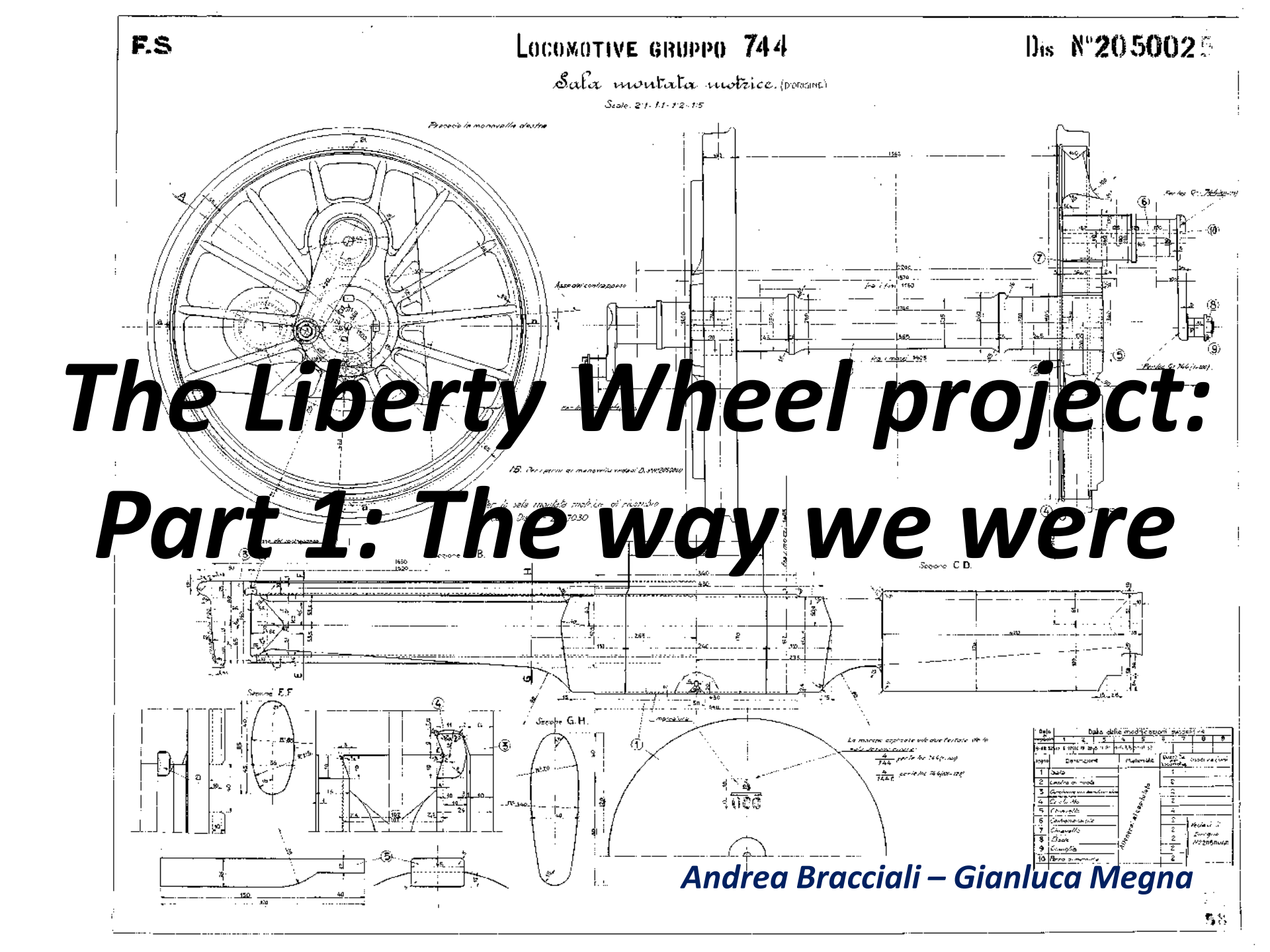
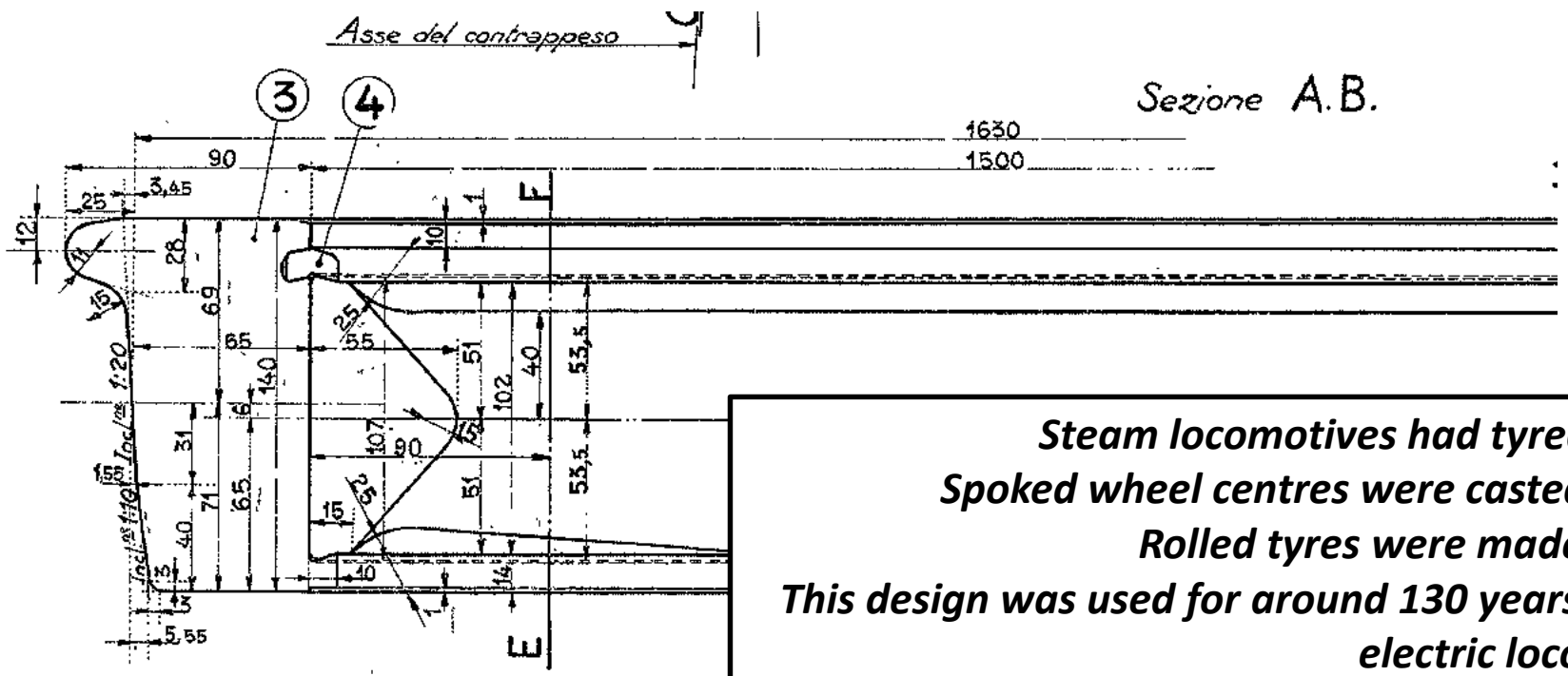
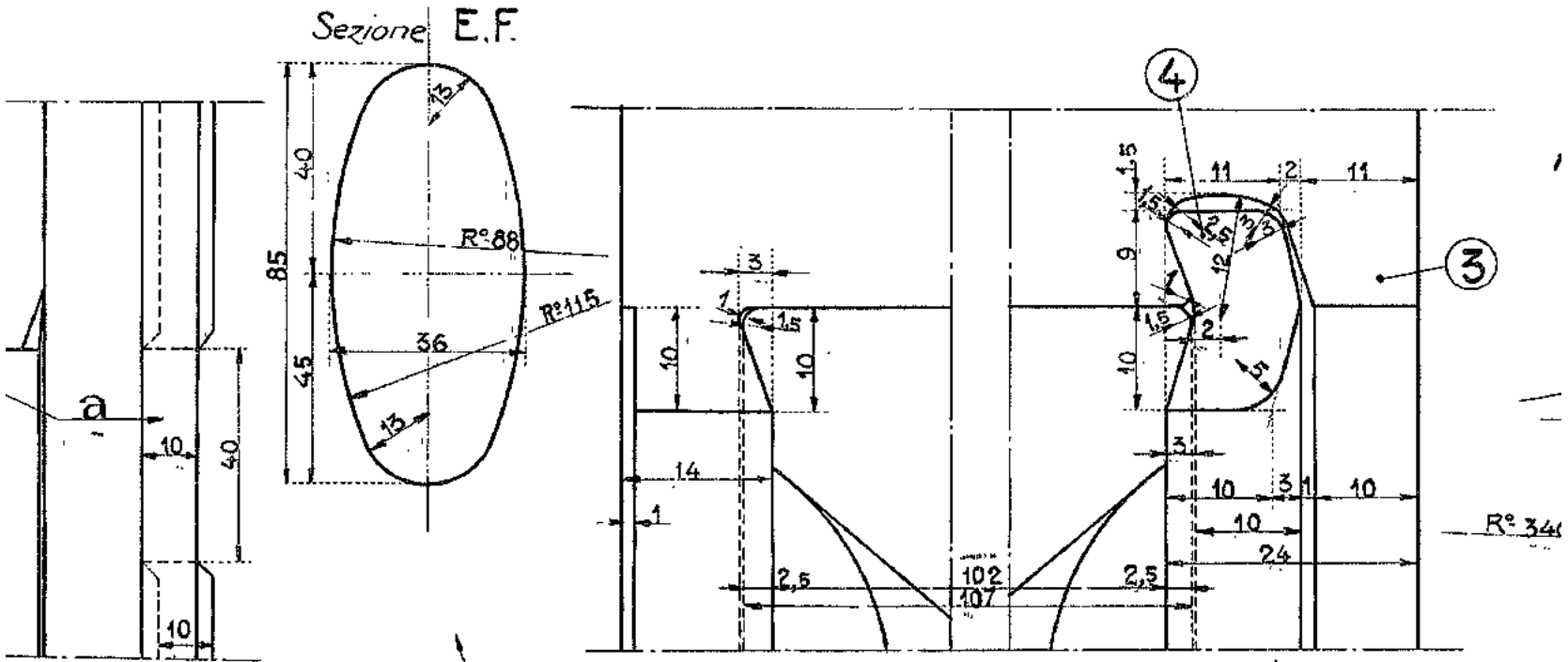


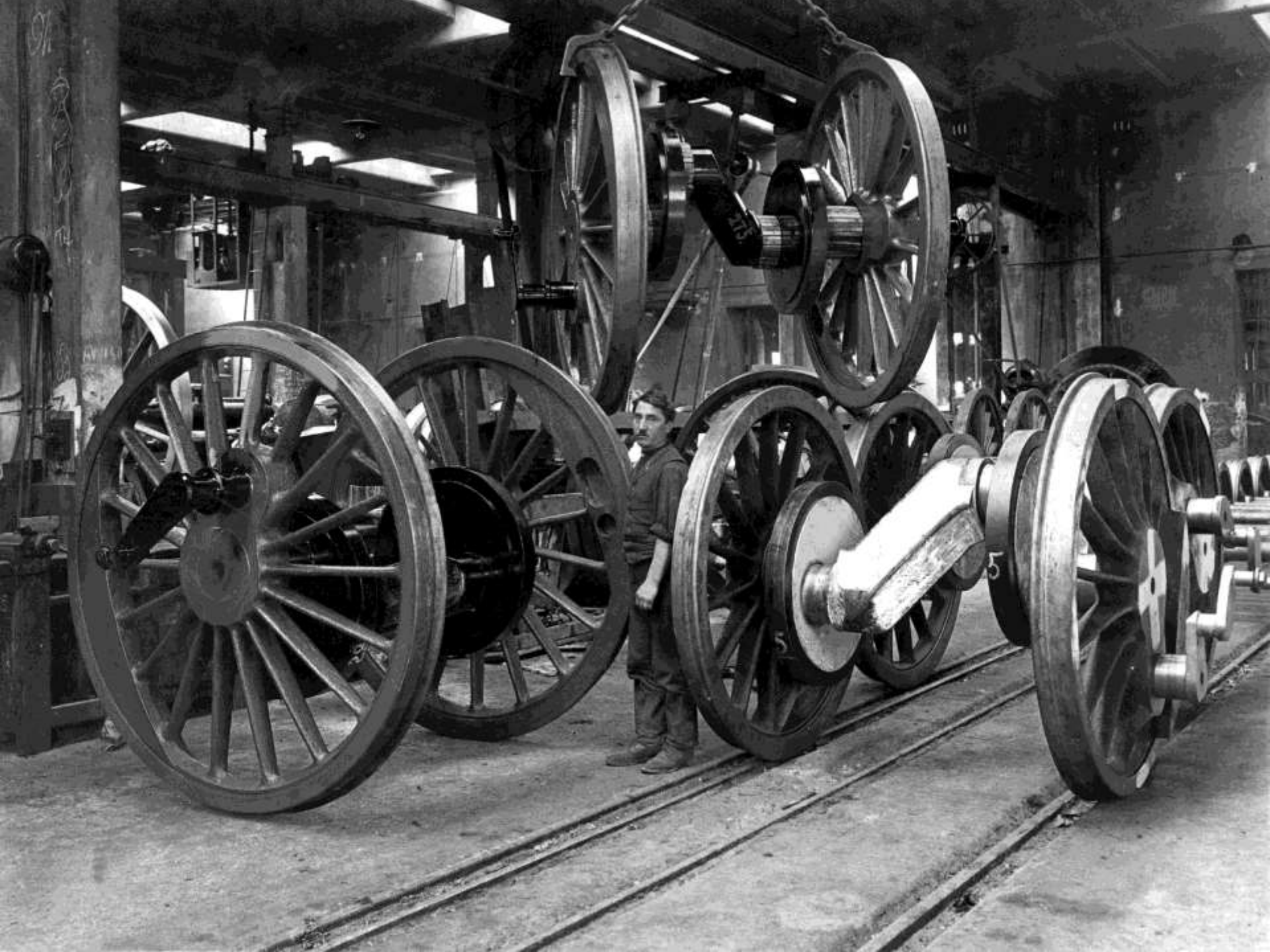
The Liberty Wheel project: Part 1: The way we were

Andrea Bracciali – Gianluca Megna



Steam locomotives had tyred wheels
Spoked wheel centres were casted in steel
Rolled tyres were made of steel
This design was used for around 130 years also for electric locomotives





The presence of rods forced the use of inboard bearings
Spokes were needed to reach journals
Wheel centres were rough (wooden models)
Many steam locos ended their life with original wheel centres

… I know what I am talking about!

The Queen of German locomotives… DB E 03 (103)
Co'-Co' wheel arrangement
Max speed 200 km/h (280 km/h during tests)
Short-term maximum power output 10.400 kW (1733 kW/axle)

Incredibly, this locomotive had tyred wheels

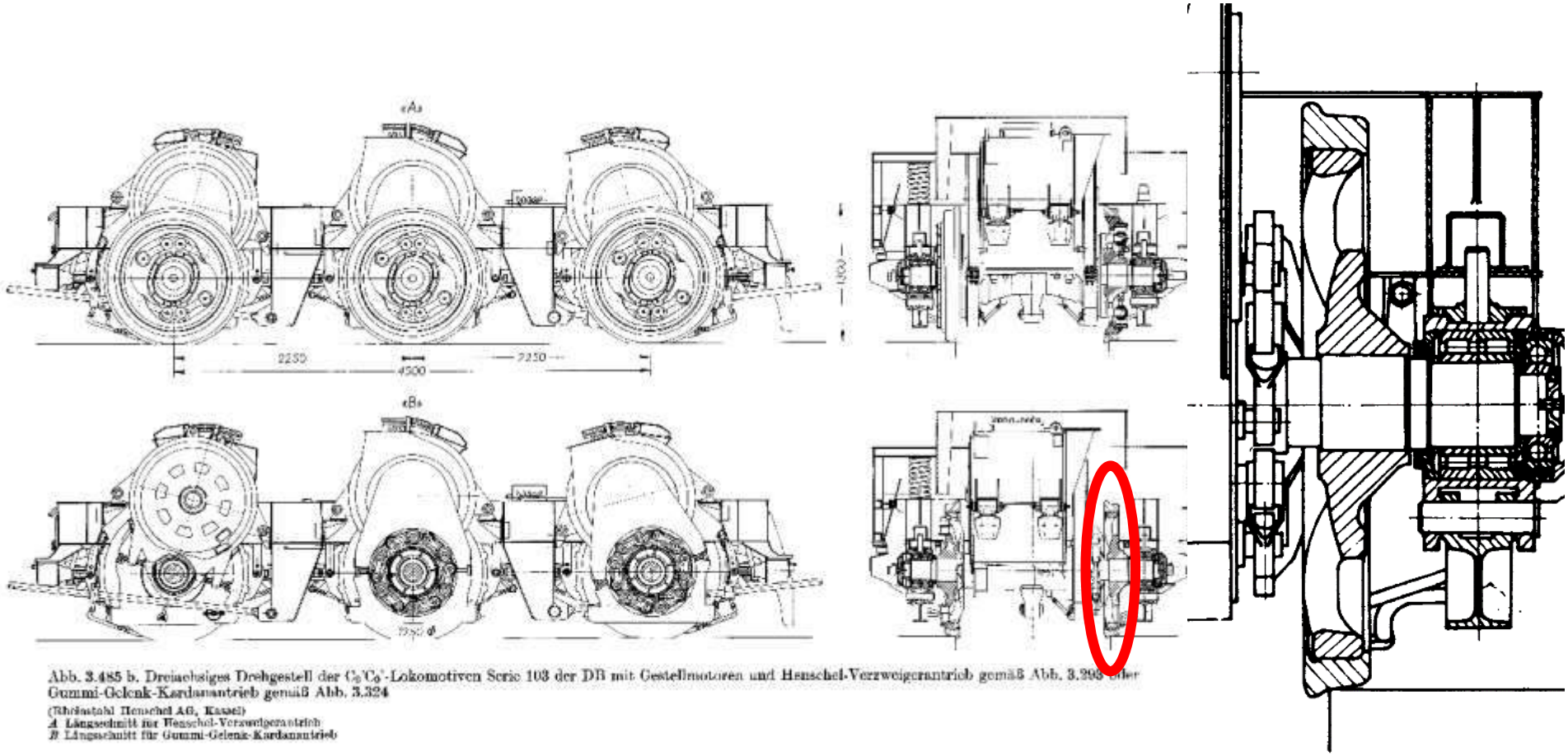
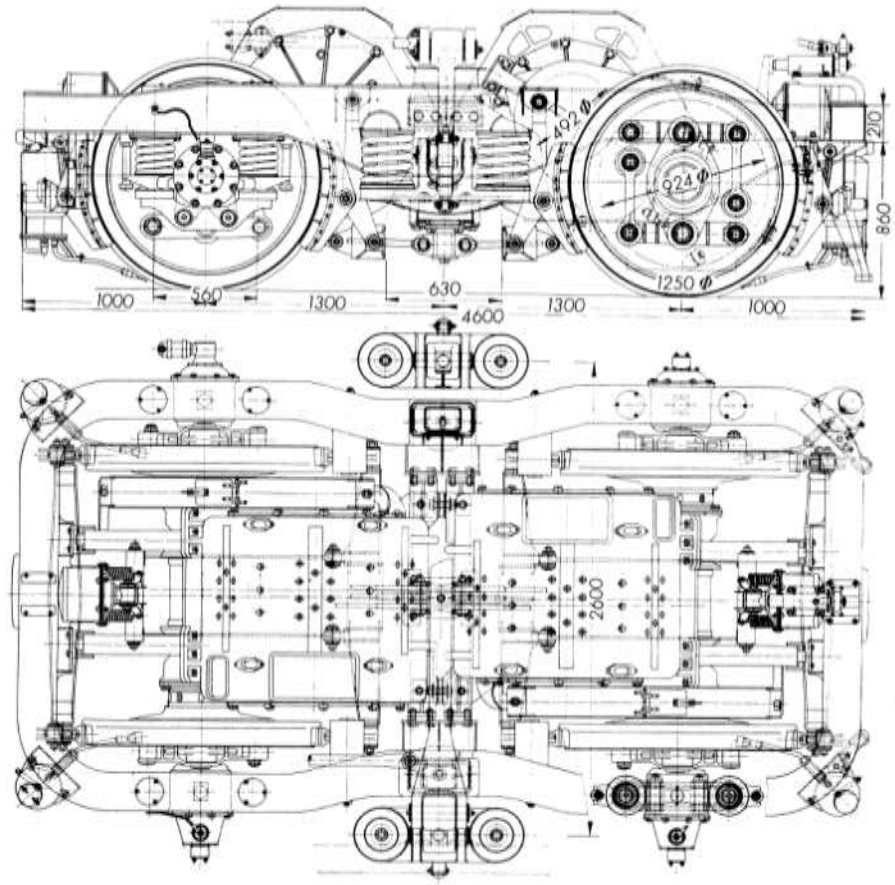


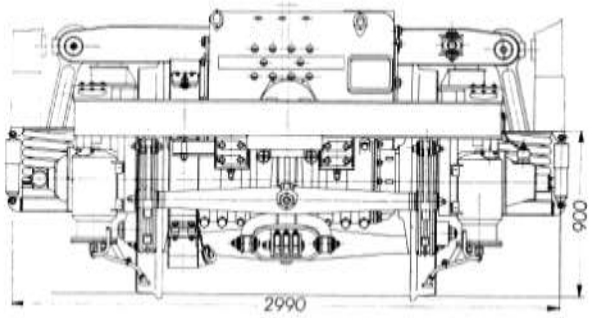
Abb. 3.485 b. Dreiachsiges Drehgestell der $C_0'C_0'$-Lokomotiven Serie 103 der DB mit Gestellmotoren und Henschel-Verzweigerantrieb gemäß Abb. 3.293 oder Gummi-Gelenk-Kardanantrieb gemäß Abb. 3.324

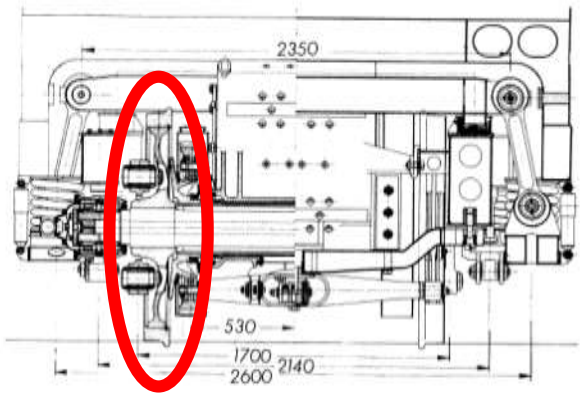
(Rheinstahl Henschel AG, Kassel)
A Längsschnitt für Henschel-Verzweigerantrieb
B Längsschnitt für Gummi-Gelenk-Kardanantrieb

The Queen of Italian locomotives… FS E444
Bo'-Bo' wheel arrangement
Max speed 200 km/h
Short-term maximum power output 6.600 kW (1650 kW/axle)

Incredibly, this locomotive had tyred wheels







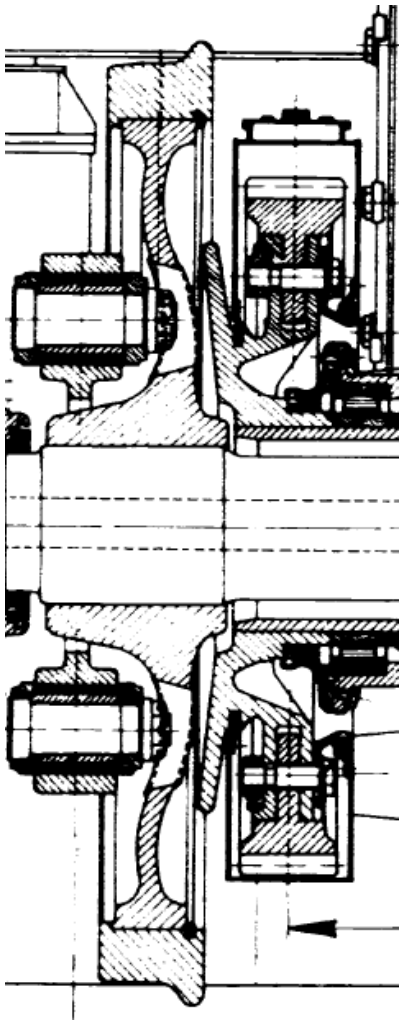


Abb. 3.432. Drehgestell ZA 1250 der $B_0'B_0'$-Lokomotiven Gruppe E 444 („Tartaruga") der FS
(Servizio Materiale e Trazione delle FS, Firenze)
Antrieb durch zwei Motoren über Zahnradgetriebe und Verzweigerantrieb gemäß Abb. 3.294

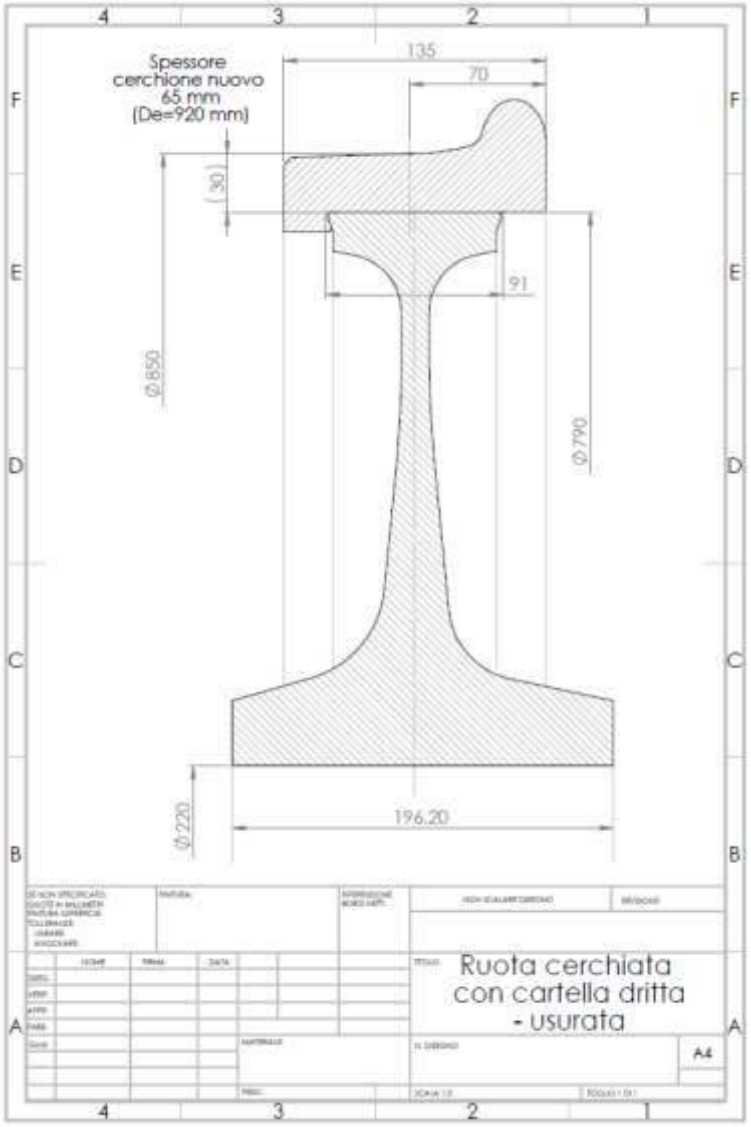
But life goes on… and in Italy the future was represented at that time by ETR500
One loco (E404.000) and some coaches were produced for testing
On 25.5.1989, the ETRX500 train reached 316 km/h

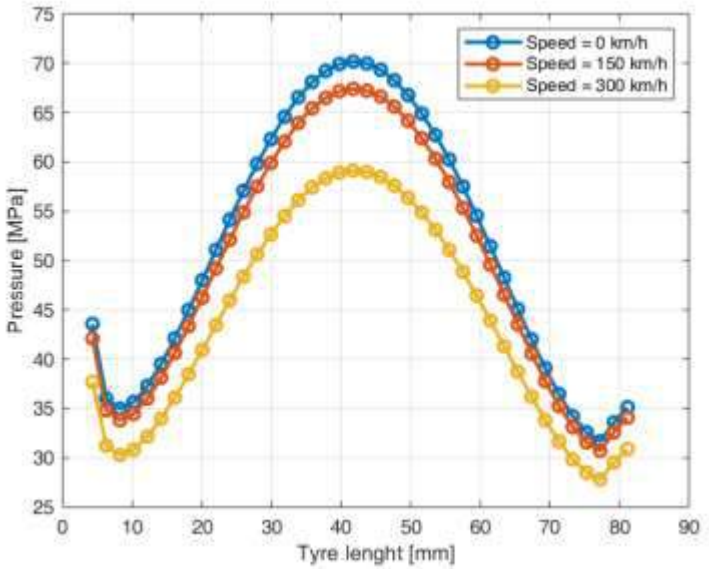
Two trainsets, called ETR Y 500, were put in service in 1990 for the football world championship

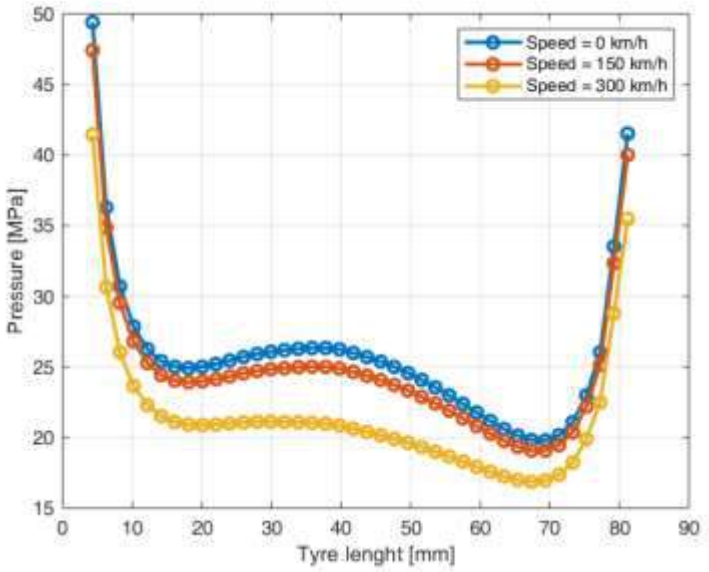
One of them reached 321 km/h in 1991, that represented the speed record in Italy until 3.2.2009 (362 km/h)

These two trains (with different locos) are still in service as diagnostic trains for RFI (ETR500 Y1 AIACE ed ETR500 Y2 DIA.MAN.TE.)

As we were often told that centrifugal forces are incompatible with high speed, we designed a «tyred ETR1000 wheel» and we checked what happened at 300 km/h…







All the locomotives (E404.000 and E404.001-004) had monobloc wheels.
Incredibly, all passenger coaches had tyred wheels.
Wheel centres had a corrugated web.

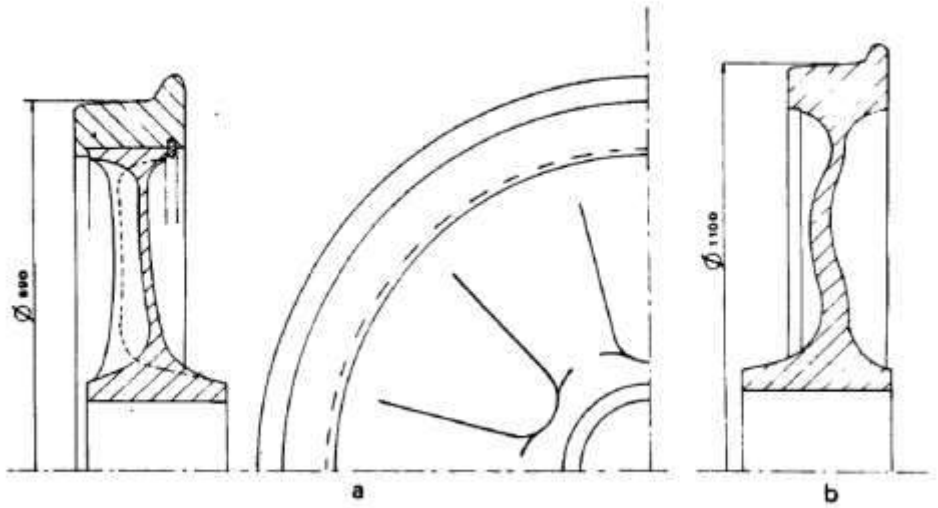
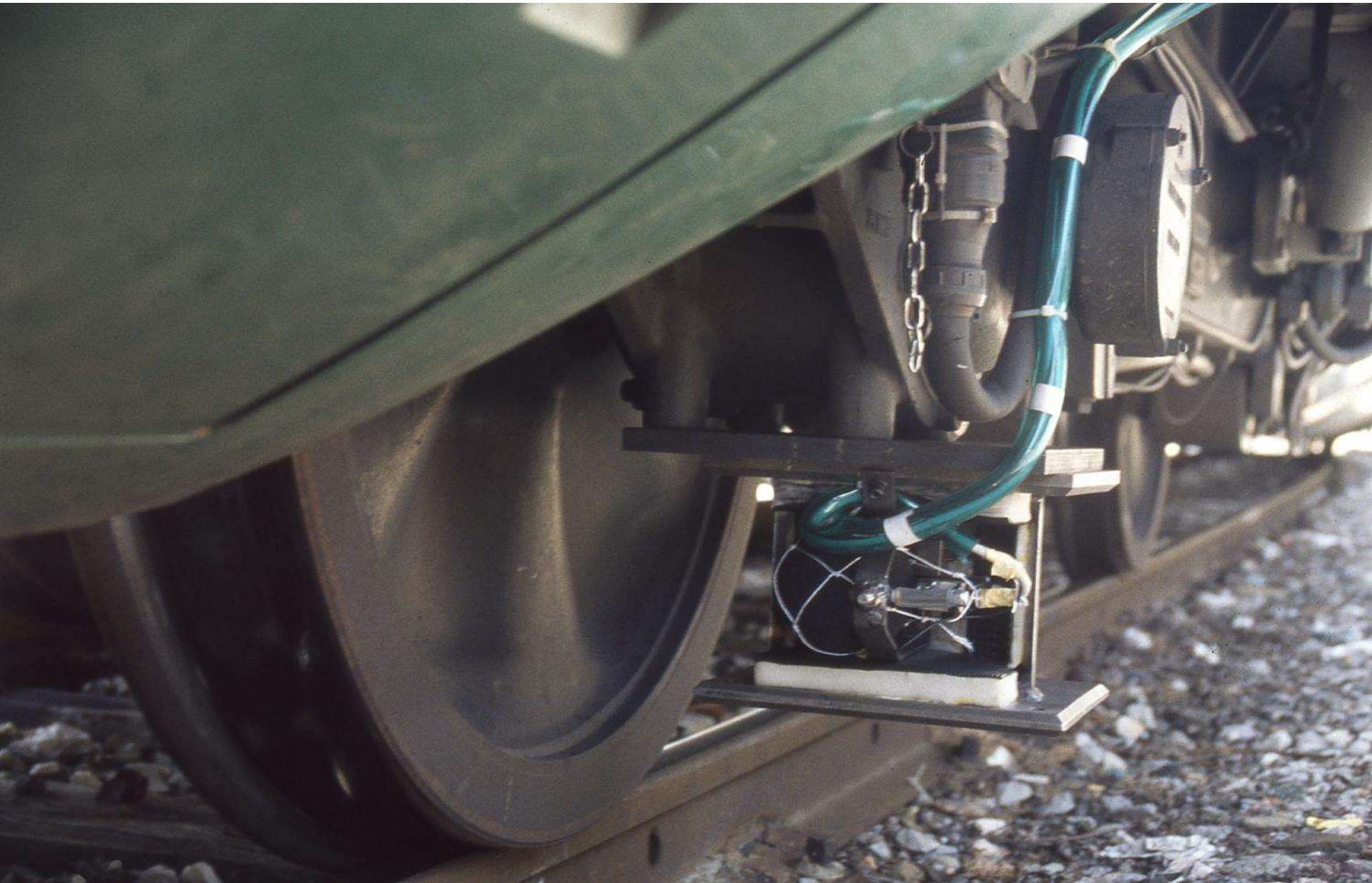


Fig. 3.6 – Vista e sezione della ruota della vettura (a) e sezione della ruota della motrice dell'ETR500 (b).

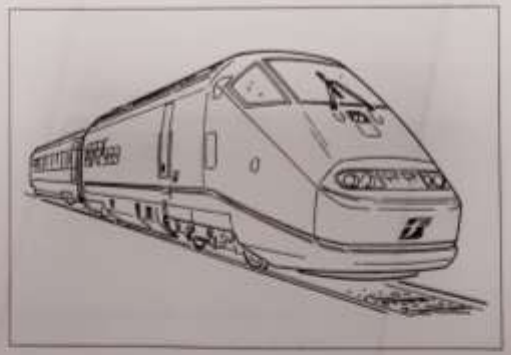
www.andreabracciali.it



It was decided to purchase new trains with both driven and trailer monobloc wheels

FERROVIE DELLO STATO S.P.A.
DIVISIONE MATERIALE ROTABILE
DIVISIONE TRAZIONE

ELETTROTRENO ETR 500/92



MANUALE PER IL PERSONALE DI BORDO
ADDETTO ALLA CONDOTTA
Volume PBC-1A: Descrizione generale di funzionamento

2.17.2 Sale montate

Il carrello è provvisto di due sale montate con ruote cerchiate calettate a caldo sull'assile (fig. 2-46).

Le ruote sono realizzate in acciaio speciale; la superficie di rotolamento dei cerchi è trattata termicamente.

Sull'assile sono calettati a caldo tre dischi autoventilanti dal diametro esterno di 640 mm.

2.17.3 Boccole

Ciascun assile è dotato di due boccole del tipo TR 443 su cui appoggia il telaio del carrello mediante dei bracci elastici. In ciascuna boccola alloggiano due cuscinetti a rulli conici che eliminando i giochi assiali permettono un buon controllo dei movimenti laterali della sala.

La boccola è provvista su entrambi i lati, di lamierini di tenuta per evitare la fuoriuscita del grasso di lubrificazione. La disposizione di questi dispositivi sulle boccole è indicata alla fig. 2-47.

Noise testing was performed on old and new wheels with an original device

Calibration of an on-board noise measuring device by simultaneous measurements of trackside noise of three different wheelsets for the ETR500 FS train

A Bracciali[1], L Ciuffi[2] and R Ciuffi[1]
[1]Dipartimento di Meccanica e Tecnologie Industriali, University of Florence, Italy
[2]Noise and Vibration Consultant

Metodo innovativo per la misura della rumorosità esterna dei convogli ferroviari

Dott. Ing. Andrea Bracciali (*) – Dott. Ing. Laura Ciuffi (**) – Prof. Ing. Renzo Ciuffi (*)

Continuous external train noise measurements through an on-board device

A Bracciali, L Ciuffi, R Ciuffi and P Rissone
Dipartimento di Meccanica e Tecnologie Industriali, Università degli Studi di Firenze, Italy

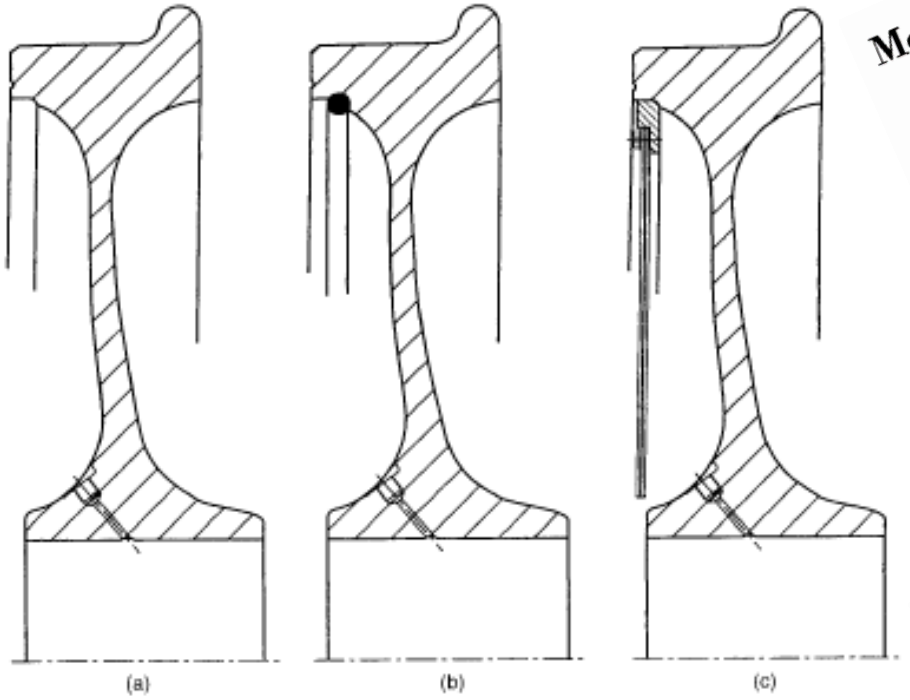


Fig. 2 The new 890 mm ETR500 wheels 'untreated', with 'dampers' treatment and with 'absorbers' treatment

New monobloc wheels were lighter and «dynamically optimized»
During tests, it was found that new wheels were on the average 7 dB(A) noisier than tyred wheels
Wheel treatments were then developed trying to reduce the noise of monobloc wheels, but noise abatement never reached the values of tyred wheels

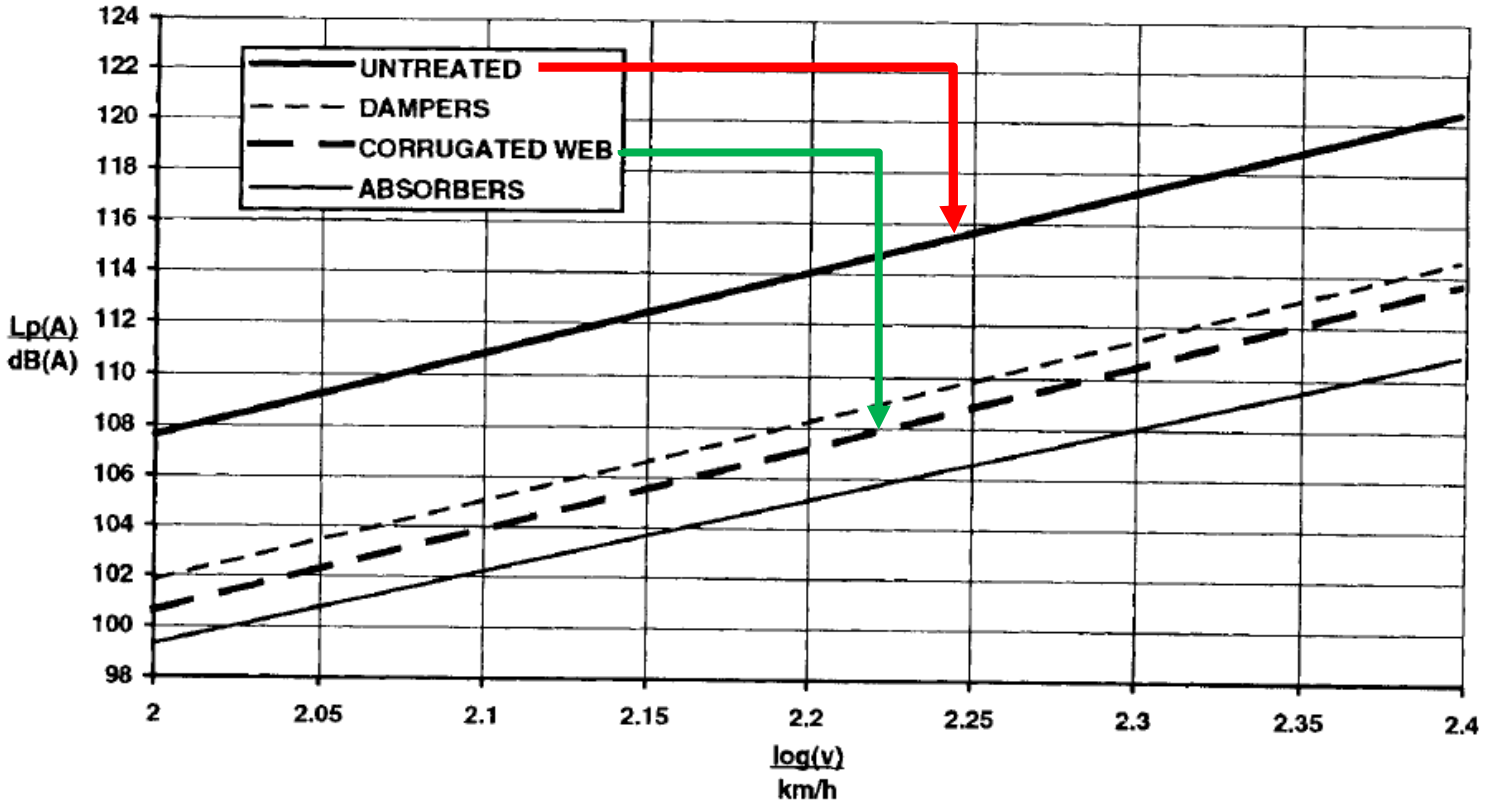


Fig. 8 Regression lines for the three wheelsets tested and ETRY500 prototype tangentially corrugated web wheelsets

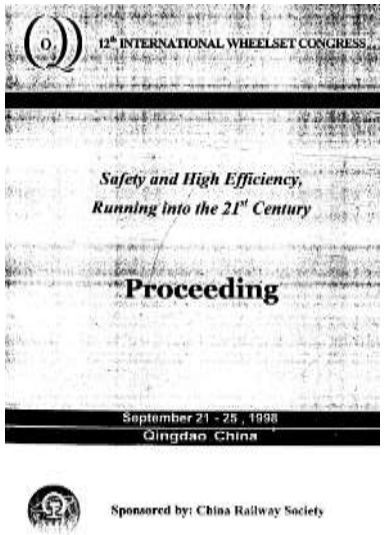
12th International Wheelset Congress in Qingdao, 21-25.9.2018
Some Japanese colleagues found out that resilient wheels «are expected to have some significant effect on reducing track deterioration»

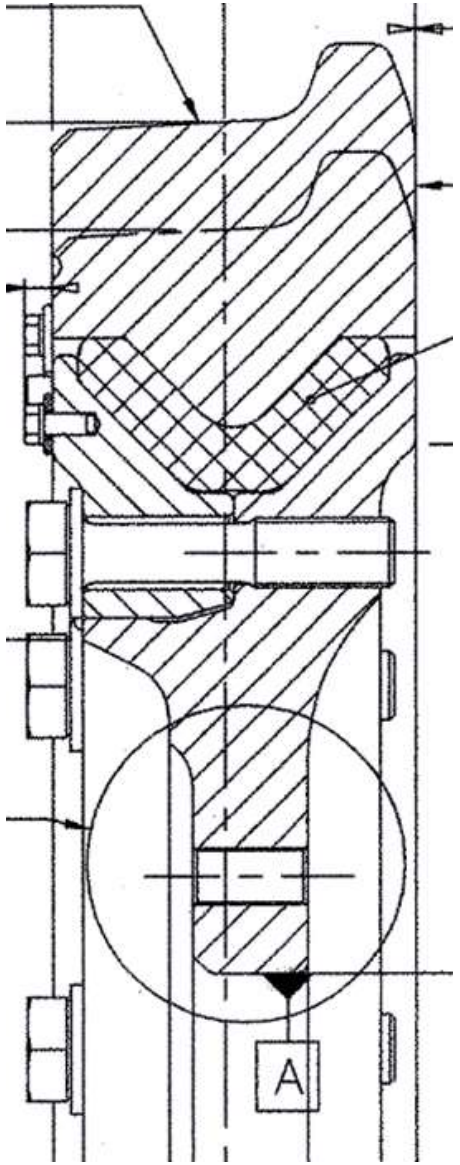
The effect of resilient wheels on track dynamics

Makoto ISHIDA, Shigeru MIURA, Akiko KONO, Kiyoshi SATOH and Hiroshi HATA

Railway Technical Research Institute

Various research and developments are carried out to increase the qualify and performance of railway such as convenience to passengers, coping with environmental issues and others. At present the development of some types of resilient wheels is newly tackled mainly from the aspects of reducing rolling noise and track maintenance for high speed trains at Railway Technical Research Institute in Tokyo (RTRI). In this study, at first, wheelset drop experiments were carried out to study the difference between the dynamic response of resilient wheels and that of solid wheels and to verify the adequacy of a very simple dynamic model of resilient wheels combined with the track dynamic model constructed at RTRI. Next, the track dynamic behaviours of resilient wheels and solid wheels at the running speed of 300 and 130km/h were studied using the track dynamic model with a resilient wheel and a solid wheel. As a result, this paper describes resilient wheels are expected to have some significant effect on reducing track deterioration.





June 5, 1998: one of the saddest days in the history of railways.
ICE 884 Munich-Hamburg derailed near Eschede, killing 101 people.
The train was equipped with resilient wheels BA 064 to reduce vibrations.
No regulations existed to develop tyred wheels.

Technical investigations were published short after hearings and sentence
It was discovered that the accident happened for a «rare or singular event»
This accident marked the end or tyred wheels in high speed, but this was a nonsense

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Engineering Failure Analysis 11 (2004) 515–535

ENGINEERING FAILURE ANALYSIS

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The railway accident of Eschede – technical background☆

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EMPA, Überlandstrasse 129, CH-8600 Dübendorf, Switzerland

Received 27 October 2003; accepted 2 November 2003

Fig. 4. Fracture surface of the broken wheel tire.

On the approximately 100 wheels which had been taken out of service before the accident no cracks or flaws have been reported when they were disassembled and scrapped. On the approximately 5000 remaining wheels removed after the accident several cracks were found in tires but no fractures. The cracks had occurred also in wheels with larger diameters than that of the accident and without pre-existing flaws. This supports the presumption of a rare or singular event which could have initiated the crack. It also supports the assumption of a generally quite low mean loading level because these cracks, which were detected later, had grown only very slowly or not at all and never reached a critical depth.

The nature of such a rare event can only be speculated about; in the official investigation of the case such topics were not brought up and because this wheel type is no longer used for high-speed trains no further research was done in this direction.

The case has shown as topics for improvement that modernisation of design rules or international standards is necessary, that realistic measurement of service loads and impact factors should be carried out previous to design work, that the weak spots need identification by tests on roller type test stands until fracture and nondestructive test of these weak spots ought to be done in the regular service checks.

Some intermediate conclusions

It is FALSE that tyred wheels are not suitable for high tractive effort

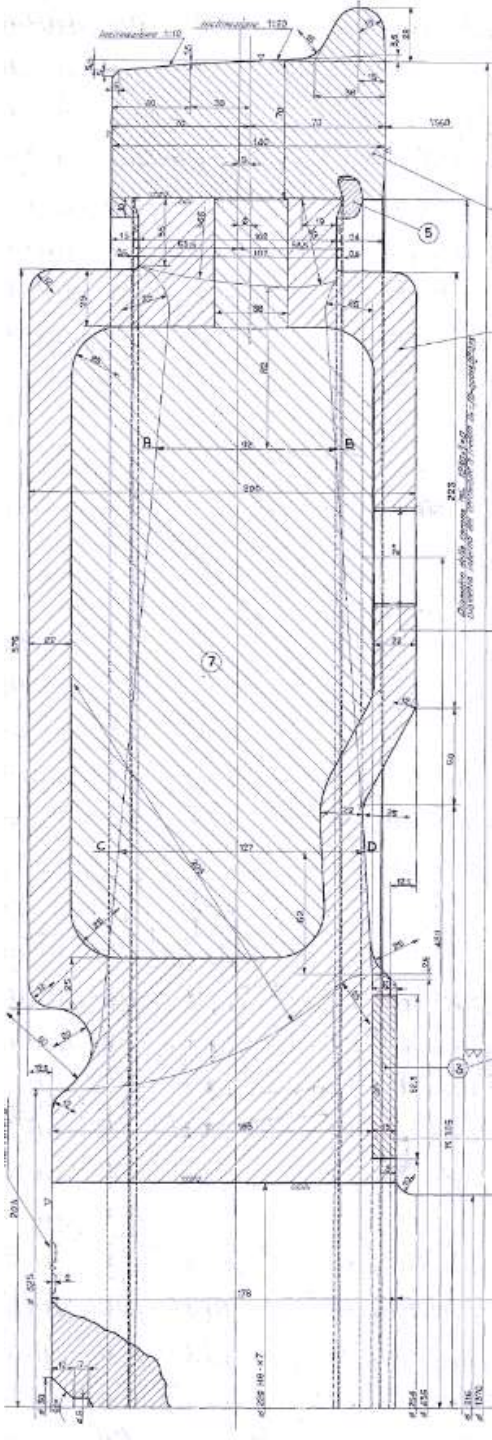
It is FALSE that tyred wheels are not suitable for high speed

It is TRUE that tyred wheels not suitable for drag braking

It is TRUE that tyred wheels are not suitable for freight wagons (but…)

It MAY be TRUE that tyred wheels are quieter than monobloc wheels

It is FALSE that the Eschede accident proved that tyre wheels are bad for high speed



Then something changed at an international level…

UIC CODE 510-2 OR

4th edition, May 2004

Translation

Trailing stock: wheels and wheelsets. Conditions concerning the use of wheels of various diameters

Matériel remorqué : roues et essieux montés - Conditions concernant l'utilisation des roues de différents diamètres
Wagen. Bedingungen für die Verwendung von Rädern verschiedener Durchmesser in Laufwerken unterschiedlicher Bauart

1.3 - Rim-tyre, tyre

1.3.1 - From 1.1.89, new wagons are to be equipped with solid wheels.

This provision is necessary to avoid tyre loosening during drag braking…

Then something changed at an international level…

INTERNATIONAL STANDARD

ISO 1005-1

Third edition
1994-08-01

Railway rolling stock material —

Part 1:
Rough-rolled tyres for tractive and trailing stock — Technical delivery conditions

Matériel roulant de chemin de fer —

Partie 1: Bandages bruts laminés pour matériel moteur et pour matériel remorqué — Conditions techniques de livraison

Introduction

At present, tyres are preferably used for repairs while new wheels are mainly manufactured as solid wheels. An important market for tyres seems to exist only in Asia and parts of Africa. However, this tendency is decreasing.

This will therefore be the last edition of ISO 1005-1 and it was decided not to include an alignment of tyre grades given in this part of ISO 1005 with the grades of solid wheels in ISO 1005-6.

This consider instead any kind of rolling stock

…as well as at an European level

L 245/402 EN Official Journal of the European Communities 12.9.2002

COMMISSION DECISION

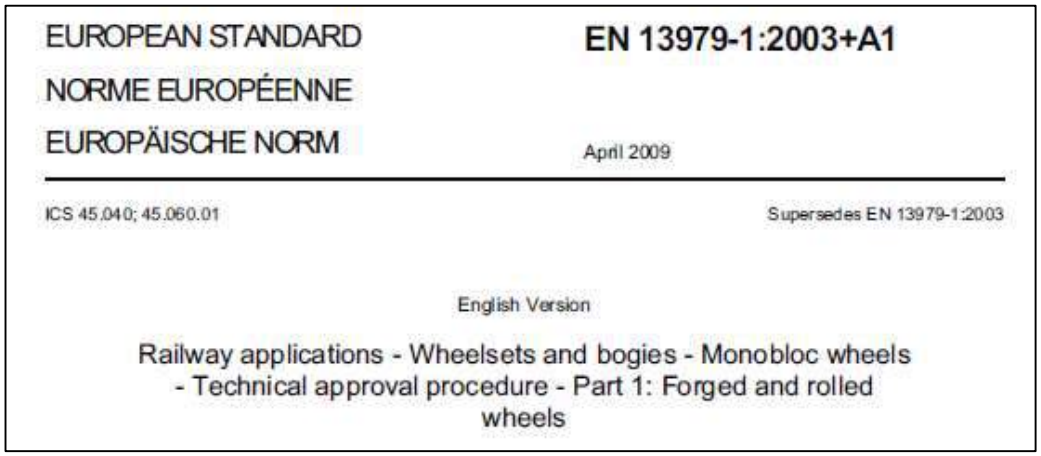
of 30 May 2002

concerning the technical specification for interoperability relating to the rolling stock subsystem of the trans-European high-speed rail system referred to in Article 6(1) of Directive 96/48/EC

(notified under document number C(2002) 1952)

(Text with EEA relevance)

(2002/735/EC)



EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 13979-1:2003+A1

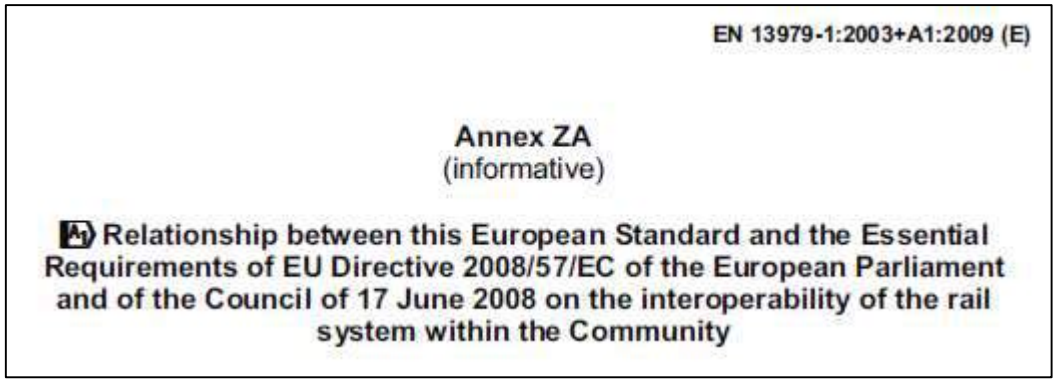
April 2009

ICS 45.040; 45.060.01

Supersedes EN 13979-1:2003

English Version

Railway applications - Wheelsets and bogies - Monobloc wheels - Technical approval procedure - Part 1: Forged and rolled wheels



EN 13979-1:2003+A1:2009 (E)

Annex ZA
(informative)

A1 Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC of the European Parliament and of the Council of 17 June 2008 on the interoperability of the rail system within the Community

Tyred wheel are never mentioned and they will never be anymore…

So, the main question is:

If tyred wheels are suitable for most of the railway vehicles, why did they disappear???