The German Contribution to Metallography: Adolf Martens and Emil Heyn

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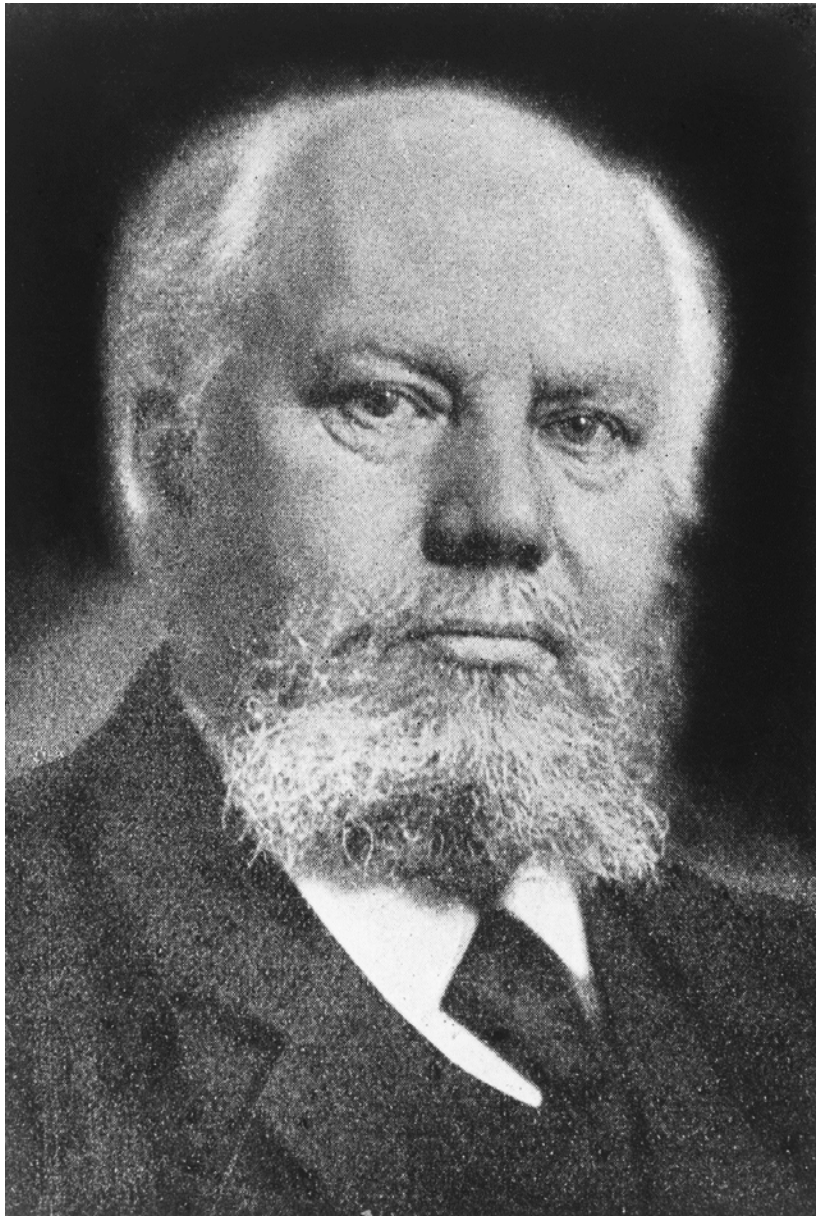
D-12200 Berlin, Germany

- **Adolf Martens and Emil Heyn, a biographical sketch**
- **their contributions to metallography**
- **their contributions to mechanical testing**
- **their contributions to materials engineering**

Adolf Martens - a biographical sketch



- **Adolf Martens was born on March 6th, 1850 in Backendorf, a small village near to Hagenow in Mecklenburg-Schwerin**
- **where his father was an estate tenant, a *Gutspächter*.**
- **Martens visited the *Realschule* (a form of secondary school) in Schwerin**
- **and started in 1867 as a locksmith, cabinet-maker and founder in the machine shop of Ernst Brockelmann in Güstrow.**

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Adolf Martens - a biographical sketch

Königliche Gewerbeakademie (Royal Industrial Academy)
Berlin, 1878-1884

- **In 1868, Martens went to the Royal Industrial Academy at the Klosterstraße in Berlin**
- **and completed his formation as an engineer in 1871**

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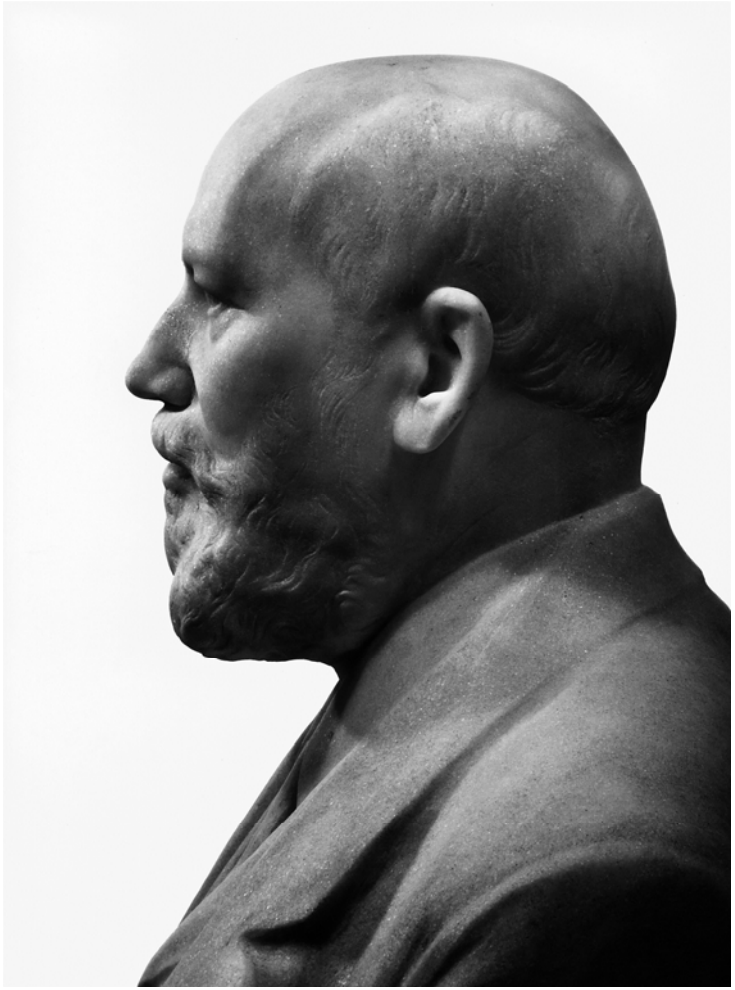
Adolf Martens - a biographical sketch

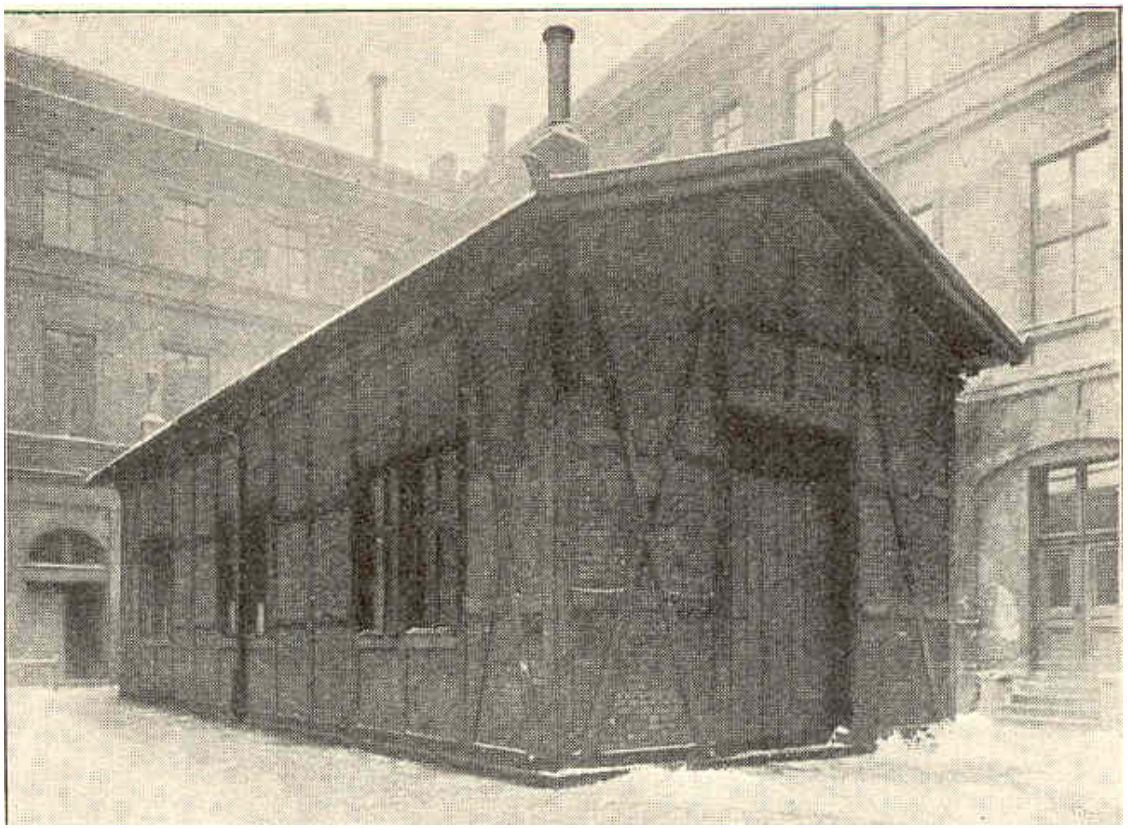
- **Martens was engaged at the Royal Prussian Railways and was initially at the *Ostbahn* (Eastern Railway) in Bromberg (today Bydgoszcz in Poland)**
- **where he was involved with bridges, metallic structures and construction supervision.**
- **In 1875, Martens changed to the Royal Railway Authority in Berlin-Blankenheim and got involved with the acceptance of rails and other steel products**
- **In this position he had intensive contacts to the iron and steel industry in Westphalia (Gutehoffnungshütte) and Silesia (Königs-Laurahütte).**



BAM, Headquarters, entrance hall

Adolf Martens - a biographical sketch

Ref. 7, page 75



Mechanisch-Technische Versuchsanstalt (Mechanical Experimental Station), Berlin, 1878

in the courtyard of the Royal Industrial Academy

- **In 1880, Martens became an assistant of Professor Consentius at the Royal Industrial Academy in Berlin.**
- **On April 1st, 1884, he was nominated Head of the Royal Mechanical Experimental Station.**
- **His staff consisted of his assistant, Prof. Rudeloff, and two technicians.**

- **The new Royal Mechanical Experimental Station grew rapidly and diversified its activities**
- **In 1884, a new facility was established at the Technical University in Berlin-Charlottenburg, new departments for oil and paper technology were created**
- **In 1889, Martens was nominated as a Professor of the Technical University**

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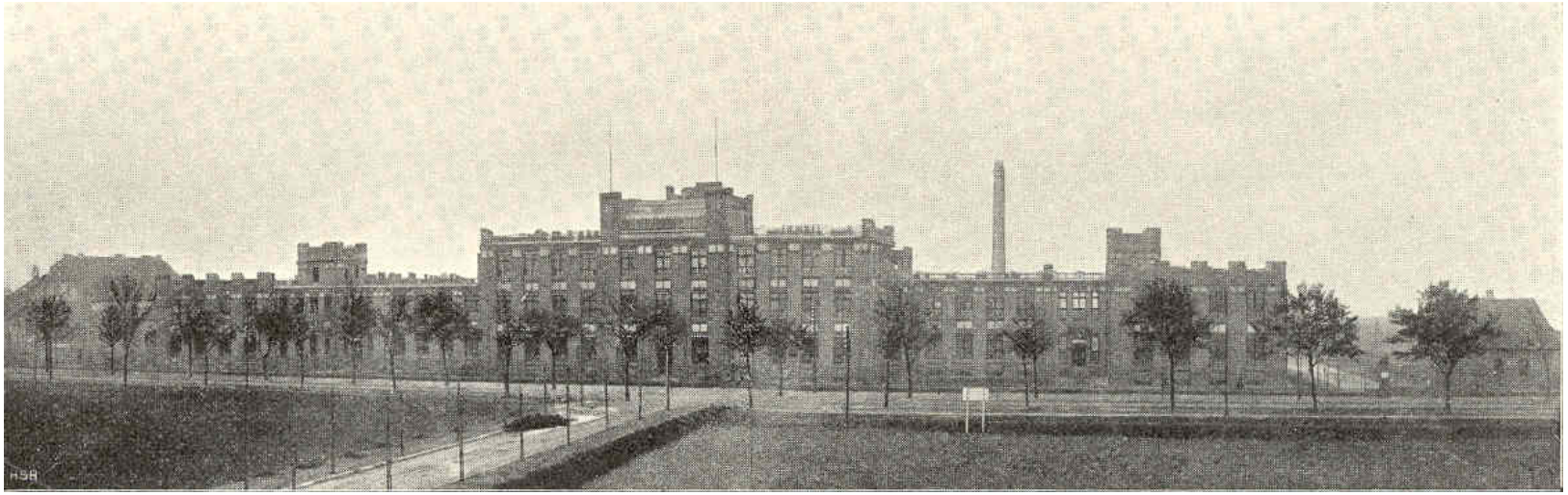
Königliche Mechanisch-Technische Versuchsanstalt (Royal Mechanical Experimental Station). Berlin-Charlottenburg, 1884 - 1904

Adolf Martens - a biographical sketch

- **In 1904, the new Institute for Materials Testing was created by merging several institutions under the direction of Professor Martens**
- **In the same year, a new headquarter was built in Berlin-Dahlem, which was expected to become a new scientific centre between Berlin and Potsdam**
- **Martens received in 1905 the title of a Dr.-Ing. E. h. by the Technical University in Dresden**



Ref. 5, page 117

Materialprüfungsamt (Materials Testing Institute), Berlin-Dahlem, 1904

as seen from Potsdamer Chaussee

Adolf Martens - a biographical sketch

- **Martens was extremely successful, the new Institute prospered enormously**
- **In 1913, he fell seriously sick**
- **Martens passed away on the evening of July 24th, 1914; he lies buried in the cemetery of Dahlem beside his son.**

Ref. 7, page 289

Abb. 157
Das Kaiser-Wilhelm-Institut für Chemie an der Thielallee 63–67 (Aufnahme aus dem Jahre 1912)

Kaiser-Wilhelm-Institut für Chemie
(Kaiser-Wilhelm-Institute for Chemistry), Berlin-Dahlem, 1912

Lise Meitner and Otto Hahn worked in this building

Emil Heyn - a biographical sketch

- **Friedrich Emil Heyn was born on July 5th, 1867 in Annaberg, a small village in Saxonia with a long mining tradition;**
- **His father was a tailor;**
- **The family Heyn moved to Freiberg 1872; Emil went there to the primary and to the secondary school;**
- **In May 1886 he started his studies in the Royal Saxonian School of Mines Freiberg, the renowned *Bergakademie;***
- **Heyn was an excellent student and draw the attention of Adolf Ledebur; 1890 he received his diploma as a metallurgist.**

Max-Planck-Institut für Intelligente Systeme
www.is.mpg.de

Emil Heyn - a biographical sketch

- **Heyn got his first position in November 1891; he joined the chemical laboratory of the steel foundry of Friedrich Krupp AG in Essen;**
- **He moved one year later to the *Hörder Bergwerks- und Hüttenverein* in Hörde, Westphalia; he was first engaged in the chemical laboratory and was later involved with the construction of two new blast furnaces;**
- **In November 1894 Heyn became a lecturer at the Royal Silesian School of Mechanical and Metallurgical Engineering in Gleiwitz (today Gliwice in Poland);**

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www.is.mpg.de

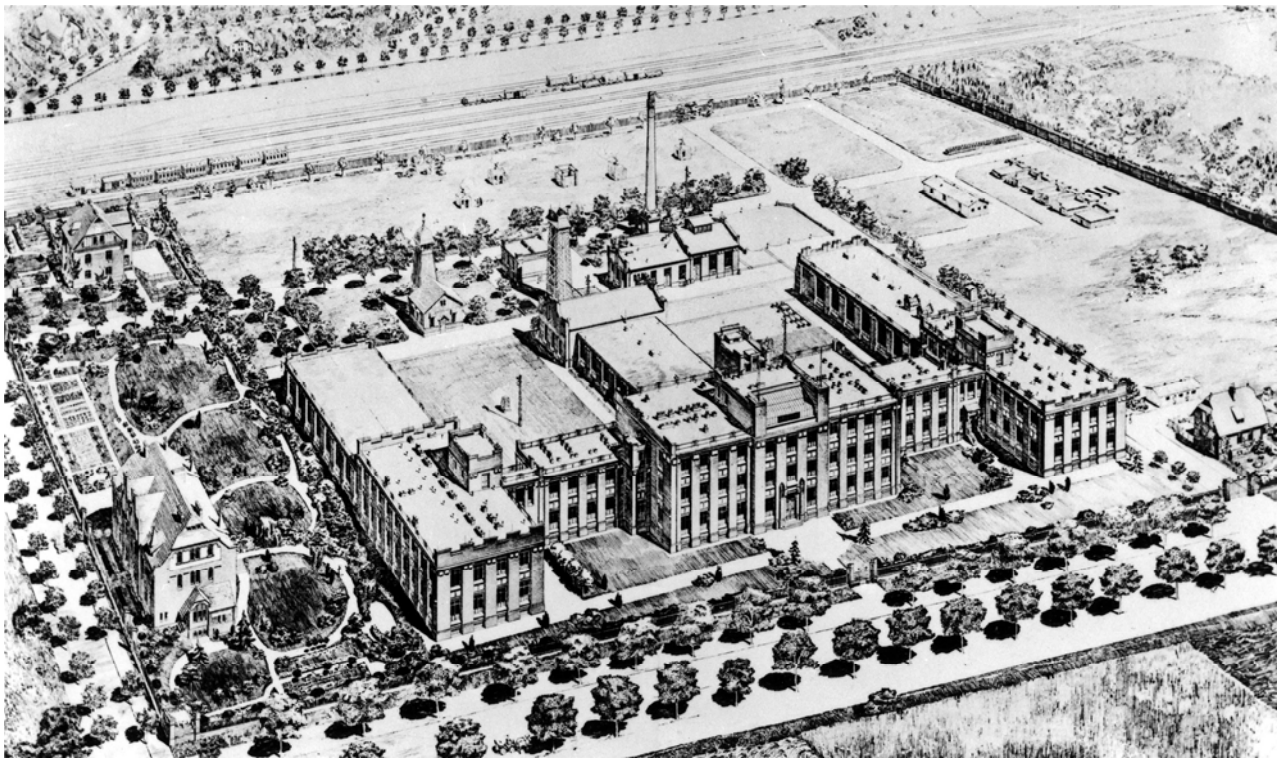
- **Following a recommendation of Prof. Ledebur, Heyn moved 1898 to the Royal Mechanical Experimental Station in Berlin-Charlottenburg as assistant of Adolf Martens in charge of the metallographic laboratory;**
- **He was also a lecturer at the Department of Mechanical Engineering of the Technical University and received his *venia legendi* on May 17th, 1900;**
- **In October 1901 he was nominated a full professor of Mechanical Technology.**

Ref. 5, page 10

Königliche Mechanisch-Technische Versuchsanstalt (Royal Mechanical Experimental Station). Berlin-Charlottenburg, 1884 - 1904

Emil Heyn - a biographical sketch

Ref. 7, page 113



Materialprüfungsamt (Materials Testing Institute), Berlin-Dahlem, 1904

- **Heyn had an important role in the construction of the new campus of the Materials Testing Institute**
- **1904 he was nominated Deputy Director; he was responsible for the chemical and metallographical departments;**
- **Heyn left the Materials Testing Institute on April 1st, 1917**
- **The *Bergakademie* Freiberg nominated Emil Heyn as a Dr.-Ing. E.h. in 1920.**

Emil Heyn - a biographical sketch

- **Heyn was a founding member of the German Society of Mining and Metallurgy – GDMB – created in 1912;**
- **Heyn was involved with the organisation of a Technical Committee on Metals with the German Society of Engineers – VDI;**
- **The German Society for Metals Research – DGM – was created out of this Committee on November 27th, 1919; Heyn was elected its first president;**
- **The highest award of DGM is the Heyn Medal; the first recipient was Gustav Tamman in 1929.**

DGM Deutsche Gesellschaft für Materialkunde eV

Emil Heyn - a biographical sketch

- **The Kaiser-Wilhelm-Institute for Steel Research was established in Düsseldorf in 1917**
- **The Kaiser-Wilhelm-Institute for Metals Research was created under the direction of Emil Heyn in 1920;**
- **The new building in Neubabelsberg – near to Potsdam – was inaugurated on December 5th, 1921;**
- **Shortly after that Heyn fell sick; he passed away on March 1st, 1922 and was buried in the cemetery of Dahlem near to Adolf Martens.**

Kaiser-Wilhelm-Institut für Metallforschung

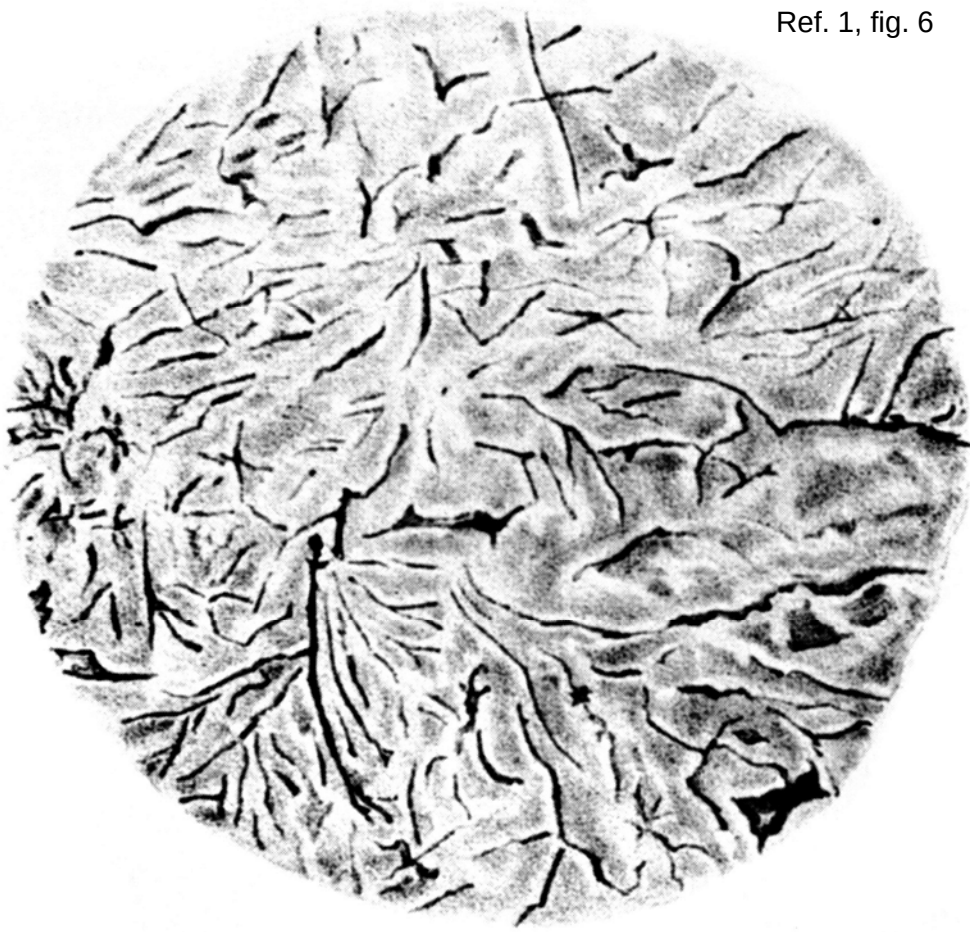
(Kaiser-Wilhelm-Institute for Metals Research), Neubabelsberg, 1921

Max-Planck-Institut für Intelligente Systeme
www.is.mpg.de

Metallography

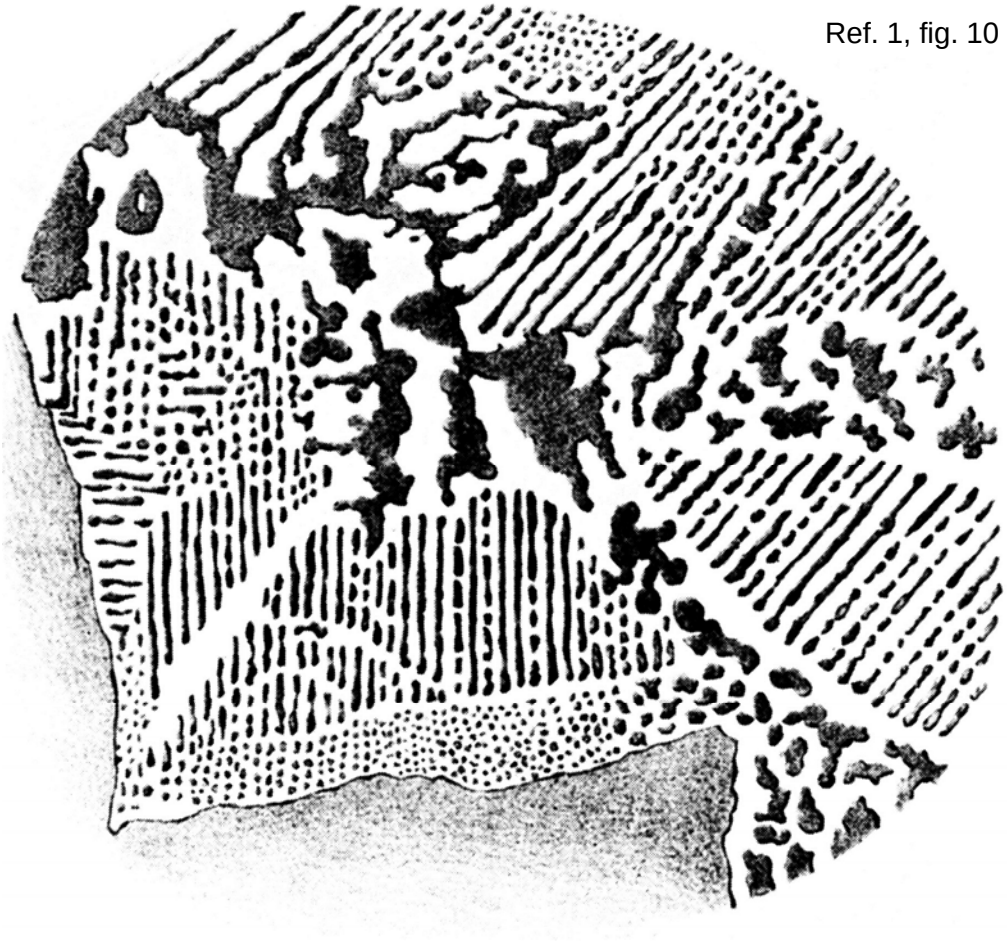
- **The pioneering work in metallography was done by Henry Clifton Sorby in Sheffield in the years from 1863 to 1887.**
- **The first activities of Martens in this field go back to the time he was in the Railway, apparently without any knowledge of the work of Sorby.**
- **Martens' first papers were published by the journal of VDI in the year 1878.**
- **His approach to the characterization of the internal structure of metals and its relation to processing was strongly influenced by the natural sciences, especially mineralogy and botany.**

Ref. 1, fig. 6



Metallographical section of a mould made of gray iron
Martens, 1878

Ref. 1, fig. 10

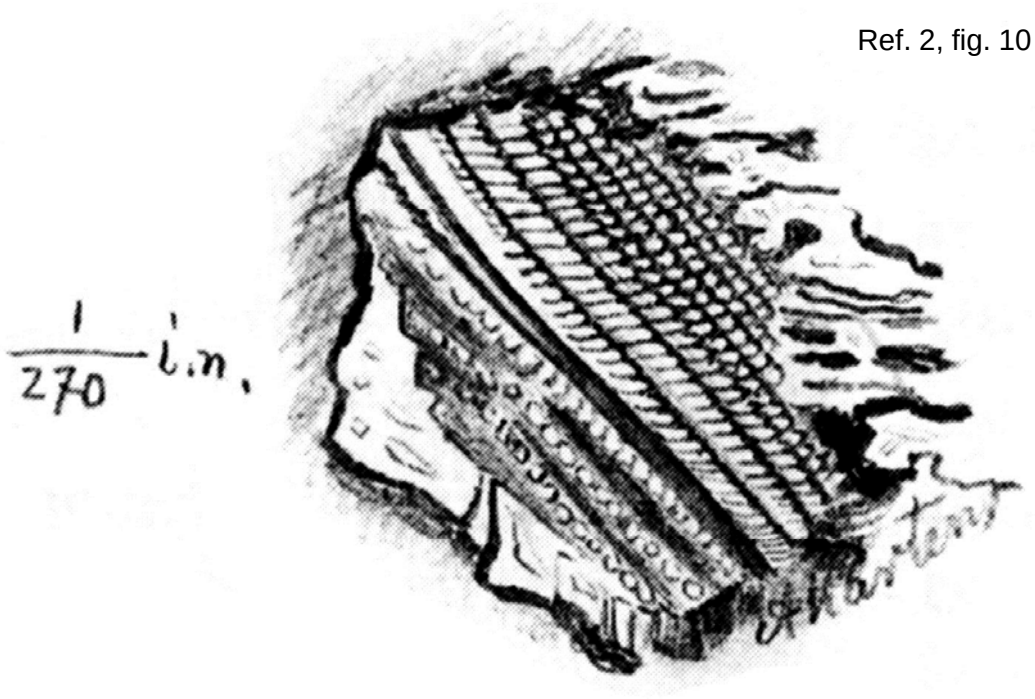


Metallographical section of a steel specimen with “Spiegeleisen”
Martens, 1878

- **Martens described carefully the structures observed in the free surface of shrinkage cavities formed in cast pieces.**
- **He drew several conclusions from the dendrites, which he called “pinetreelike crystals“**
- **Another important element for his studies was the morphology of cleavage and of fracture surfaces**

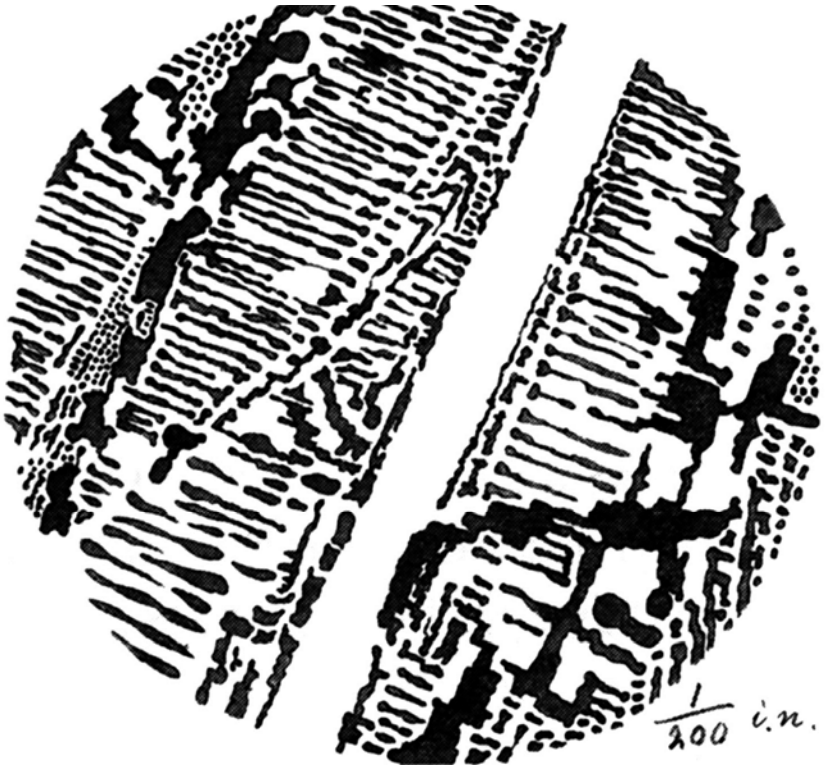
- **The most important innovation of Sorby and Martens was the investigation of sections of the objects under investigation.**
- **The techniques for grinding and polishing were adopted from mineralogy.**
- **The importance of consumables for the quality and reproducibility of the results was carefully described in his papers**
- **Also the etching techniques were carefully developed, Martens described several chemical etchants and their applicability.**

Ref. 2, fig. 10



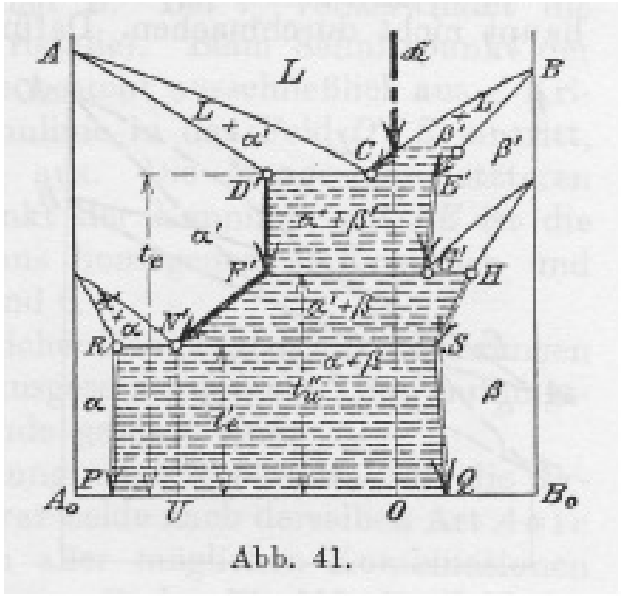
Fracture surface of a steel specimen with “Spiegeleisen”
Martens, 1878

Ref. 3, fig. 10



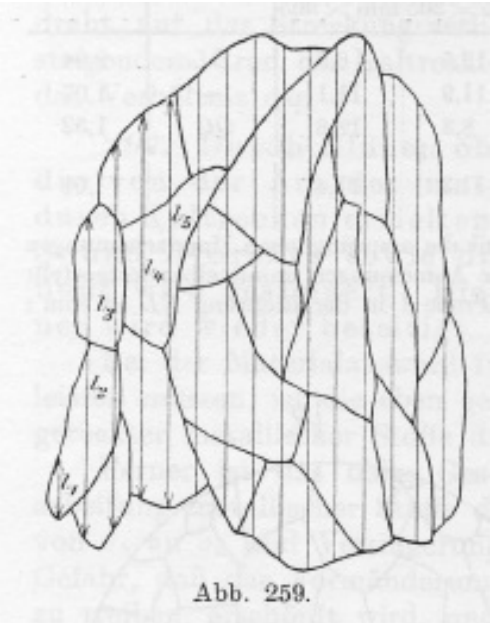
Metallographical section of a steel specimen with “Spiegeleisen” Martens, 1878

- **In 1895, Floris Osmond published in France a paper describing a general method for the microstructural analysis of carbon steels.**
- **Osmond described the characteristics of several metallographical constituents observed in steels.**
- **Following the mineralogical approach, he gave denominations to these constituents:**
  - **sorbite after Henry Clifton Sorby**
  - **troostite after Louis-Joseph Troost**
  - **martensite after Adolf Martens**



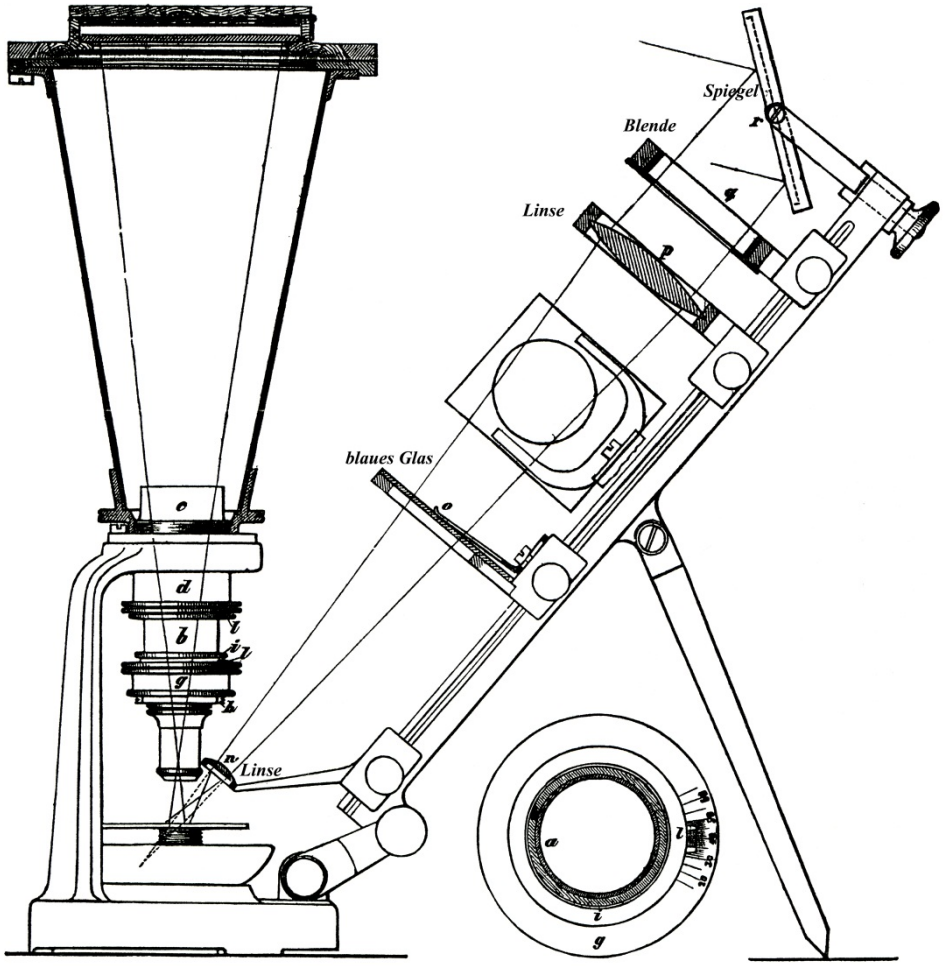
Handbuch der Materialienkunde, Bd. II, p. 51

- **Heyn gave in his *Handbuch* (1912) a very elegant, clear overview of the use of phase diagrams in the metals science; his name is related to the dual description of the Fe-C diagram;**
- **Heyn developed several reagents for specifical applications in describing the structure of metallic materials; he introduced a solution of cuprammonium chloride as a reagent for steels;**



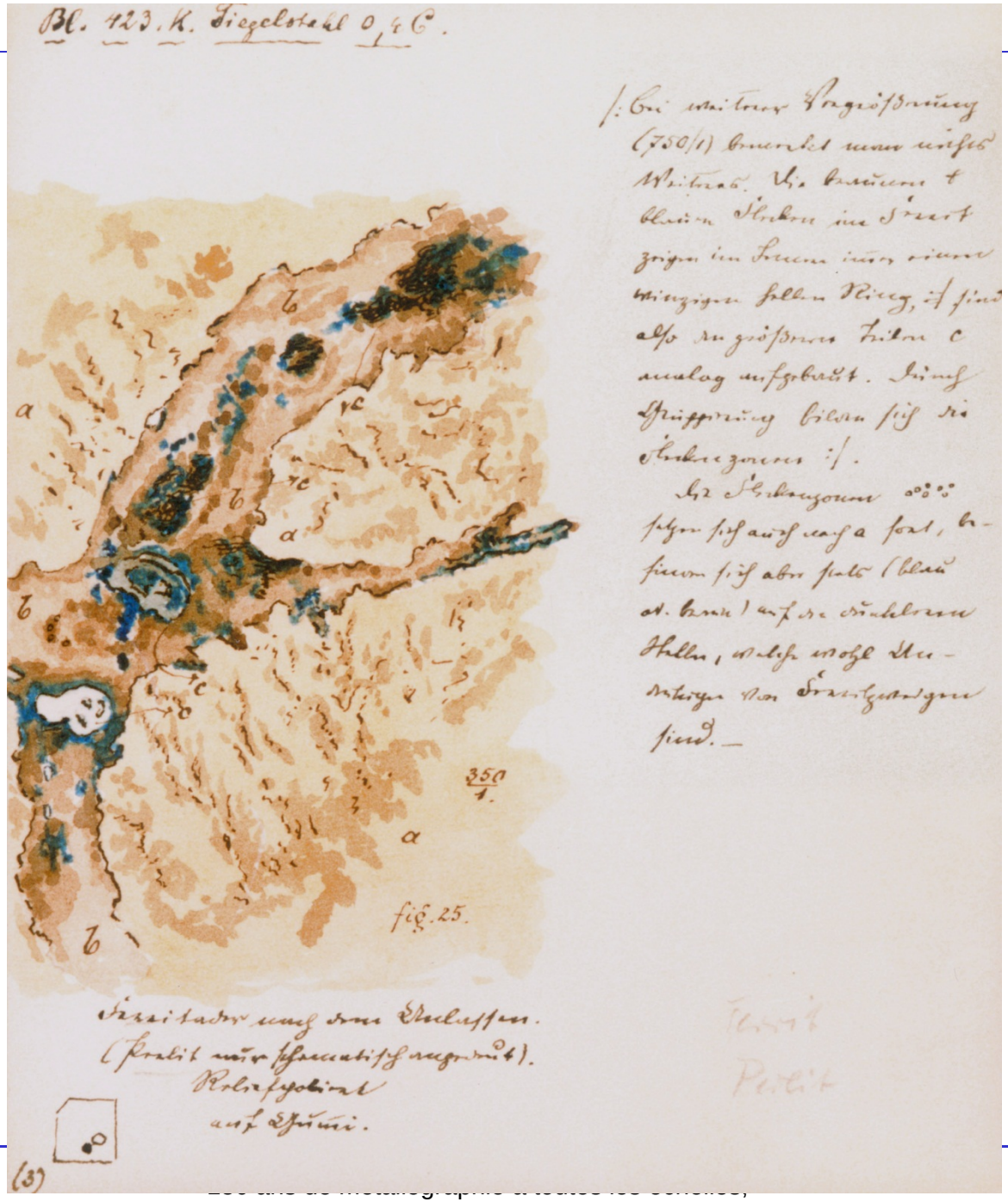
Handbuch der Materialienkunde, Bd. II, p. 267

- **Heyn also described the use of intercepts for the quantitative analysis of grain size; he discussed thorougly the influence of the grain morphology in the determination of grain size**
- **This method is currently known as Heyn Lineal Intercept Procedure (see e.g. ASTM E112)**

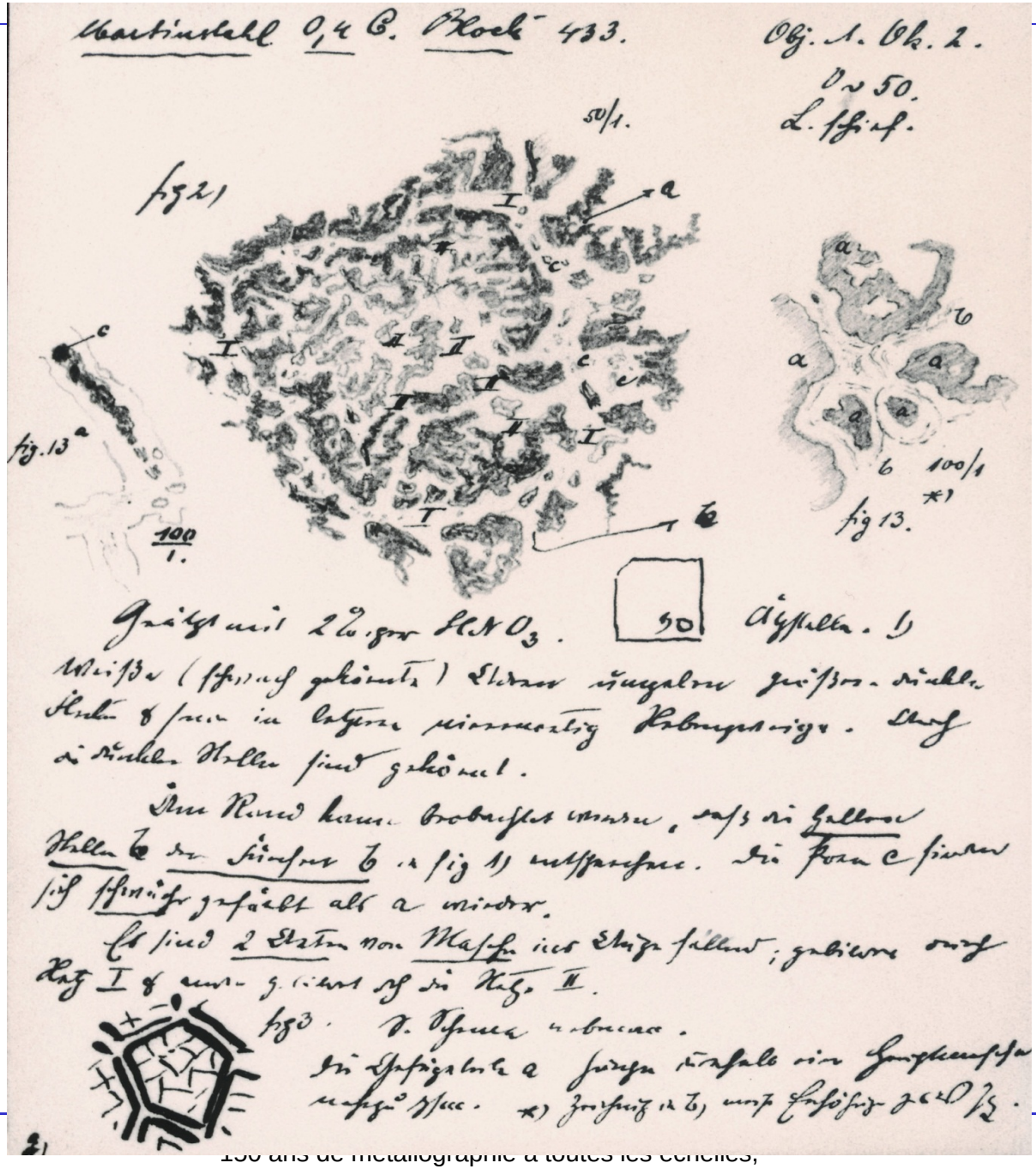


Ref. 4, fig. 2

- In a paper published 1880 in the *Central-Zeitung für Optik und Mechanik*, Martens described a new microscope suitable for the analysis of metallic sections at high magnification.
- An important element of this microscope was the oblique illumination of the specimen.
- Photographic plates could be directly exposed: Martens also gave practical advices for the deposition of adequate emulsions on glass plates.
- He was absolutely convinced of the much more powerful method of drawing the observed microstructure, which led to a more intense knowledge of the subject.



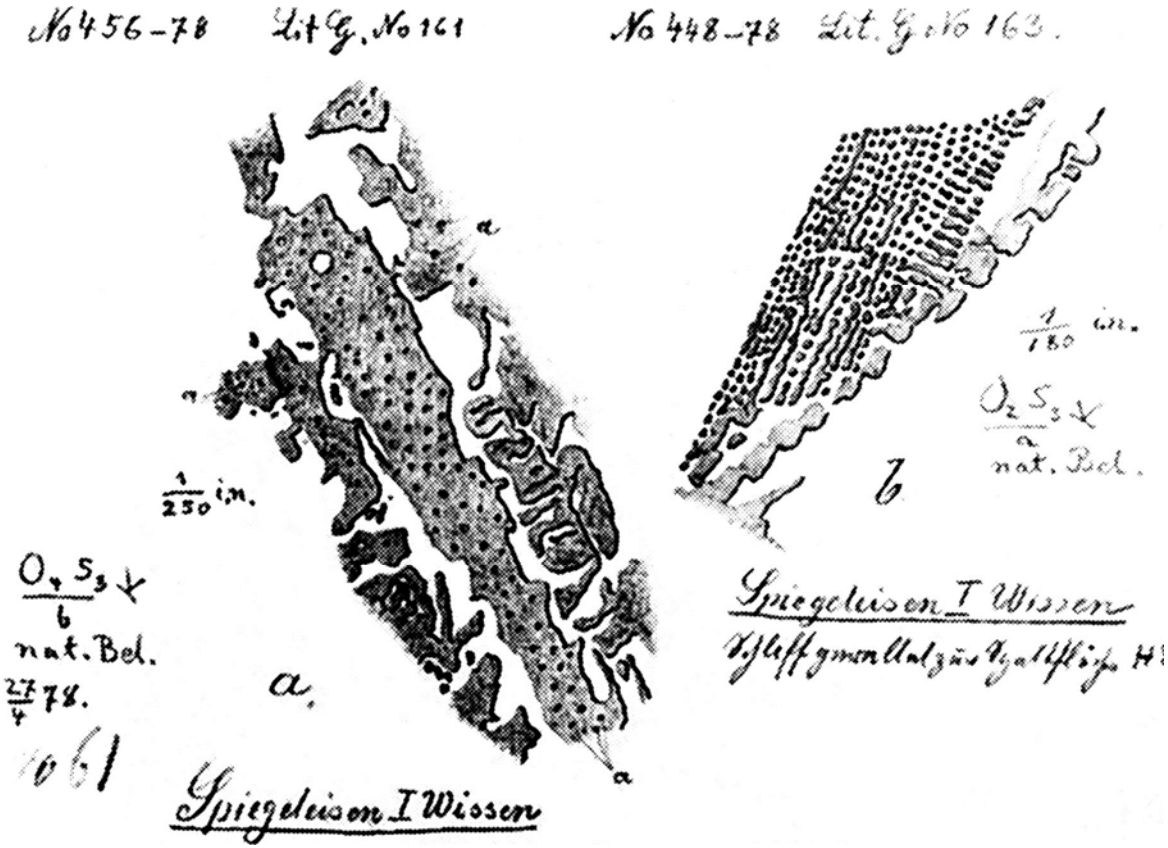
Notebook of Adolf Martens, BAM, library



Notebook of Adolf Martens, BAM, library

Notebook of Adolf Martens,
BAM, library

Cleavage surface of a steel specimen with “Spiegeleisen”
Martens, 1878



Metallographical sections of a steel specimen with “Spiegeleisen”, Left hand of section normal to the cleavage surface, right hand parallel to it
Martens, 1878

Mechanical Testing

Ref. 5, page 305

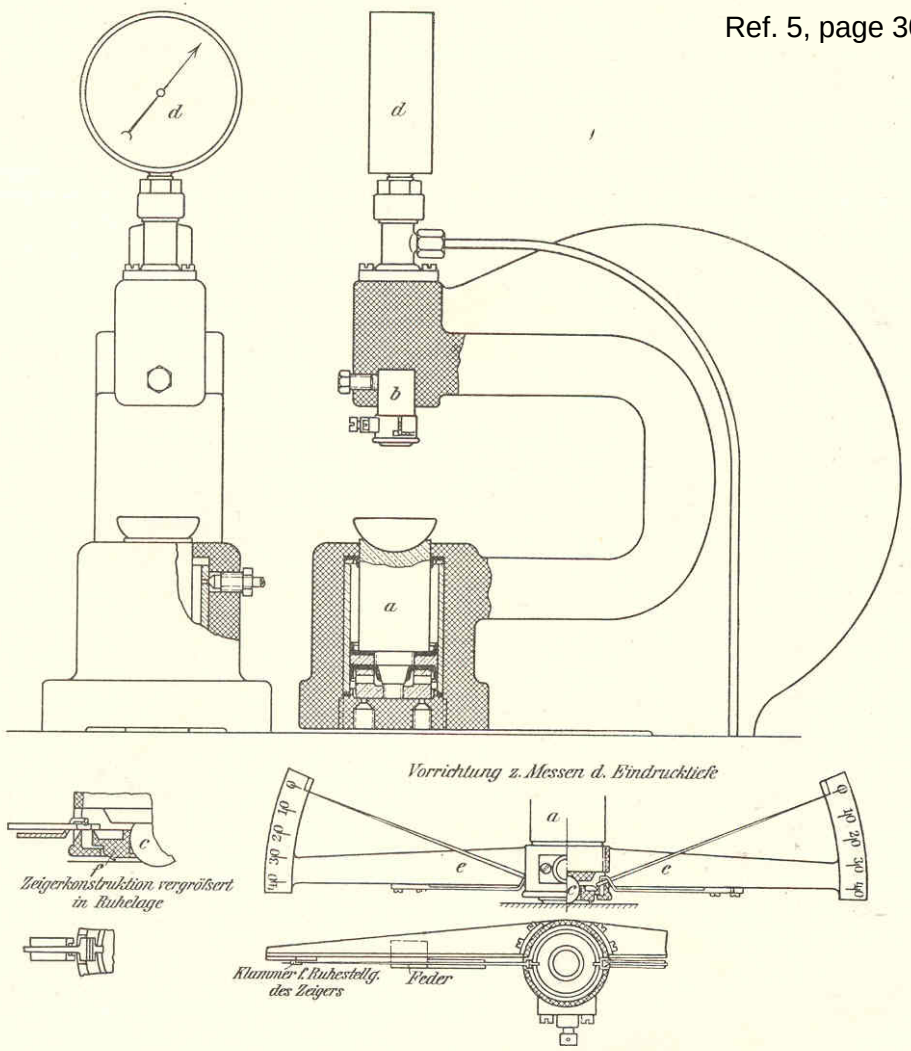


Fig. 238a. Brinelscher Härteprüfer von Martens. Werkstatt der Anstalt.

Ref. 5, page 306

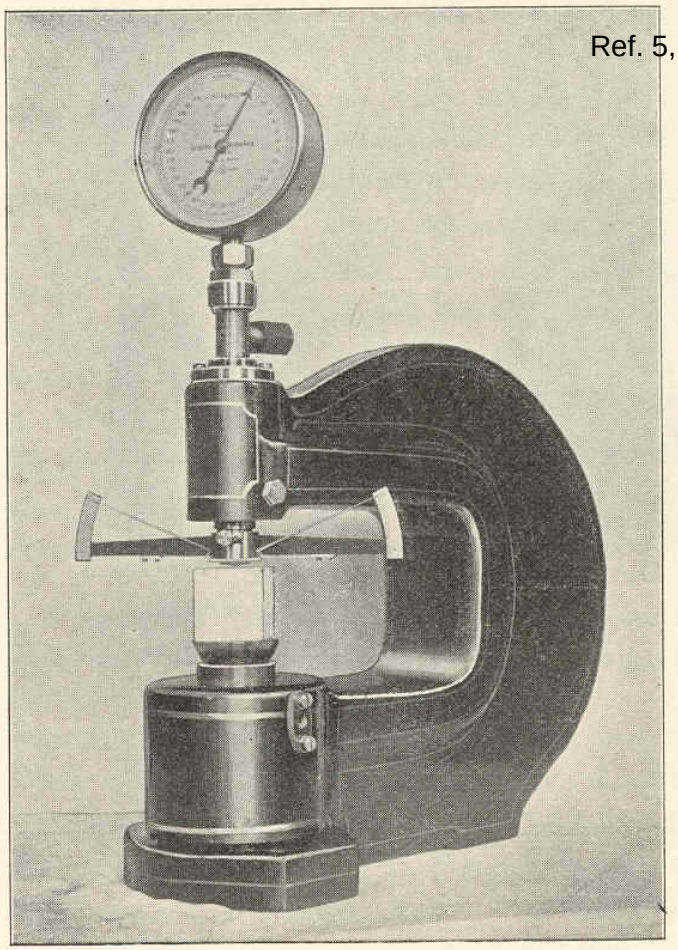


Fig. 238b. Brinelscher Härteprüfer von Martens. Werkstatt der Anstalt

Brinel hardness tester, design by Martens, workshop

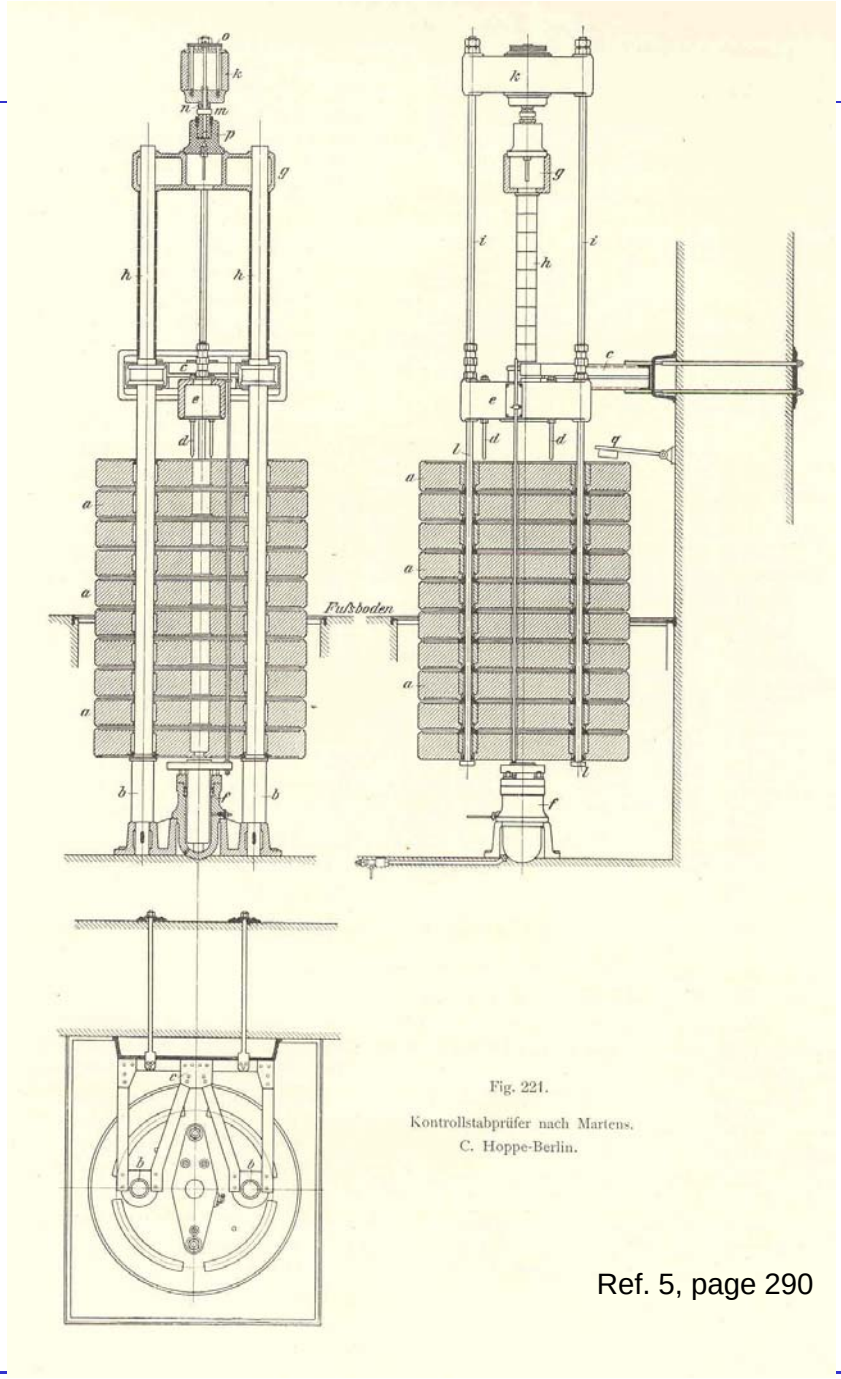


Fig. 221.

Kontrollstabprüfer nach Martens.
C. Hoppe-Berlin.

Ref. 5, page 290

Ref. 5, page 311

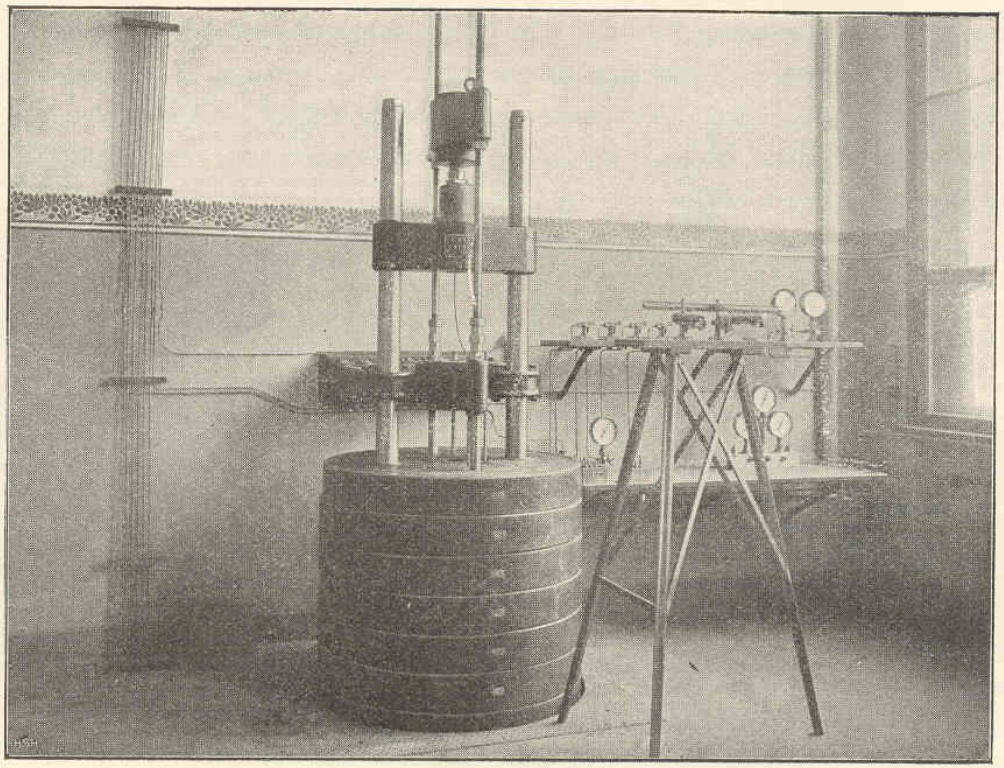


Fig. 248. Kontrollstab- und Manometerprüfung.

Calibration of load cells and manometers

10 plates of cast iron, 1.000 kg each

design by Martens, Co. Paul Hoppe, 1898

Mechanical testing - 4 MN compression testing system

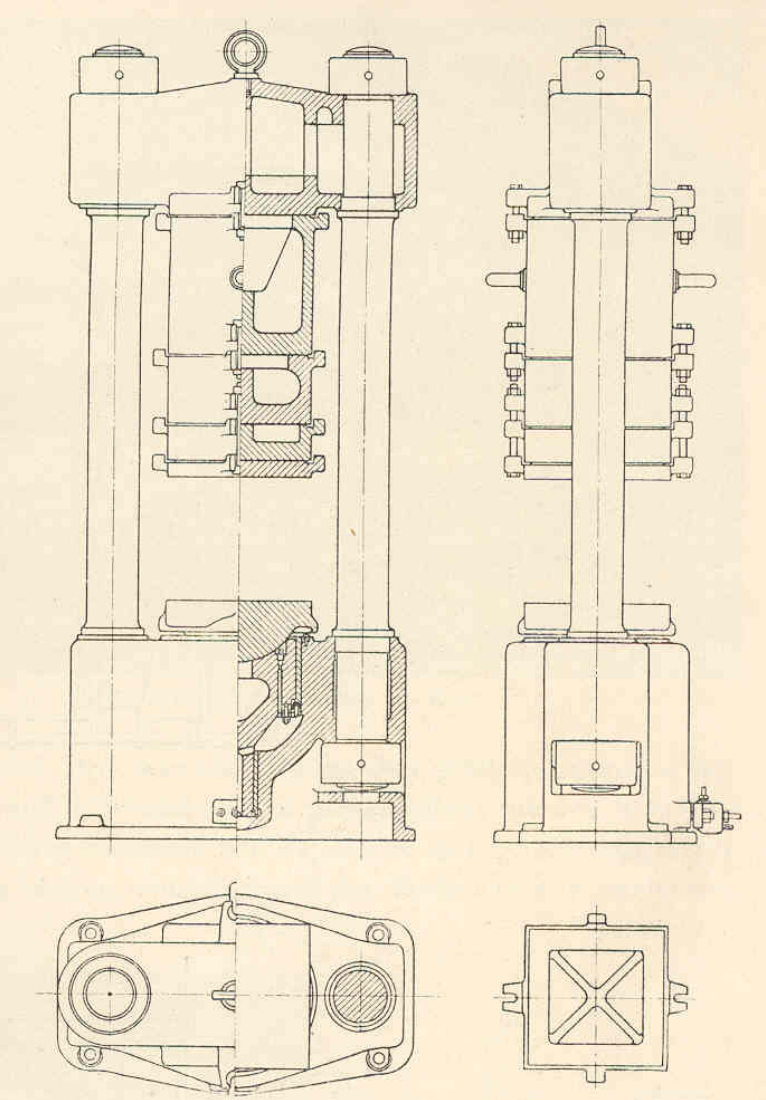


Fig. 322. 400 000 kg-Presse nach Martens.
Maschinenbaugesellschaft Nürnberg.

Ref. 5, page 352

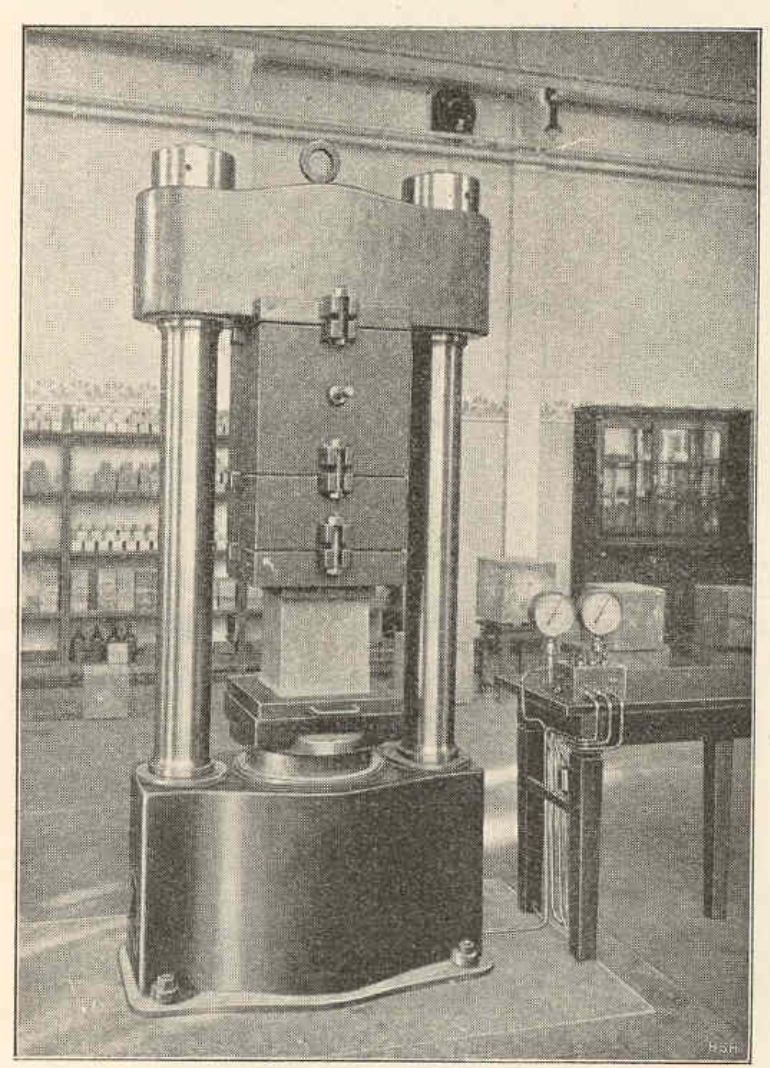


Fig. 321. 400 000 kg-Presse nach Martens.
Maschinenbaugesellschaft Nürnberg.

Mechanical testing - 500 kN testing systems

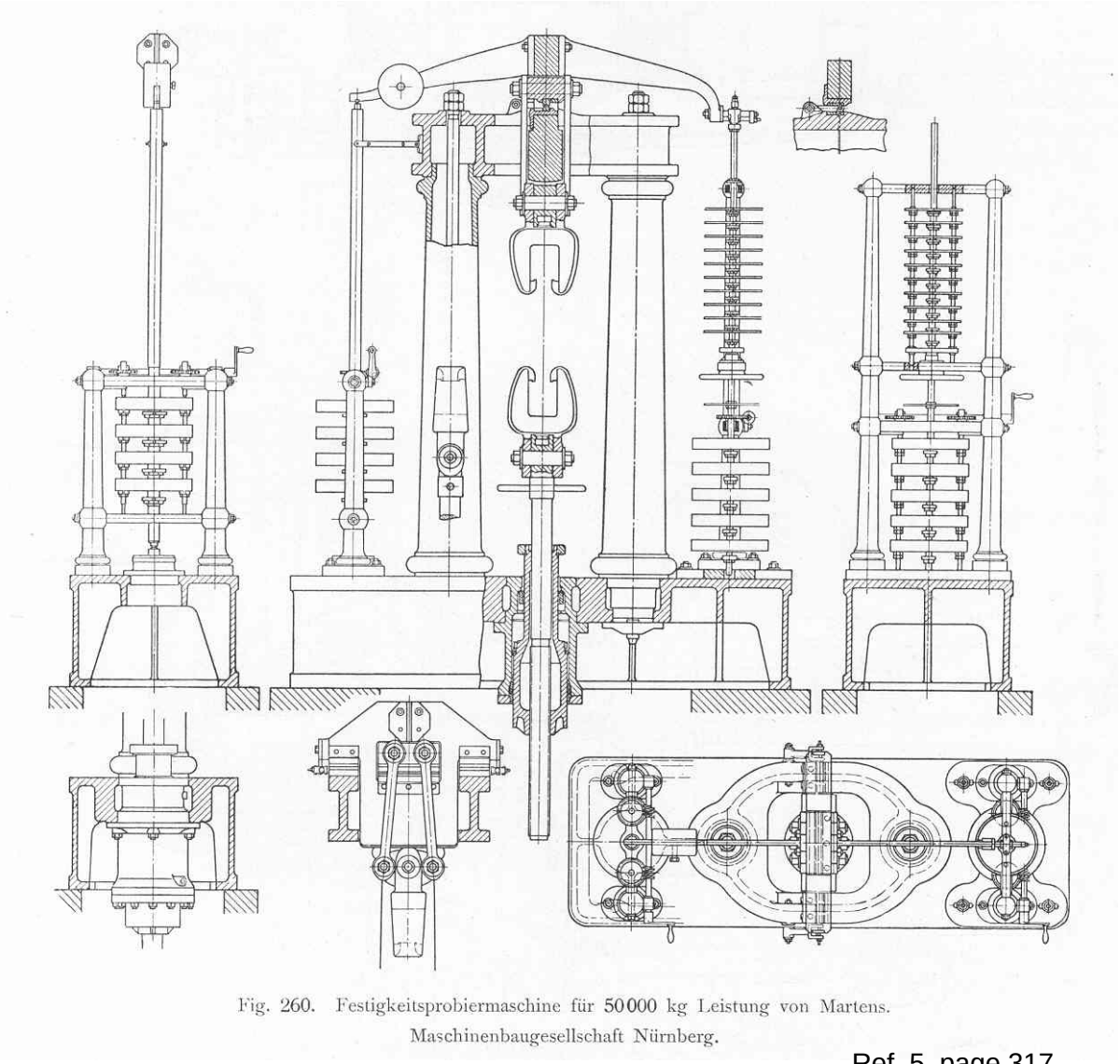


Fig. 260. Festigkeitsprobiermaschine für 50000 kg Leistung von Martens. Maschinenbaugesellschaft Nürnberg.

Ref. 5, page 317

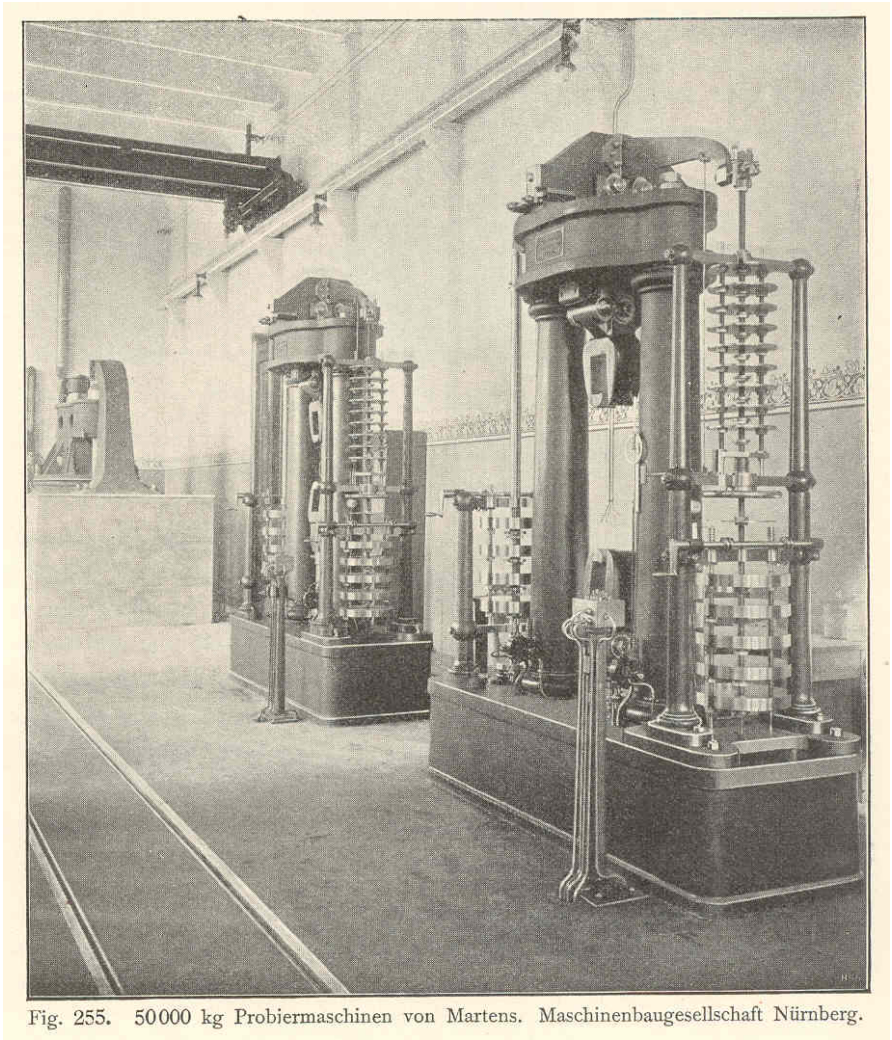


Fig. 255. 50000 kg Probiermaschinen von Martens. Maschinenbaugesellschaft Nürnberg.

Ref. 5, page 314

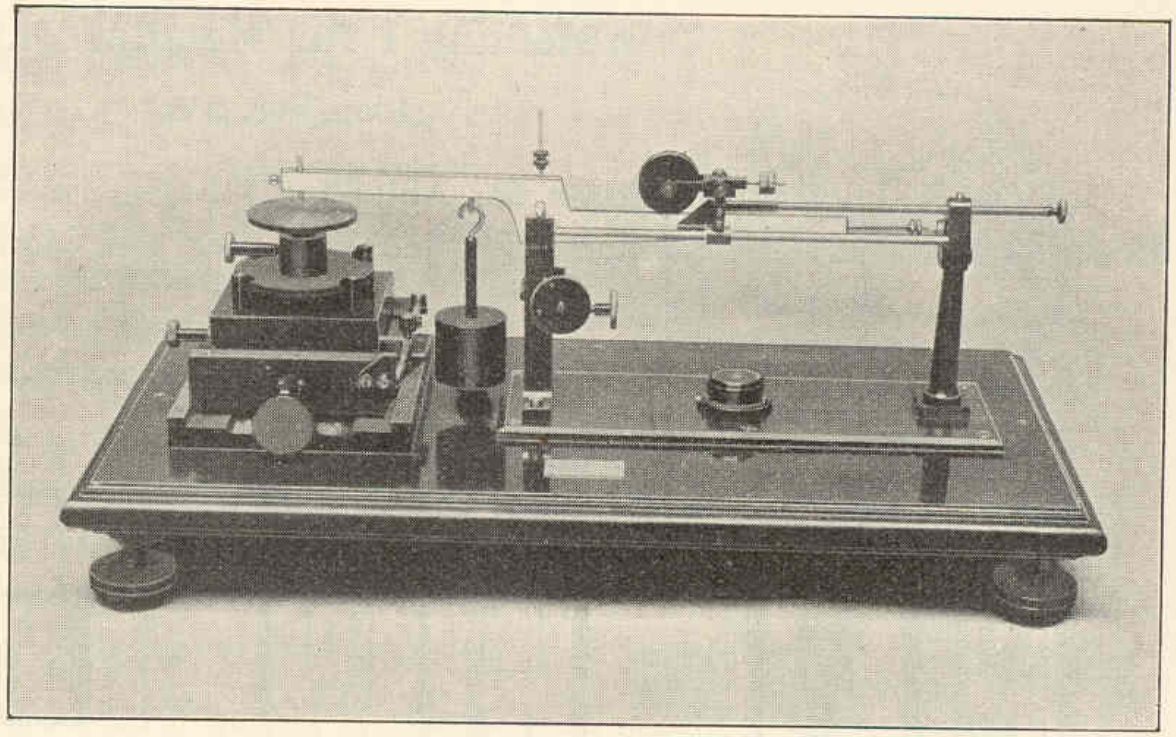


Fig. 236. Ritzhärteprüfer von Martens.
Anstalts-Mechaniker.

Ref. 5, page 304

Scratch hardness tester
conical diamond, 90 °; varying load
design by Martens, workshop

Mechanical testing - Tensile testing system for cement

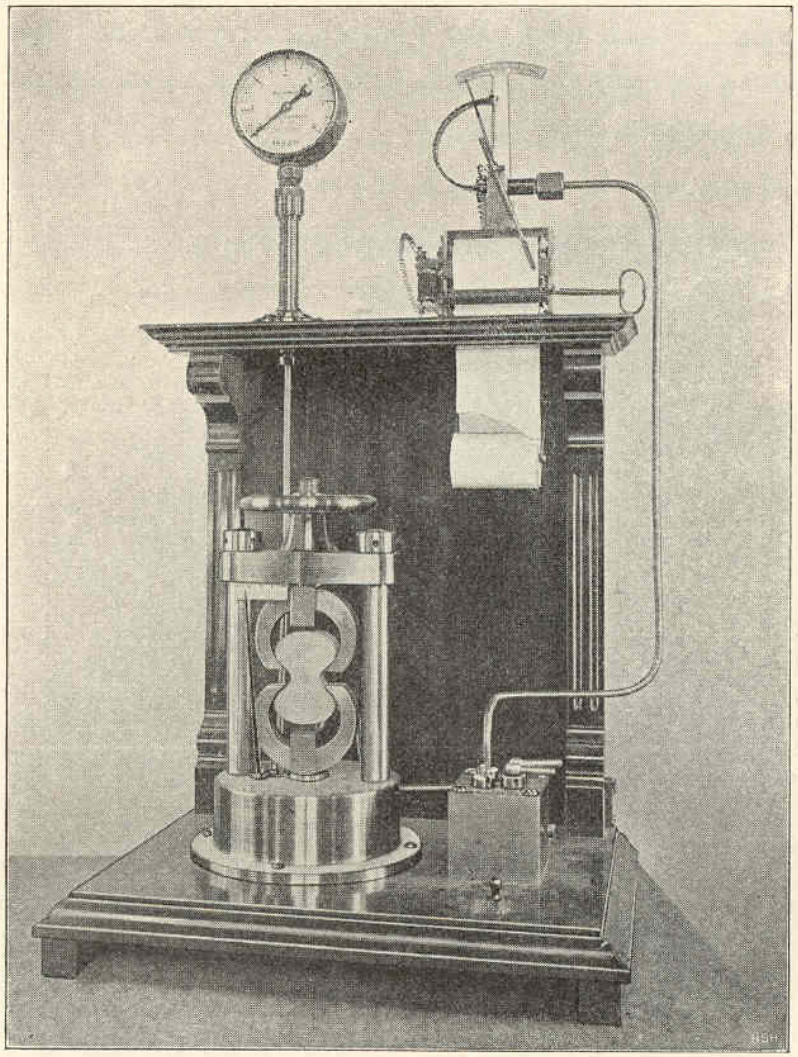


Fig. 327. Zugfestigkeitsprüfer für Zement von Martens.
Maschinenbaugesellschaft Nürnberg.
Ventile und Schreibmanometer von R. Gradenwitz-Berlin.

Ref. 5, page 355

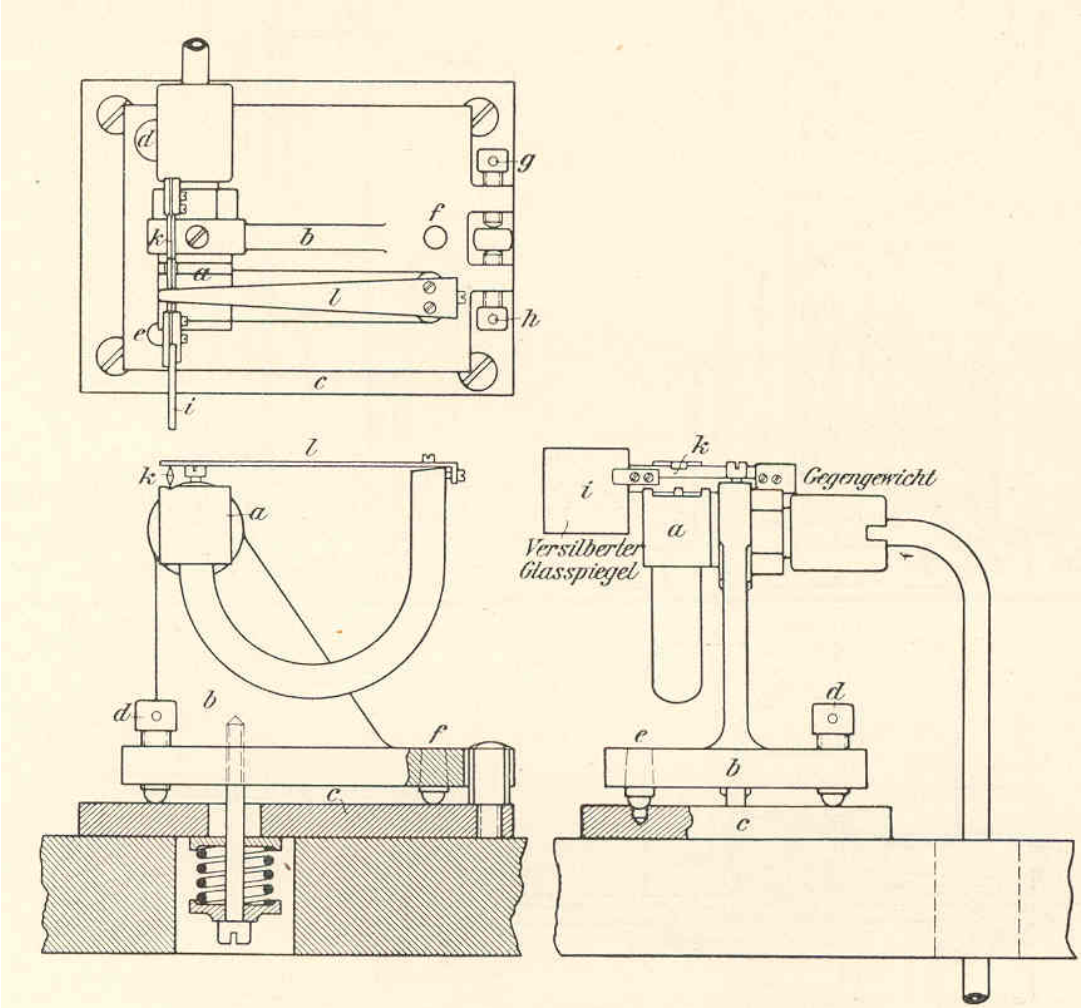


Fig. 226. Manometer mit Spiegelablesung von Martens.
Schäffer & Budenberg-Buckau.

Ref. 5, page 295

Manometer with mirror measurement, design by Martens

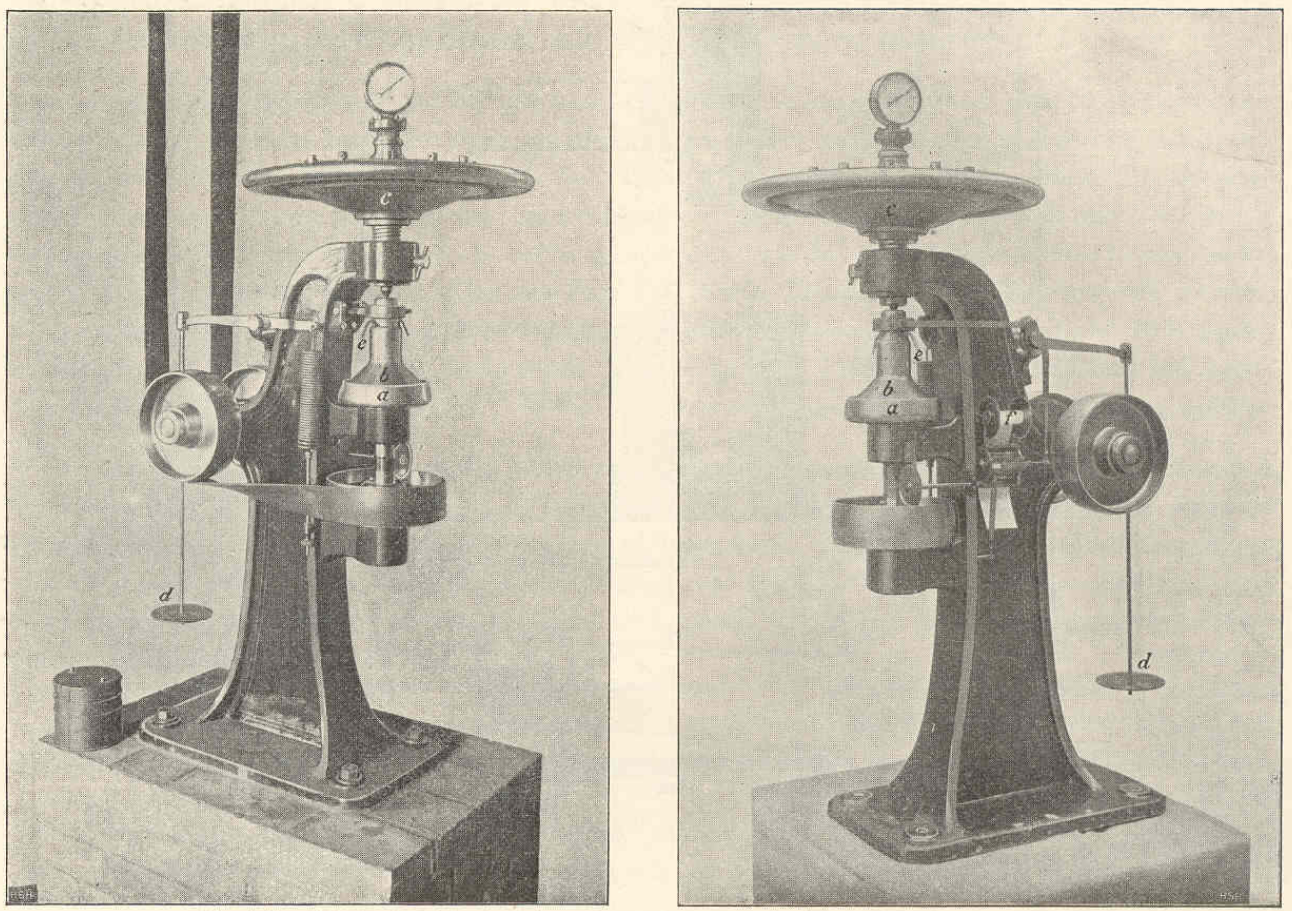


Fig. 240. Schmierölprobiermaschine von Martens. Mechanische Werkstatt der Anstalt.

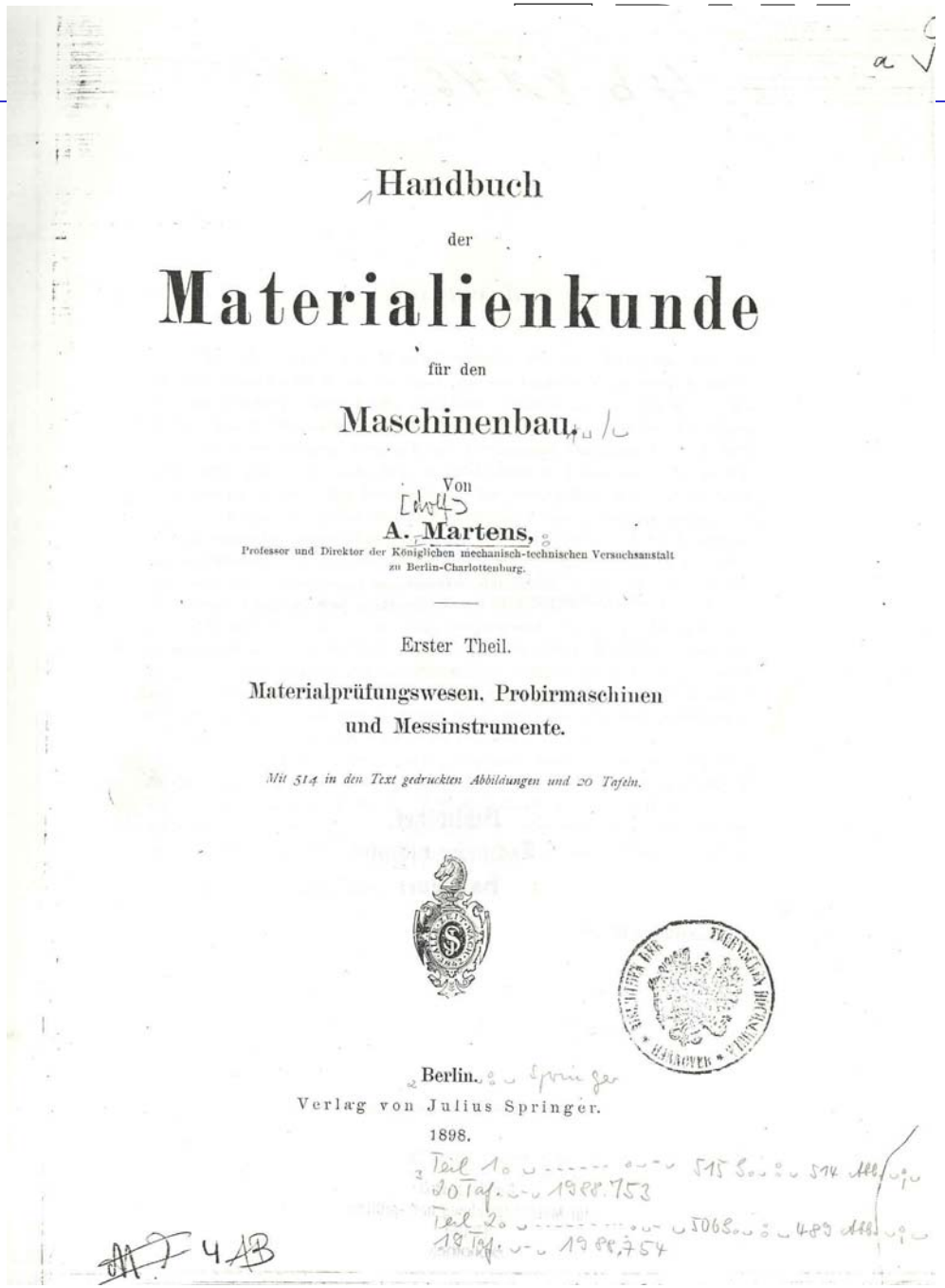
Ref. 5, page 306

Testing of lubricant oil change of viscosity under continuous loading, analysis of decomposition products

design by Martens, workshop

Materials Engineering

- **Adolf Martens**
  Handbook of Materials Technology for Mechanical Engineering
  Part I - Materials Testing
  Berlin: Julius Springer, 1898



Handbuch

der

Materialienkunde

für den

Maschinenbau.

Von

A. Martens,

Professor und Direktor der Königlichen mechanisch-technischen Versuchsanstalt zu Berlin-Charlottenburg.

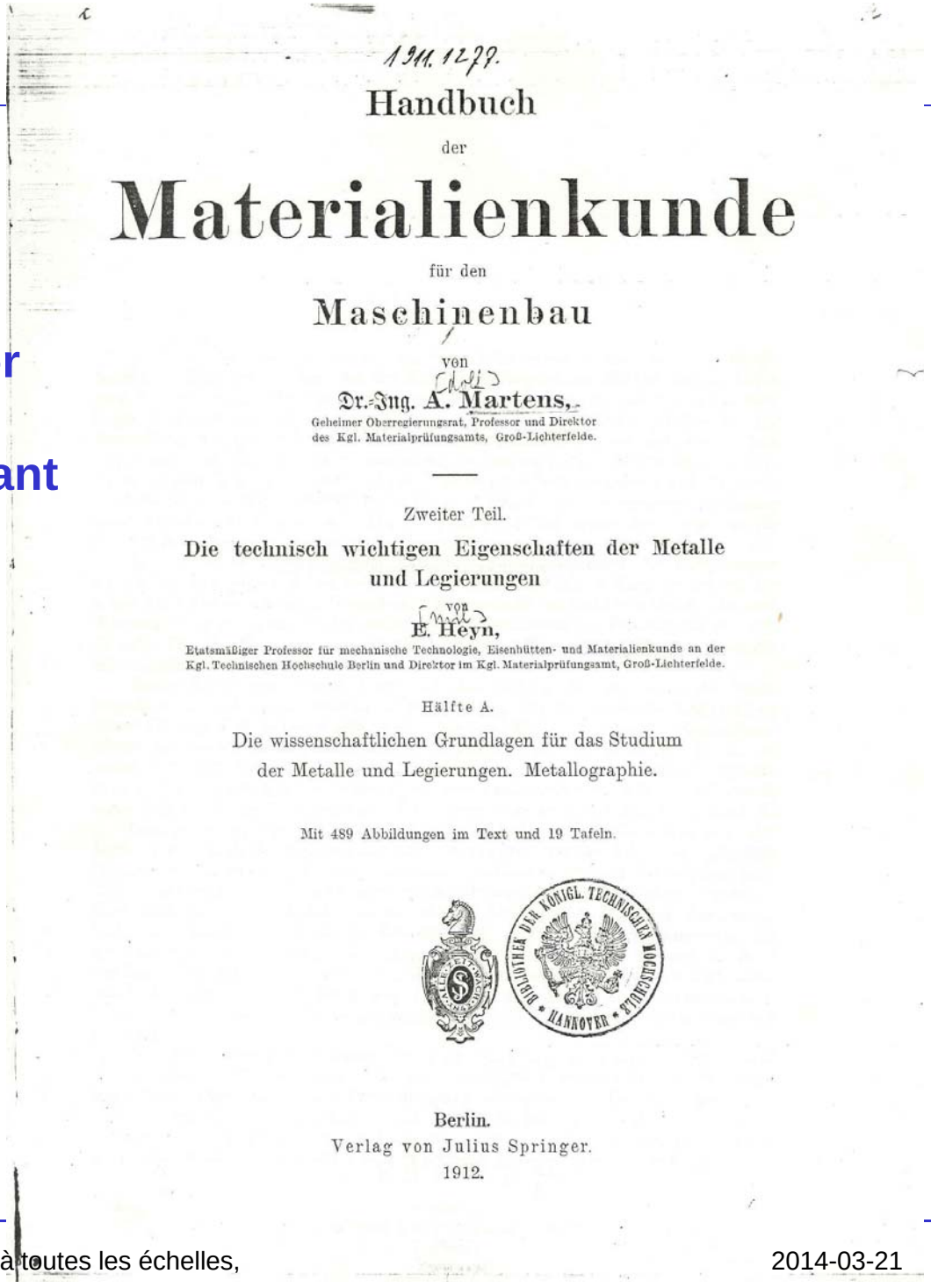
Erster Theil.

Materialprüfungswesen. Probirmaschinen und Messinstrumente.

Mit 514 in den Text gedruckten Abbildungen und 20 Tafeln.

Berlin.
Verlag von Julius Springer.
1898.

- **Emil Heyn**
  Handbook of Materials Technology for Mechanical Engineering
  Part II - The technically most important properties of metals and alloys
  Edited by Adolf Martens
  Berlin: Julius Springer, 1912



1911.1279.

Handbuch

der

Materialienkunde

für den

Maschinenbau

von

Dr.-Ing. A. Martens,

Geheimer Oberregierungsrat, Professor und Direktor des Kgl. Materialprüfungsamts, Groß-Lichterfelde.

Zweiter Teil.

Die technisch wichtigen Eigenschaften der Metalle und Legierungen

von

E. Heyn,

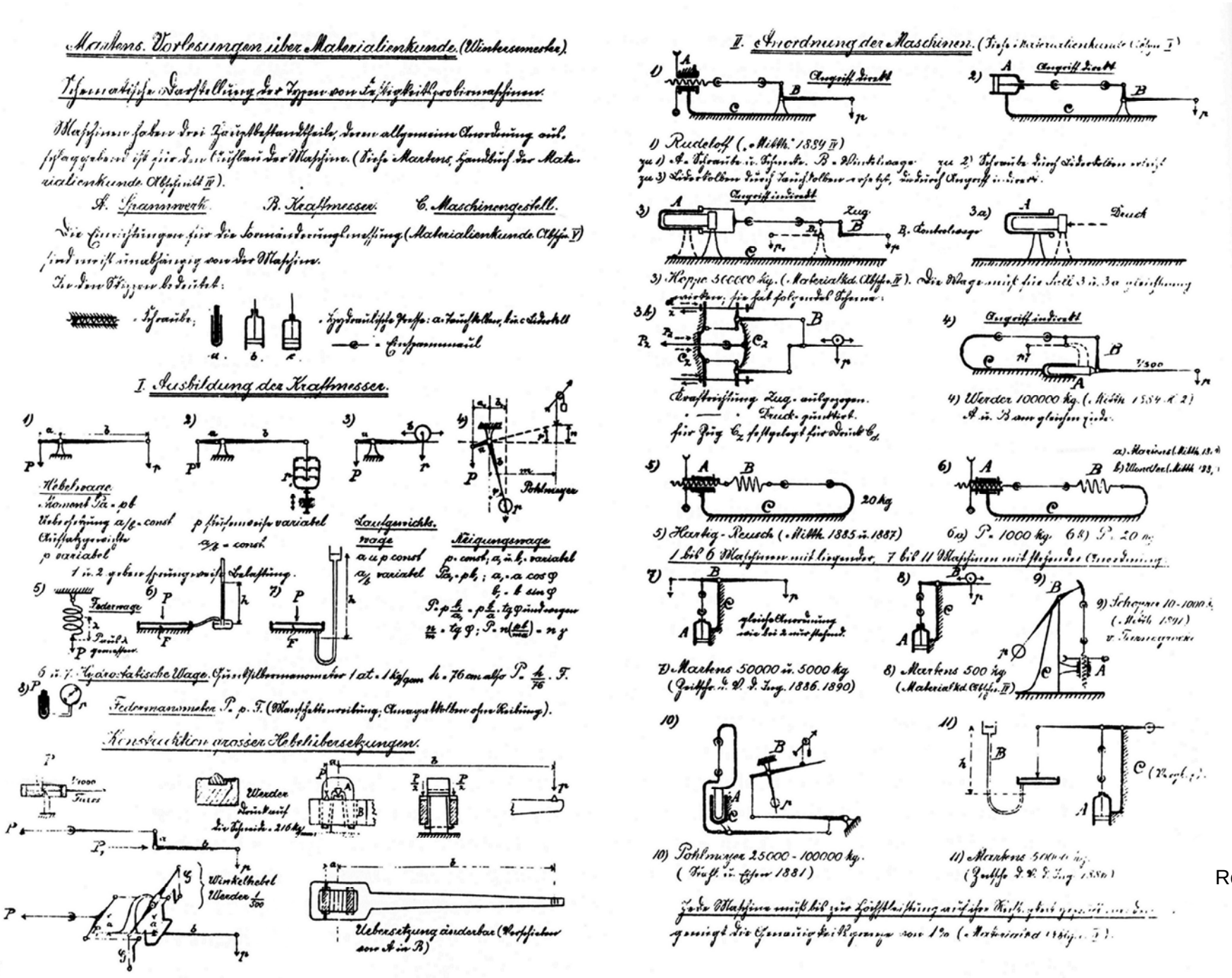
Etatsmäßiger Professor für mechanische Technologie, Eisenhütten- und Materialienkunde an der Kgl. Technischen Hochschule Berlin und Direktor im Kgl. Materialprüfungsamt, Groß-Lichterfelde.

Hälfte A.

Die wissenschaftlichen Grundlagen für das Studium der Metalle und Legierungen. Metallographie.

Mit 489 Abbildungen im Text und 19 Tafeln.

Berlin.
Verlag von Julius Springer.
1912.


Martens. Vorlesungen über Materialienkunde. (Wintersemester).
Schematische Darstellung der Typen von Festigkeitsprobirmaschinen.
A. Spannwerk. B. Kraftmesser. C. Maschinengestell.
I. Ausbildung der Kraftmesser.
Hebelwage
Federwage
Laufgewichts-wage
Neigungswage
Pohlmeyer
Werder
Winkelhebel
II. Anordnung der Maschinen.
Ref. 7, page 88

- **Heyn recognized the importance of notch sensitivity in designing and manufacturing machine elements; he developed mechanical tests for evaluating the behaviour of metallic components with notches;**

Abb. 385.

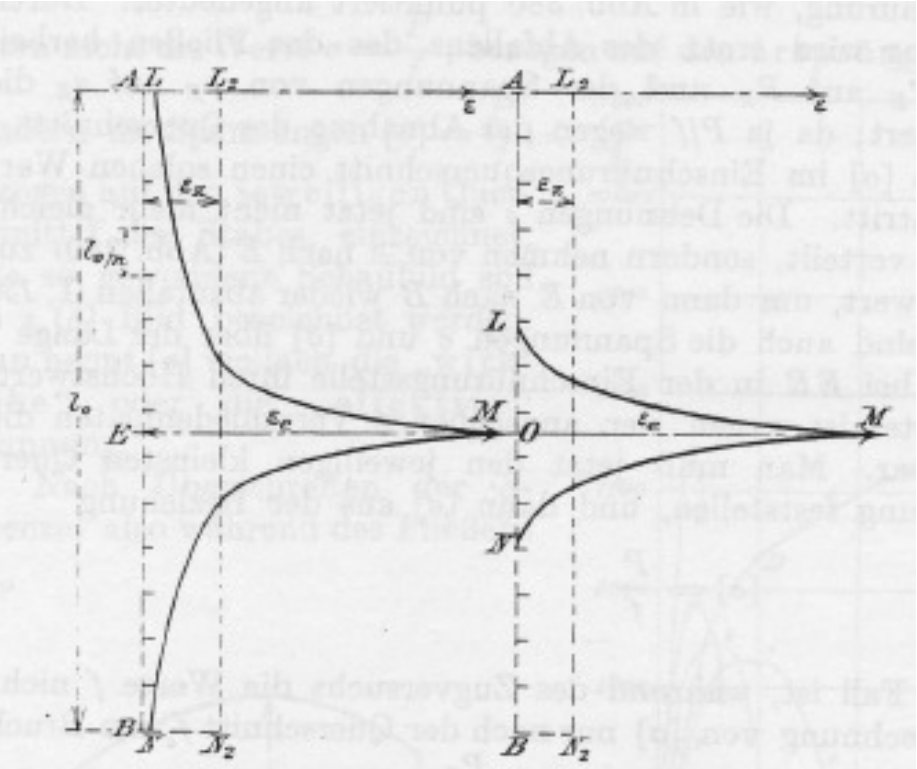


Abb. 383. Abb. 384.

Handbuch der Materialienkunde, Bd. II, p. 372

- **Adolf Martens made important contributions to materials engineering, especially in the fields of metallography and mechanical testing of materials**
- **His name is tightly connected to the martensitic transformation and to martensite, even though he did not work directly in this area**
- **His name is also directly connected to the instrumented indentation testing, the Martens hardness, HM (DIN EN ISO I4577-3, according to ISO/TC 164/SC 3 "Hardness Testing of Metals“, meeting on June 20th, 2000 in Berlin)**

- **Emil Heyn also made important contributions to materials engineering, especially in the fields of metallography and physical metallurgy**
- **His name is tightly connected to the determination of grain size and of chemical etching of metallographic sections.**
- **In recognition of his contribution the most important award of the German Society for Metals Research is denominated Heyn medal**

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