



Hall B1
December 10th



10:30 – 10:50 Conference opening

10:55 – 11:35 „Power system of Krka – Šibenik“, Marko Delimar

11:40 – 12:25 „Methods for calculation of the shortest path in professional GPS car-navigation systems“, Ivica Siladić

12:25 – 13:20 Pause

13:20 – 13:55 „Metro line No.1 in Budapest“, Péter Kádár

14:00 – 14:45 „Storage and disposal of radioactive waste“, Saša Medaković

14:50 – 15:35 „Power system protection – Where are we today?“, Meliha Selak

15:40 – 16:10 „Ancillary services in distribution network: Where are the opportunities?“, Andrej Gubina


16:15 – 17:00 „Electromobility in Croatia“, Dražen Crnković (Ducati Komponenti d.o.o.), Ivica Skorić i Domagoj Puzak (HEP d.d.)



IEEE Student Branch Zagreb

Unska 3, 10 000 Zagreb

sb.zagreb@ieee.org



***Krka-Šibenik
Electric Power System 1895***

Marko Delimar

Zagreb Energy Conference, 10 December 2015

Present day



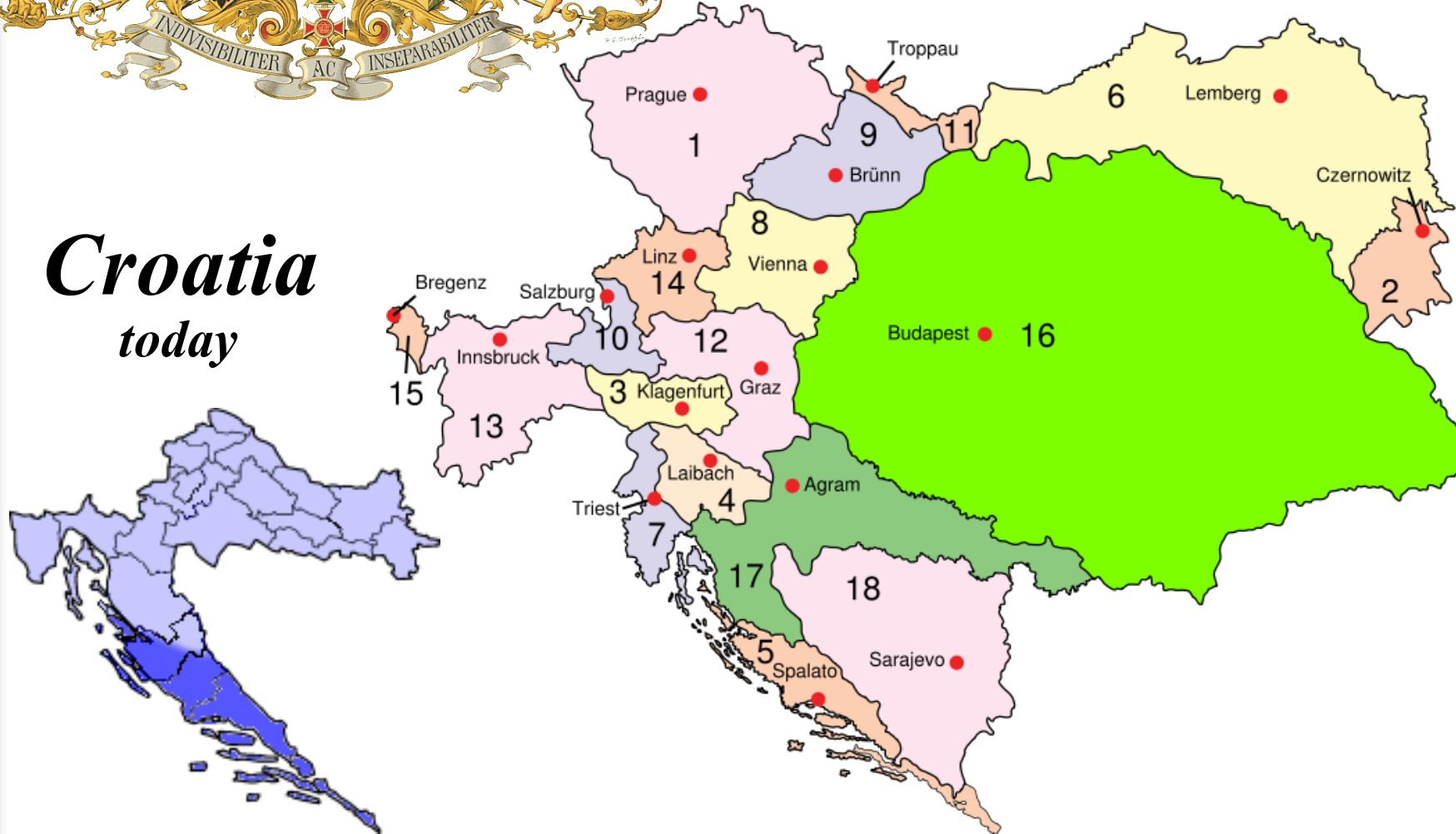
Europe – 1895





Austro-Hungarian Monarchy

Croatia today



Franz Joseph I (1830-1916)

Emperor of Austria, King of Hungary



- Franz Joseph I (German)
- I. Ferenc József (Hungarian)
- Franjo Josip I (Croatian)
- Francis Joseph I (English)
- ruled from 1848-1916
- his 68-year reign is the third-longest in the recorded history of Europe



Imperial Easter Tour of Dalmatia

April 1875



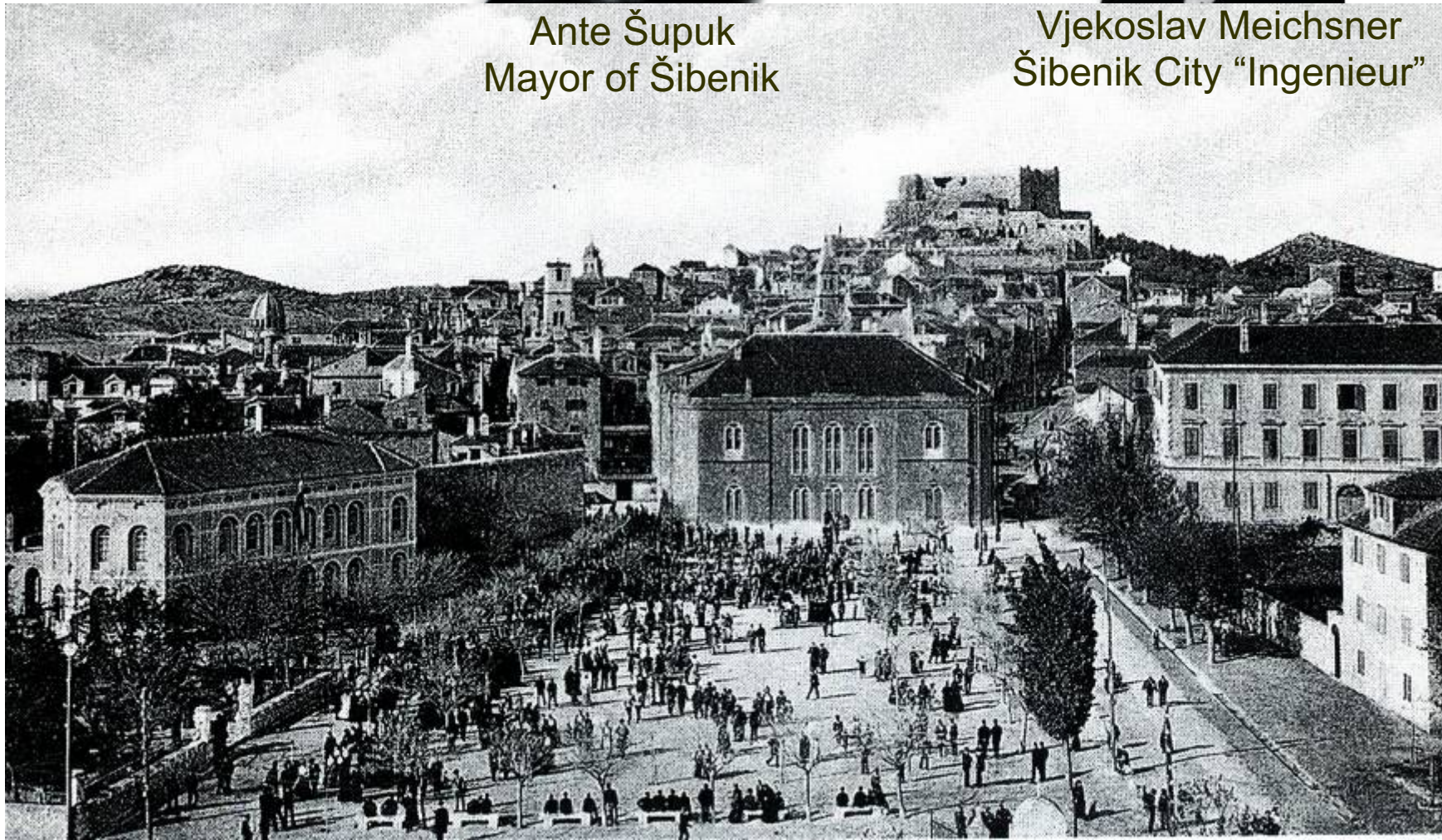
Šibenik



Ante Šupuk
Mayor of Šibenik



Vjekoslav Meichsner
Šibenik City "Ingenieur"



Šibenik City Hall



1882 – New York

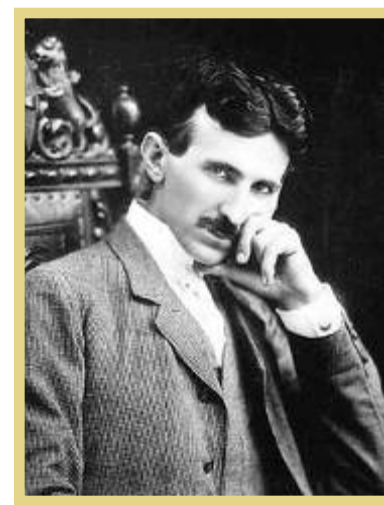
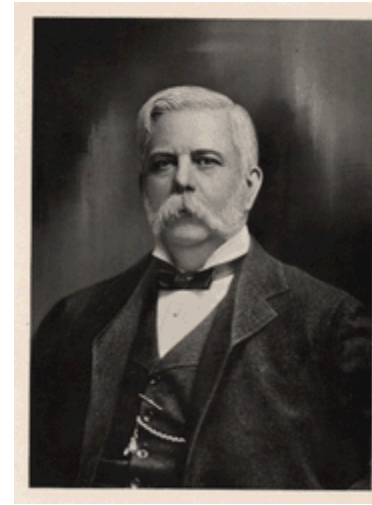
- **Edison builds a first DC network – Electric lights in New York**

1883 – 1890 in Croatia

- **10 DC power plants built**
- **9 thermal, 1 hydro**
- **Rijeka (1885) – sixth theater in the world connected to a power grid (New York, London, Paris, Milan, Vienna, Rijeka)**

War of Currents - 1880's

- Thomas Edison
- DC
- Nikola Tesla
- George Westinghouse
- AC



Tesla's address to the AIEE

- **At an AIEE meeting on May 16, 1888, Nikola Tesla delivered a lecture entitled A New System of Alternating Current Motors and Transformers, describing the equipment which allowed efficient generation and use of alternating currents...**

1891 – Frankfurt Exhibition

- first long-distance AC transmission
- 175 km from Laufen to Frankfurt
- Marko Šupuk attended the exhibition



Tesla's address at Zagreb City Hall

- **In May 1892 Nikola Tesla delivers a lecture in Zagreb City Hall trying to convince the City of Zagreb to start building an AC power plant**
- **at the same time the construction of the AC power system in Šibenik had already begun**

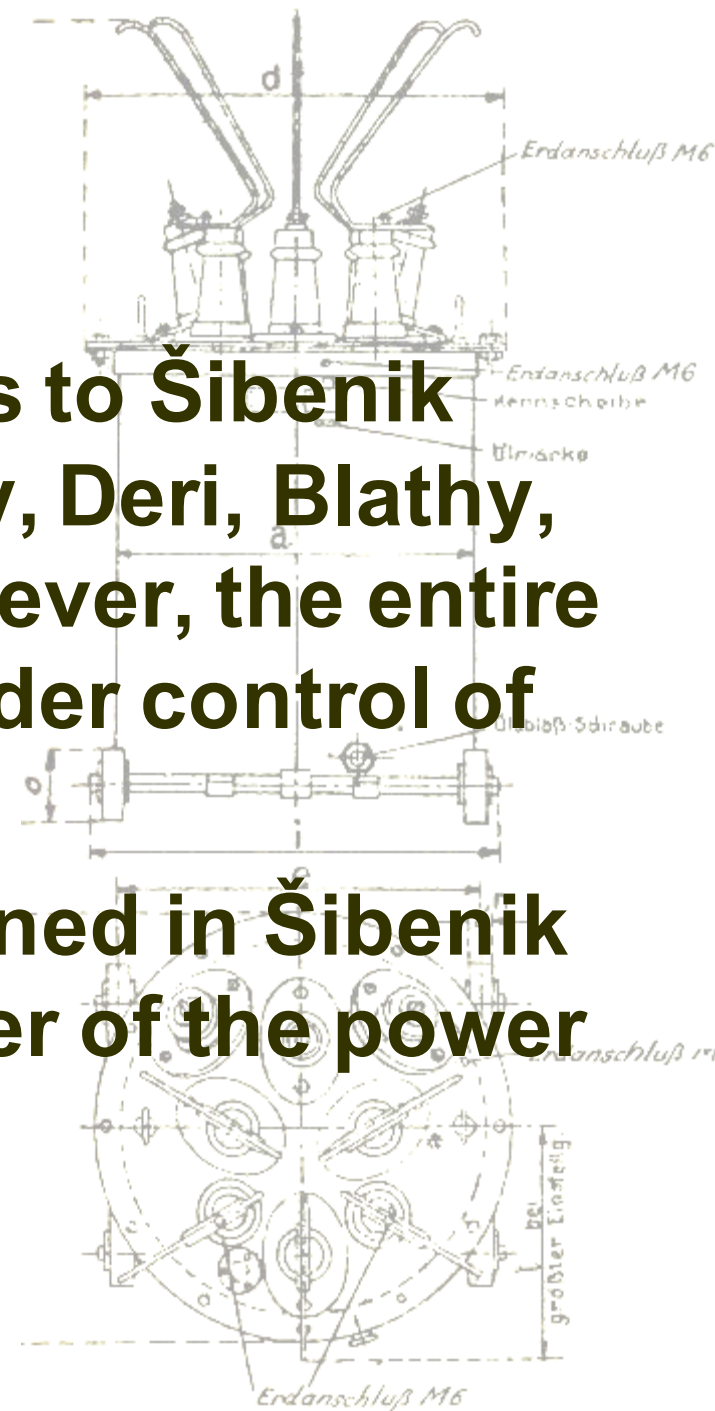


Šibenik – the beginning

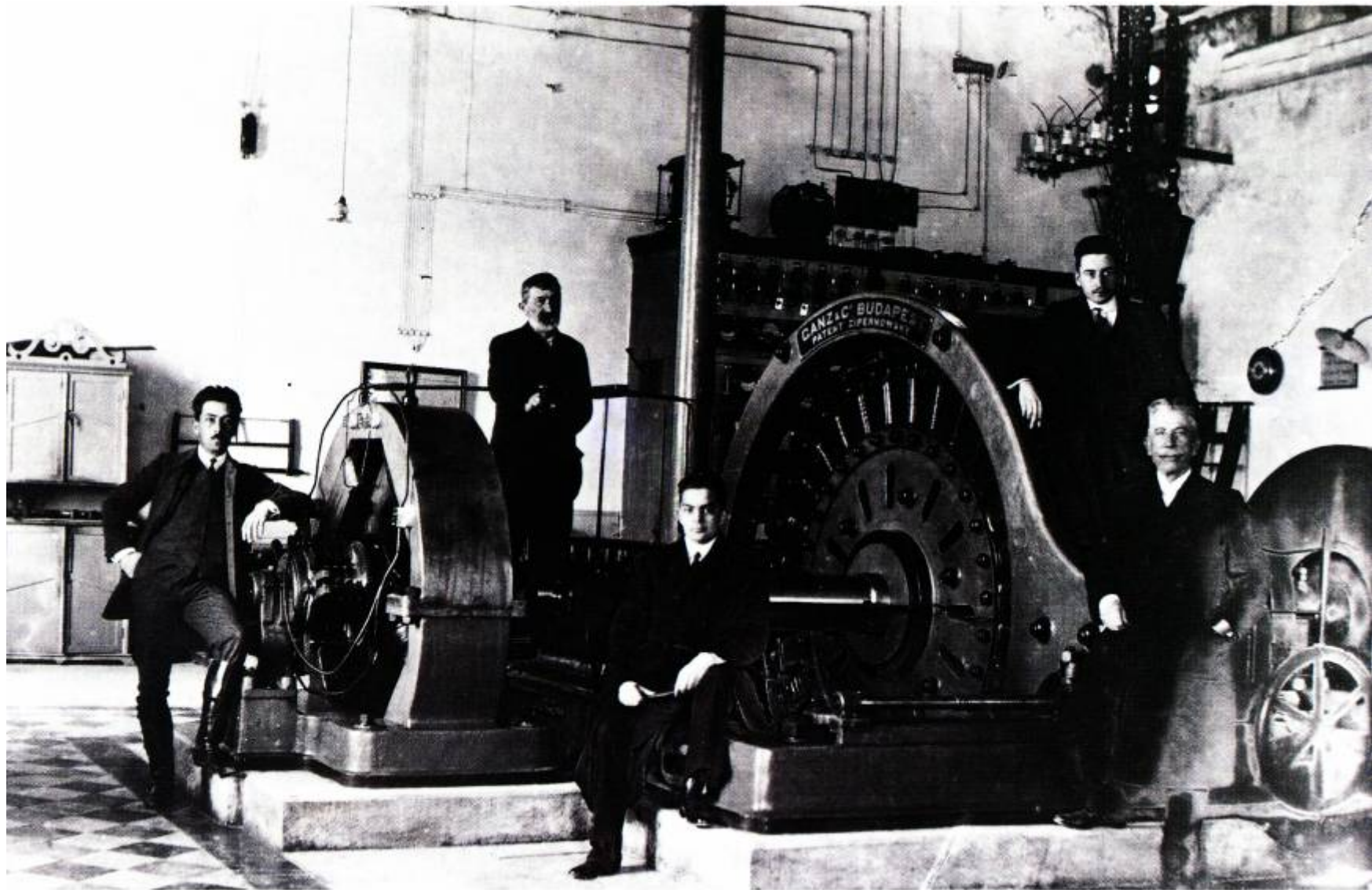
- Šupuk and Meichsner contact Ganz
- Ganz agrees to build an "experimental system" in Šibenik
- the system would consist of
 - hydro power plant
 - transformers
 - transmission line
 - distribution network
 - meters and other equipment

Preparation

- Ganz sends top experts to Šibenik (including Zipernowsky, Deri, Blathy, Zerial, Zorzenoni); however, the entire production remains under control of Meichsner and Šupuk
- Ettore Zorzenoni remained in Šibenik as chief technical officer of the power plant after it was built
- Karoly Zipernowsky – transformers
- Miksa Deri – circuit-breakers
- Otto Titusz Blathy – watt-meter

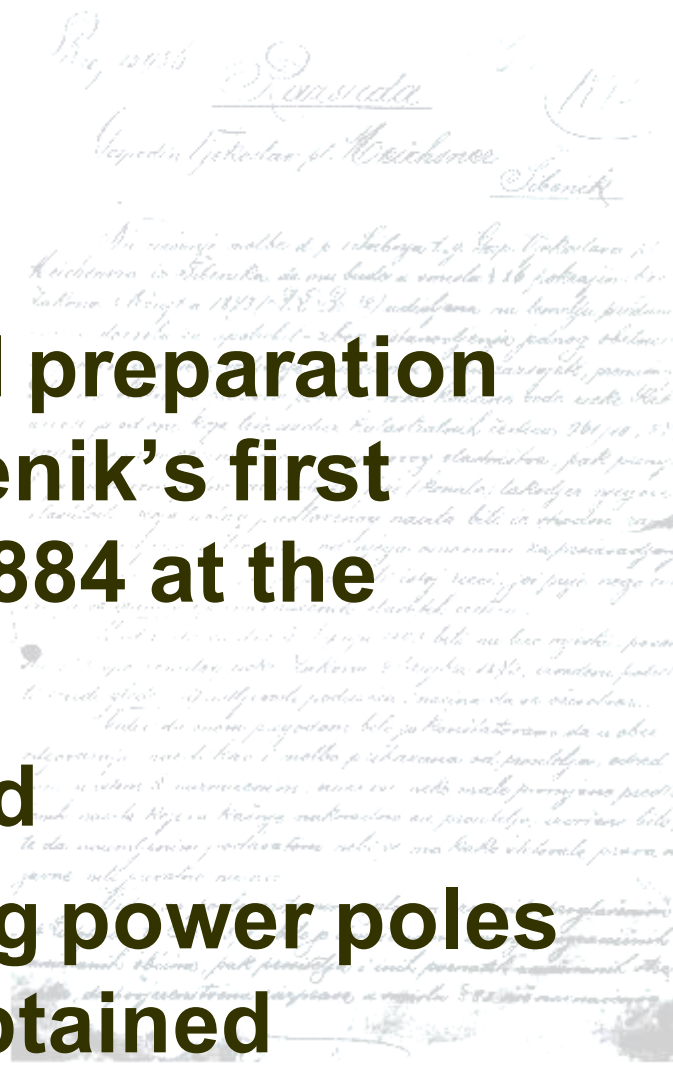


Šupuk family and associates



Construction begins

- **after months of detailed preparation the construction of Šibenik's first power plant begins in 1884 at the location called Jaruga**
- **building permit obtained**
- **a concession for placing power poles on the county land is obtained**
- *at approximately the same time G. Westinghouse begins building the Niagara Falls plant*



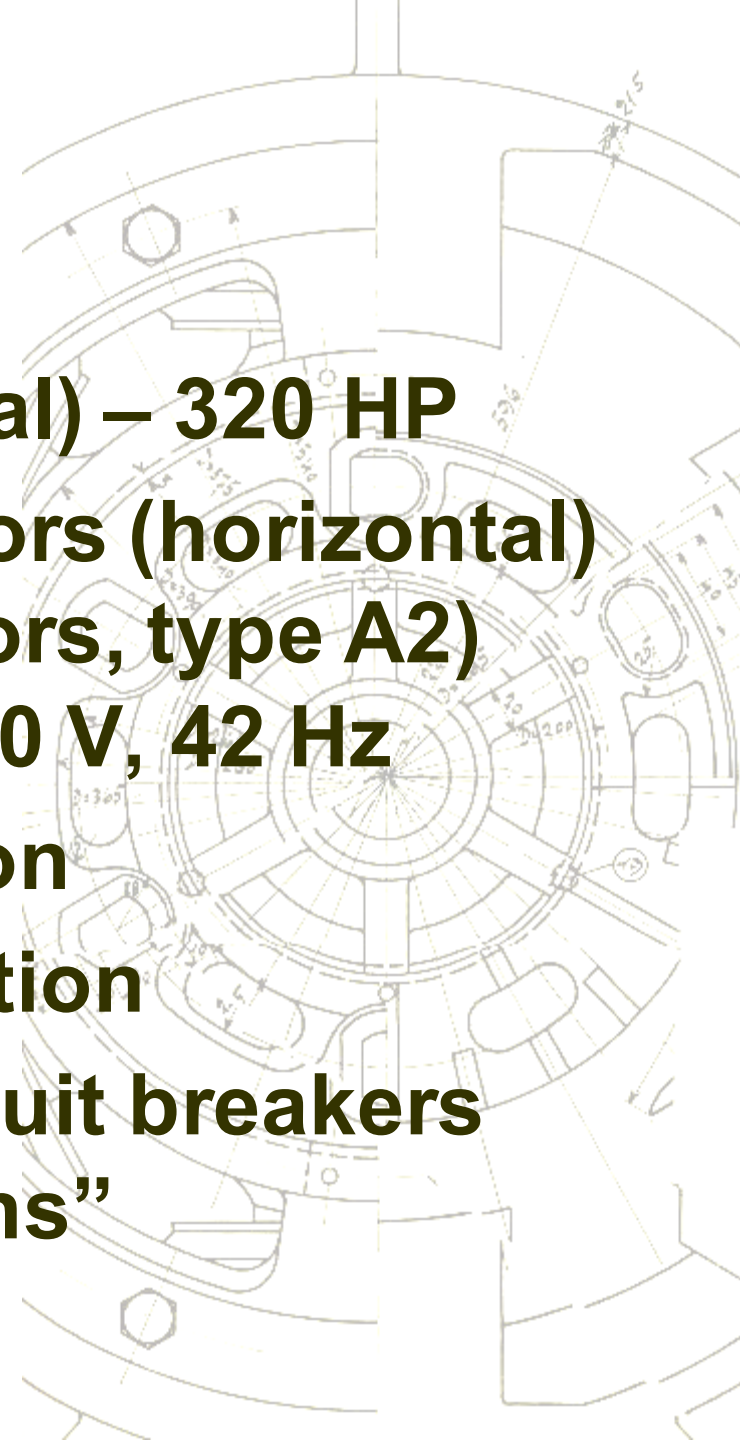
Krka Power Plant

Jaruga 1



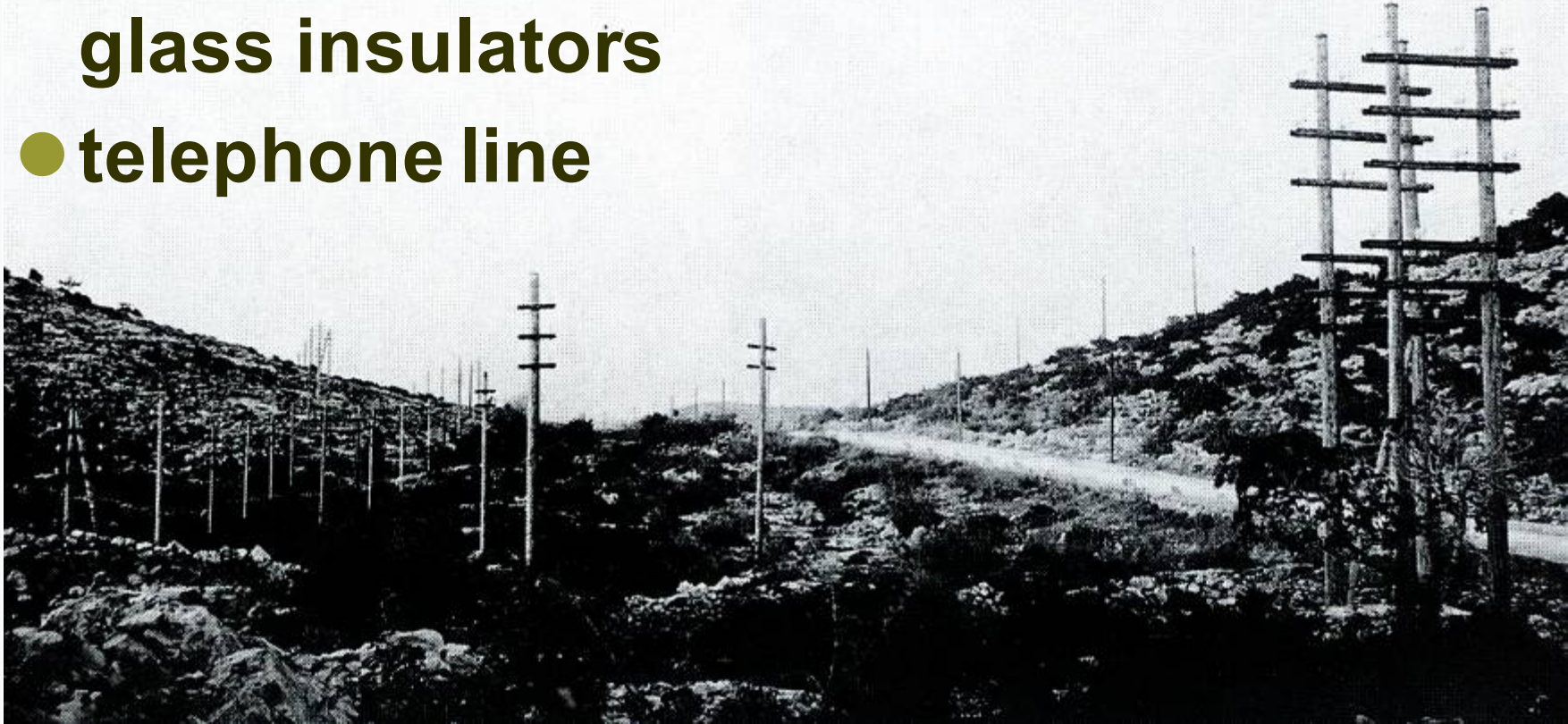
Power plant

- **Girard turbines (vertical) – 320 HP**
- **Ganz 2-phase generators (horizontal)
(Zipernowsky alternators, type A2)
315 1/min, 320 HP, 3000 V, 42 Hz**
- **manual water regulation**
- **manual voltage regulation**
- **simple protection: circuit breakers
and over-voltage “horns”**



Transmission lines

- 3000V, 11 km, 360 poles
- 35 and 50 mm² conductors
- bottle shaped, oil-filled glass insulators
- telephone line



Transformers

- 6× 3000/110 V (Zipernowsky)
- 5 transformers were located on roofs
- 1 in a stand-alone transforming station



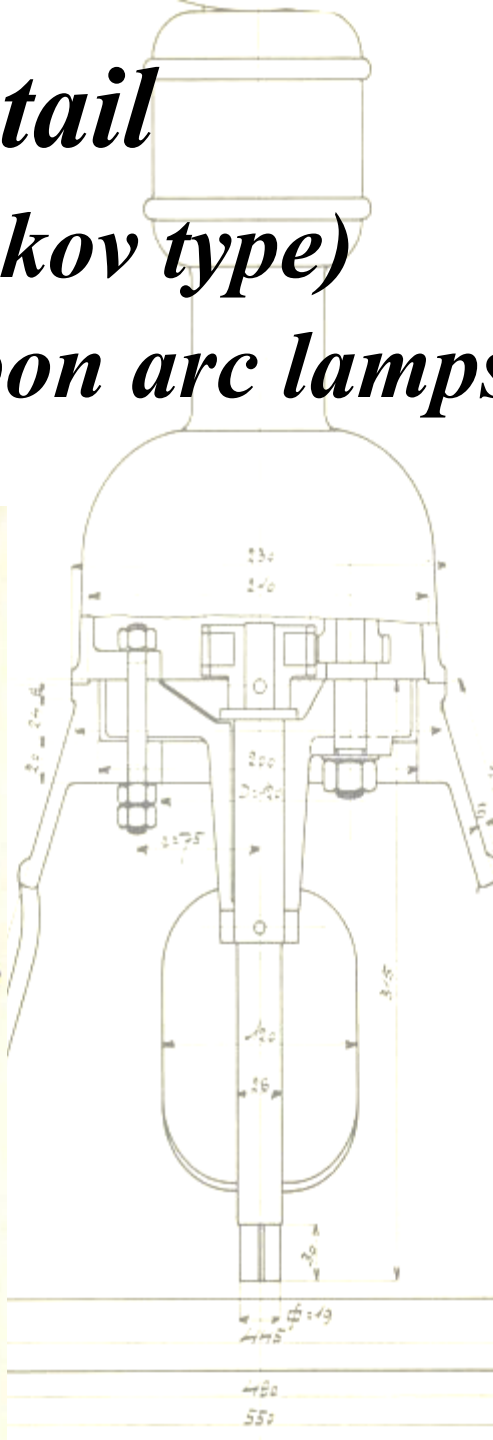
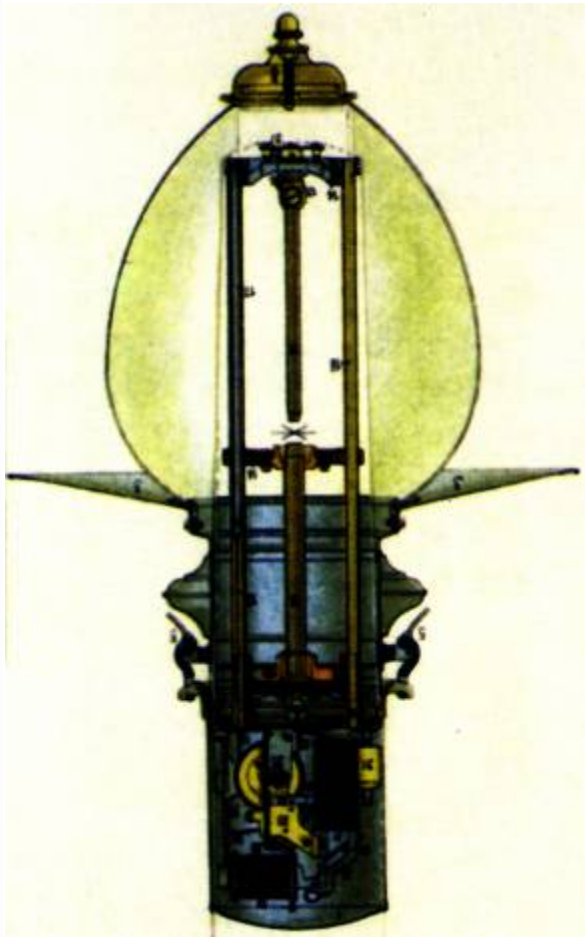
Street lamps



Street lamps



Lamps – detail
Ganz (Jablockov type)
– electric carbon arc lamps



28 August 1895

- **Electric power delivered to Šibenik**
- **324 electric lamps illuminate Šibenik on the first night**
- *Niagara Falls power plant opened two days before Jaruga, supplying the nearby aluminum factory; power delivery to Buffalo begun one year later*

1904 – Jaruga 1 and Jaruga 2



1903 – Jaruga 2

- **Ganz**
- **Francis turbine 3500 HP (later two)**
- **2-phase generator 2625 kVA, 15000 V, 42 Hz (later $2 \times 2625 = 5250$ kVA)**
- **new 12 km line, 4×50 mm² Cu (2× 2-phase) to a large factory in Crnica (Šibenik), 360 poles**
- **transforming station 15000/6000/3000 V**
- **parallel operation with Jaruga 1**

1906 – HPP Manojlovac (Miljacka)

- **third HPP in Šibenik**
- **first on a 3-phase system**
- **4 horizontal Francis turbines (6000 HP)**
- **4×5200 kVA, 30000 V, 42 Hz**
- **35 km 30 kV line, 2×3×62 mm² Cu**

- **Jaruga 1 and Jaruga 2 reconstructed for 3-phase systems, all plants interconnected into a single power system**

Šupuk family legacy

- **Marko Šupuk died in 1903**
- **Ante Šupuk died in 1904
(Mayor for 28 consecutive years)**
- **Šupuk and Meichsner built a city water supply, brought railway to Šibenik, built a County Courthouse, a High school, pavilion type hospital (first and biggest in Austria-Hungary)**

1914 – Jaruga 1 disassembled

- **Austrian army takes over all three power plants in Šibenik**
- **they close down Jaruga 1, move all usable parts to Jaruga 2, and use 15 tons of copper for bullets**
- **Jaruga 1 was never reconstructed**
- **Jaruga 2 is still in operation**

International associations

- **Šupuk&Son Electric Company was one of the six founders of EURELECTRIC (1925)**
- **Šupuk&Son Electric Company was also involved with the foundation of Cigre (1921)**

Time-scale

