tires for automobiles was the Michelin brothers, André and Édouard. They drove the car in the 1895 Paris-Bordeaux road race.



# The availability of Natural rubber to be secured

- Hevea Brasiliensis was growing wild in Brazil
- Ruthless exploitation in the forests –”The Devils milk”
- 1873-1876 rubber seeds was brought to London
- Seeds sprouted in Kew Garden
- Plantations set up in Malacca and Ceylon
- The production of rubber developed quickly and the tapping technique was improved
- Still 42 % of world consumption of rubber polymers is NR



# Technological break through in rubber compounding

Three most important events during the first decade in the 20<sup>th</sup> century:

*Introducing of accelerators*

*Reinforcement with carbon black*

*Introducing of antioxidants*

Resulting in improved mechanical properties, improved life-length and higher productivity



## One of the men behind



Research for improvement of properties and productivity:

- 1904-1906 made George Oenslager experiments with use of carbon black, accelerators and antioxidants
- 1905 Aniline used as first accelerator
- 1914 First use of carbon black as reinforcement reported by Goodrich Tire Company
- 1920 Antioxidants are more common used
- 1948 Oenslager receives **The Charles Goodrich medal**



# 70 years development of curing systems

Year	1850	1880	1905	1920
Rubber	100	100	100	100
Sulphur	8	8	6	3
Zinc Oxide	-	5	5	5
Aniline	-	-	2	-
Stearic acid	-	-	-	1
MBT	-	-	-	1
Optimal curing time, min at 142 °C	360	300	180	30

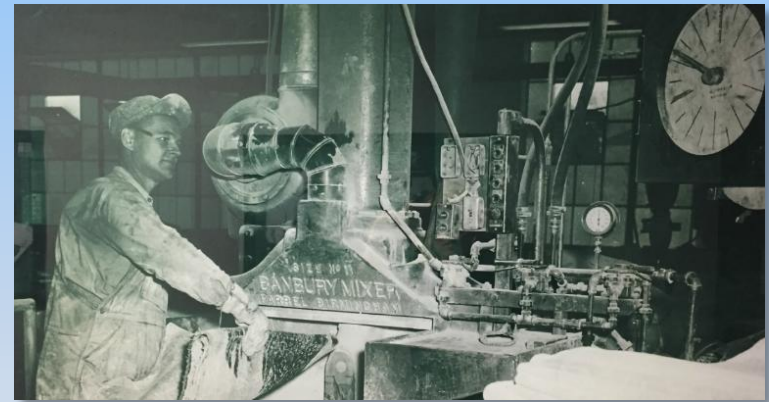
Source: Natuurrubber 26/2002

Even carbamates and guanidines available 1920

With thiurams introduced 1930 and sulfenamides 1937 the curing systems used to day more or less already in operation

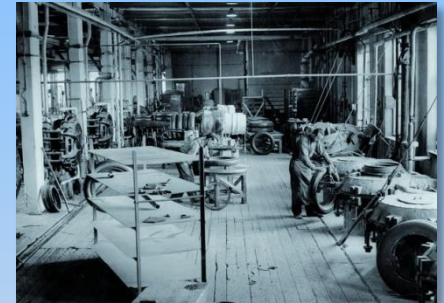
# Mixing technology

- Early compounding took place either in single rotor machines such as Hancock's Pickle, or on two roll mills.
- First internal mixer machine was a twin rotor design patented by Paul Pfeleiderer in 1878/1879.
- F.H. Banbury designed 1916 the Banbury which soon was the standard machine in bigger factories



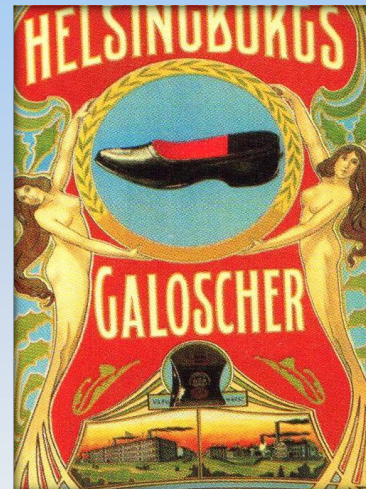
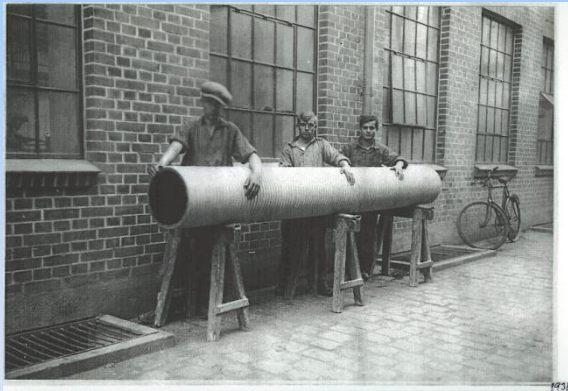
# The Nordic rubber industry started early

- ❖ 1888 Skandinavisk Gummi Compagni AS
- ❖ 1889 Dansk Gummivarefabrik limiteret
- ❖ 1890 Skandinavisk Gummiaktiebolaget i Viskafors
- ❖ 1890 Helsingborgs Gummifabrik AB
- ❖ 1891 Norsk Remfabrik AS
- ❖ 1893 Gislaved Gummifabrik AB
- ❖ 1896 Viking AS
- ❖ 1896 AB Velox, 1905 to be Trelleborgs Gummifabrik AB
- ❖ 1896 AS Schiönning's Gummifabrik AS
- ❖ 1898 Soumen Gummitehdas Oy to later be Nokian Tyres



# Early product manufacturing in Nordic countries

- Galoshes
- Bicycle tires
- Hoses
- Belts
- Technical rubber products



## World War I and rubber

- During World War I, motor vehicles had a key role for transport of troops and equipment. That needed tires of rubber which became a raw material of strategic importance.
- The plantations in the British colonies Malaya and Ceylon dominated the rubber market. The Entente practically had a monopoly.

Source: International encyclopedia of the first World War



# World War I and rubber

- German chemical industry had tried early to find replacement for natural rubber
- First synthetic rubber, methyl rubber, made by Bayer 1906 but tires failed due to short life length
- During the war German produced 24 000 ton of methyl rubber IISRP
- Truck tires produced during the war failed normally after around 2000 kilometers

Source: International encyclopedia of the first World War



## Word War I and rubber

A less known result of war struggles:

- When the fronts began to freeze and with no end in sight, the sexual hygiene of the troops became a matter of growing concern, and protection from diseases was necessary
- Julius Fromm developed a dipping technique to produce a seamless condom using a solution of rubber in benzene and cold curing with carbon disulphide



# Synthetic rubber 1920 -1940

- Driving forces for new polymers was the automotive industry and the military demands
- First task was to find replacement for natural rubber
- Other goals to achieve resistance to fuel and higher temperature

## Results:

- 1930 Thiokol was put into production as the first oil resistant rubber
- 1933 SBR (Buna S) production started in Germany
- 1934 Chloroprene rubber (Neoprene) goes into full production
- 1937 Nitrile rubber (Buna N) in full production
- 1937 Butyl rubber manufacturing started





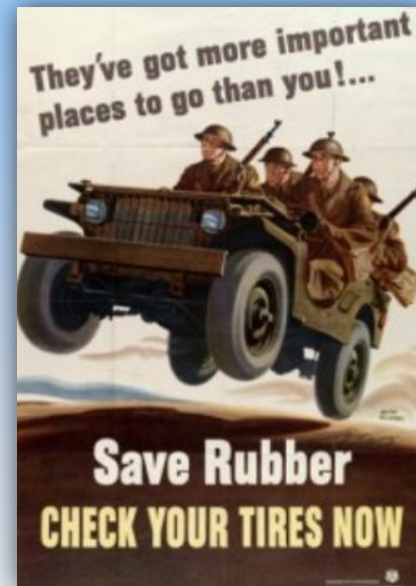
# World War II and rubber

- ❖ Japan conquered Southeast Asia and the world's natural rubber becomes unavailable to England and USA.
- ❖ An incredible project was fulfilled in USA by increasing the production of GR-S (SBR) from 3 700 tons in 1942 to 756 000 tons 1945 – an increase over 2000 %
- ❖ Ultimately, the nation spent as much on its rubber program as it did on the nuclear bomb. (According to NIST)



## The reclaim was widely used

All over Europe and America old tires, boots etc were collected to be used for reclaim manufacturing  
The technology was improved and the pan process widely replaced by the reclamator technique



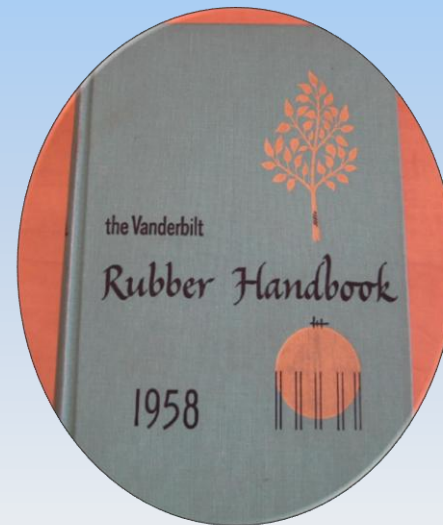
# Ideas coming back

- In the 1940s Dandelion were grown in Sweden to be used for rubber production
- The Swedish rubber industry were forced to contribute for experiments at the Agricultural University in Ulltuna
- The project died after some years
- In 2014 it is reported that Continental are testing tires made on rubber from Dandelion



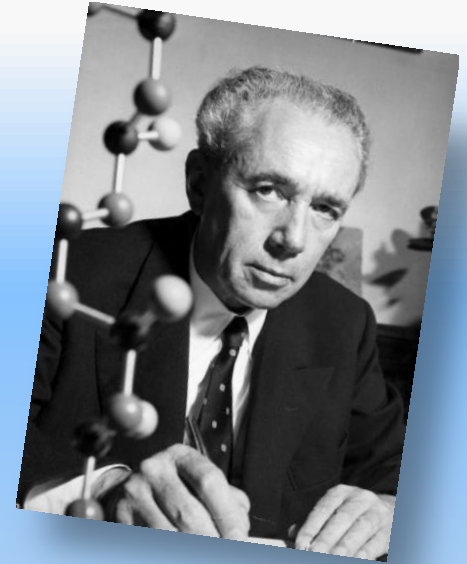
## Rubber compounding in the 1950's

- Still more of an art than a science
- Vanderbilt Handbook – the “bible” all over the world
- Great activities from raw material manufacturers to transfer knowledge to the product manufacturers



## From 1945 until to day

- Silicon rubber started to be produced 1945
- Polyurethane Rubber on the market in the 1950's
- Fluor rubber coming on the market 1955
- EPM in production 1957
- Butadiene Rubber in use 1957
- EPDM on the market 1963
- TPE introduced 1972
- Hydrated Nitrile Rubber commercialized 1988
- And a lot of other specialty polymers
- Carbon black types were further developed
- The chemical industry offered new additives



Professor G. Natta

## Example of what new polymers made possible

- Fluor rubber contributing to new sealing technology in tuff chemical and thermal environment
- Butadien rubber contribute to increased life length for tire and several industrial products
- EPDM making non blooming, non cracking seals in vehicles and buildings to a reasonable cost
- HNBR giving possibilities to better performance of products on e.g. oil rigs and in timing belts
- TPE – giving rubber industry chance to compete with plastic in many fields and opposite



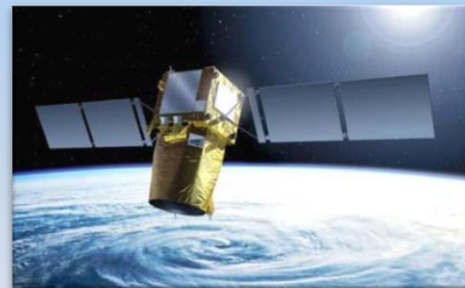
# Results of the polymer and additives developments

*The Rubber Industry was ready for new demanding requirements from e.g.*

Airplane Industry



Space Industry



Deep sea oil extraction business



# Successful product examples

Buildings isolated against damages from earthquake



Seals to protect sensible equipment in the robots Spirits and Opportunity on the planet Mars

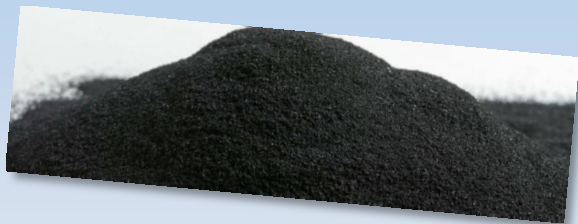


Rubber parts for jet fire protection on oil rigs



## What can we expect from the future?

- Rubber even more important engineering material
- Broader limits for the use of rubber
- New sources to compete with NR
- Synthetic polymers based on renewable substrates
- More efficient reuse of old products
- Less use of non renewable resources
- New high performance polymers



Photos: Virtual Rubber Substitutes AB

Thank you for your attention!

Good Luck with the future!