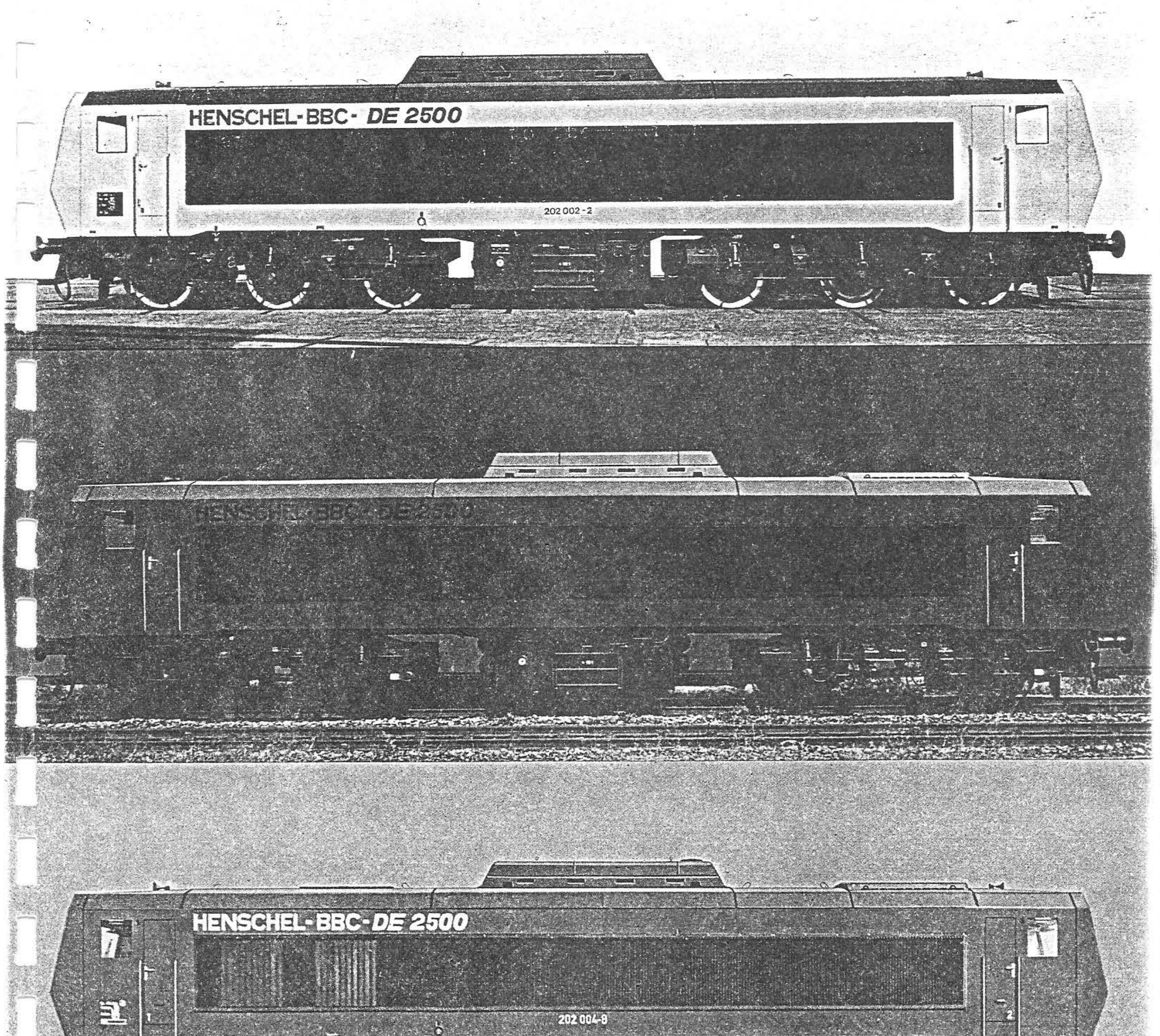
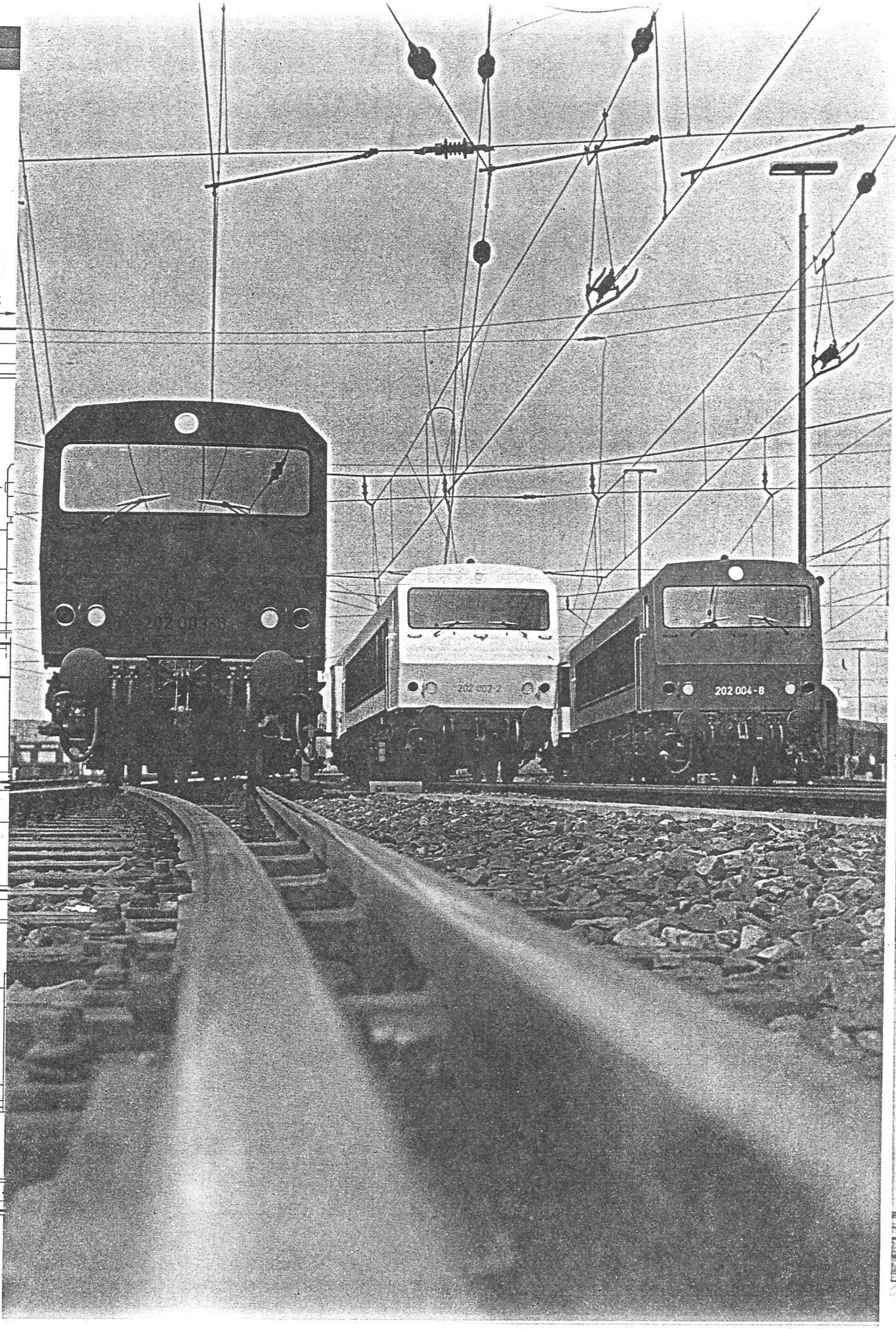
BBC
BROWN BOVERI

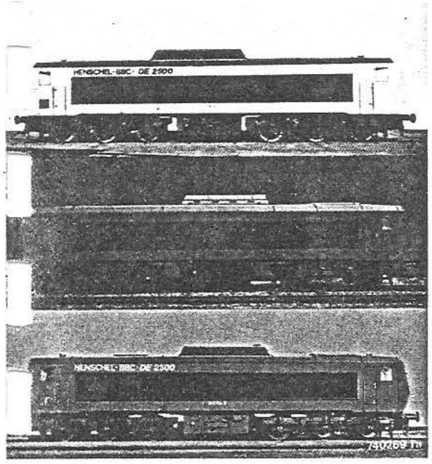
Asynchronous motor drive for Diesel locomotives

Publication No.
D VK 40810 E

Henschel-BBC-DE 2500




202 002-2
202 004-8



500 HP
comotives with electric brake and
all extras weight approx. 80 t only

Contents

Asynchronous motor drive for Diesel locomotives

Henschel-BBC-DE 2500

Many years of development
and operation trials
have made it possible to use the

robust
economic
maintenance-free

ASYNCHRONOUS MOTOR

for the power transmission
of diesel-electric locomotives.

Advantages of the new technology

Practically no wear and maintenance since

the asynchronous motor requires
- no commutators
- no brushes
- no sliprings
- no uninsulated parts

the inverter incorporates
- no contacts
- no fuses
- no movable parts

the generator incorporates
- no commutators
- no sliprings
- no brushes

the bogie incorporates
- no laminated springs
- no frictional areas
- no axle-box guides
- no bogie pivots.

No slipping or skidding since
- all motors are connected in parallel
- all motors are fed with equal frequency
- all motors have a very steep torque-speed characteristic
- all motors are thus electrically coupled
- the electronic control prevents simultaneous slipping of all axles.

High tractive efforts since
- the asynchronous motors are always operating at the most economical point
- the asynchronous motors feature very small losses so that no thermal problems will arise
- the asynchronous motors have a considerable reserve capacity
- the utilization of adhesion is very high as the total tractive effort has not to be reduced due to individual axles with a poor adhesion factor.

Electric braking down to standstill since
- the electronic system allows regulation down to standstill
- with the asynchronous motor the characteristic may be the same during braking and traction
- there are no thermal problems.

Simple power supply to electric train heating system
- since simple power distribution between traction and auxiliaries is possible
- since the power for train heating will not require a special generator
- since the power for train heating may be taken from the d. c. intermediate circuit
- since the inverter for traction separates completely main generator and traction motors
- since the electronic control ensures that the diesel engine is loaded to its nominal data only regardless of the service conditions prevailing.
- since the regulation of the main generator has not to be performed according to the conditions applying to traction.

Dynamic brake feeds into the heating system of the coaches
- since both brake resistor and heating supply are connected to the intermediate d. c. circuit
- since the electronic control allows parallel operation
- since the inverter for the heating can also control the heating voltage.

Diesel-engine-sparing operation
- since the three-phase power transmission does not have a rigid load characteristic
- since the power transmission adapts itself to the capability of the diesel engine
- since the nominal values of the filling will not be exceeded at any load
- since the failure of individual cylinders has not to be compensated by the remaining ones
- since the diesel engine will not run at the fuel injection limit even when it is running up to speed
- since poor fuel qualities will not be compensated by more fuel
- since the power input of the three-phase power transmission will be decreased when the exhaust-gas temperatures are too high
- since the diesel engine has not to be accelerated to maximum speed for obtaining high tractive efforts on starting
- since individual axles cannot slip and since thus the diesel engine output has not to be reduced.

Very good running qualities
- since the axles are guided by links
- since the bogie is pivoted to the body by means of links
- since the asynchronous motor is small
- since the asynchronous motor is very light
- since the bogie weights are thus low.

Slight resistance to running
- since there are no axlebox guides
- since there is no friction in the springs
- since there is no friction caused by bogie pivots
- since there is no commutator friction in the motor.

Simple monitoring and fault locating
- since faults are indicated by luminous diodes in the electronic system
- since fault indication stays on for 5 minutes even in the case of voltage failure
- since the racks and modules allow ready replacement
- since there are simple possibilities of disconnecting defective parts
- since sufficient test points for normal instruments are installed
- since design and arrangement are very clear.

Clear layout and ease of operation
- since the electronic system regulates all actions and processes automatically
- since no ammeters are required as the power transmission involves no thermal problems
- since the locomotives are provided with "up-down" control for traction and braking
- since only a minimum of instruments and switches is required
- since the driver's cab incorporates the latest advances in ergonomy
- since symbols have been chiefly used for identification purposes.

Further saving in brake shoes
- since the electric brake is capable of **slowing down** the train **until standstill.**

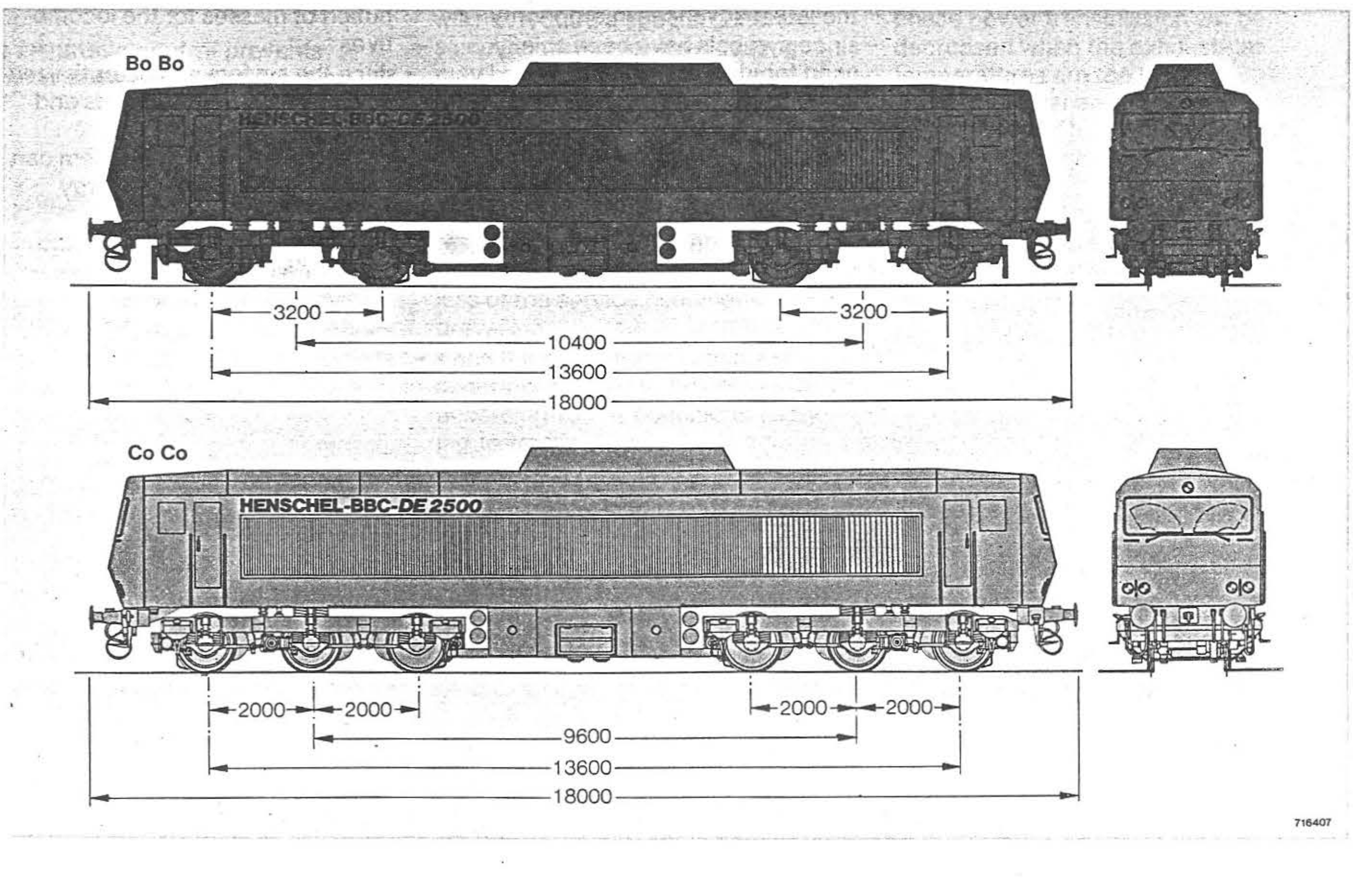
Greater fuel economy
- since the three-phase transmission has a high efficiency
- since the starting losses are negligible
- since the diesel engine has not be accelerated to maximum speed for maximum tractive effort
- since the load characteristic of the power transmission can be adapted to the most favourable fuel consumption of the diesel engine.

Future-oriented technology
- since the asynchronous motor has reserve capacity
- since the modular design allows increase in power by parallel connection
- since future-oriented technologies are used for the inverter system and electronic system
- since the asynchronous motor results in light-weight bogie and thus allows an optimum distribution of masses for the locomotives
- since the system can be optimized both for high tractive efforts and high speeds
- since, on principle, the system can be used for all kinds of energy supply
- since the system represents the basis for all linear motor drives.

Main data

As universal locomotives both for heavy freight and fast passenger service, the locomotives feature both a very high tractive effort at starting and a maximum speed of 140 km/h.

Main data	Wheel arrangement Bo Bo	Wheel arrangement Co Co
Track gauge	1435 mm and up	1000 mm and up
Rated output of diesel engine	2500 HP	2500 HP
Wheel diameter new	1100 mm	1100 mm
Bogie wheel base	3200 mm	2000 mm
Distance between the bogie pivots	10400 mm	9600 mm
Length between buffers	18000 mm	18000 mm
Maximum speed	140 km/h	140 km/h
Tractive effort at starting	27 Mp	27 Mp
Effectiveness of electric brake	0–140 km/h	0–140 km/h
Tare weight	76 tonnes	80 tonnes

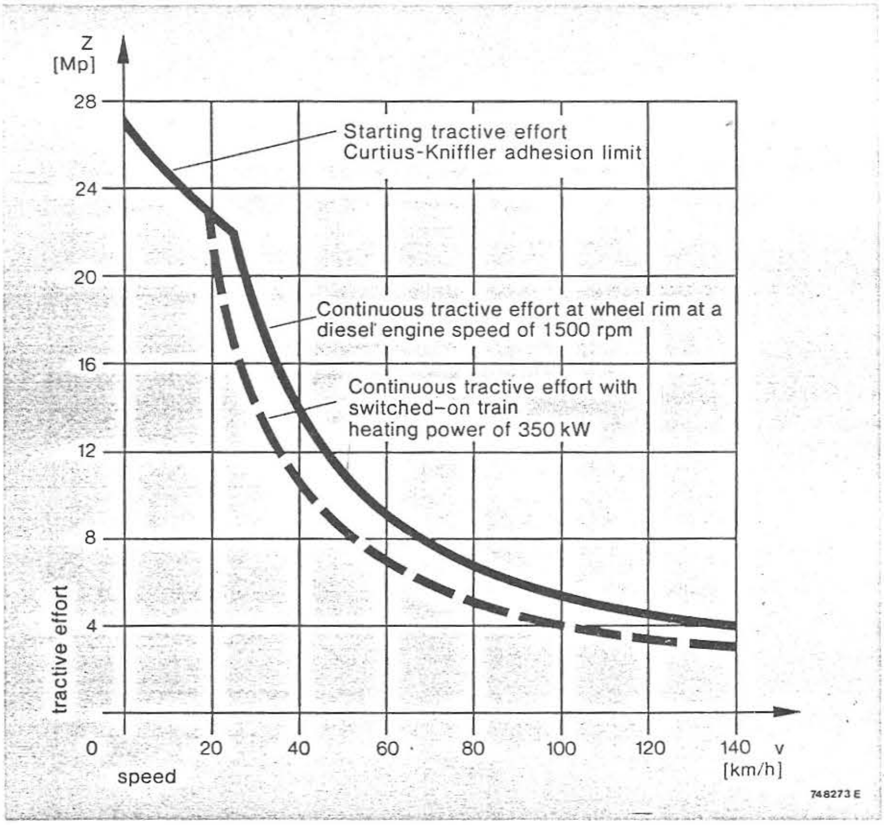


Tractive effort diagram
Braking effort diagram

Tractive effort diagram
The tractive effort diagram is based on a rating of the diesel engine of 2500 HP. The starting tractive effort is determined by the adhesion limit of $\mu = 0.33$.

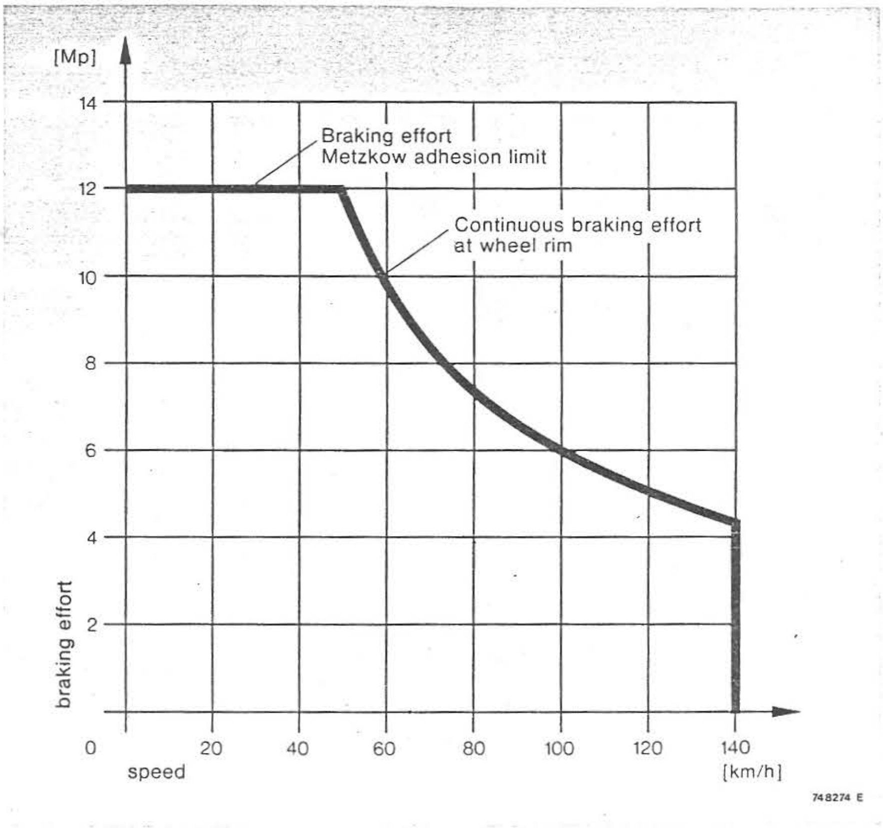
An important feature of the electric power transmission is the possibility of adapting the traction power to the power available. During normal operation, the diesel engine remains loaded with constant power regardless of the amount of power required for the auxiliaries. The power not required for the auxiliaries is used for traction.

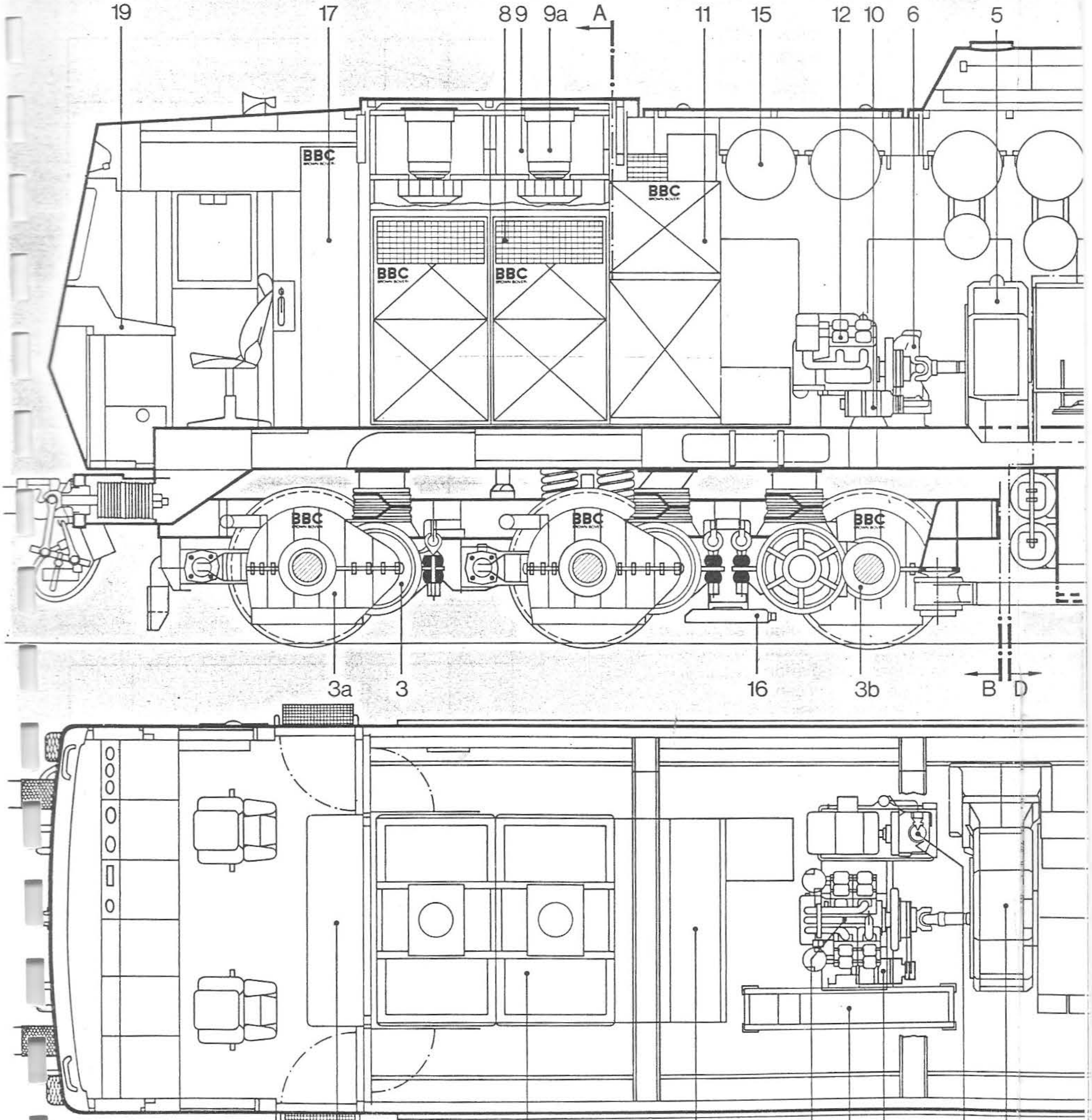
The same applies when heating is switched on. The second tractive effort curve shown in the diagram is obtained when the full heating power is required.



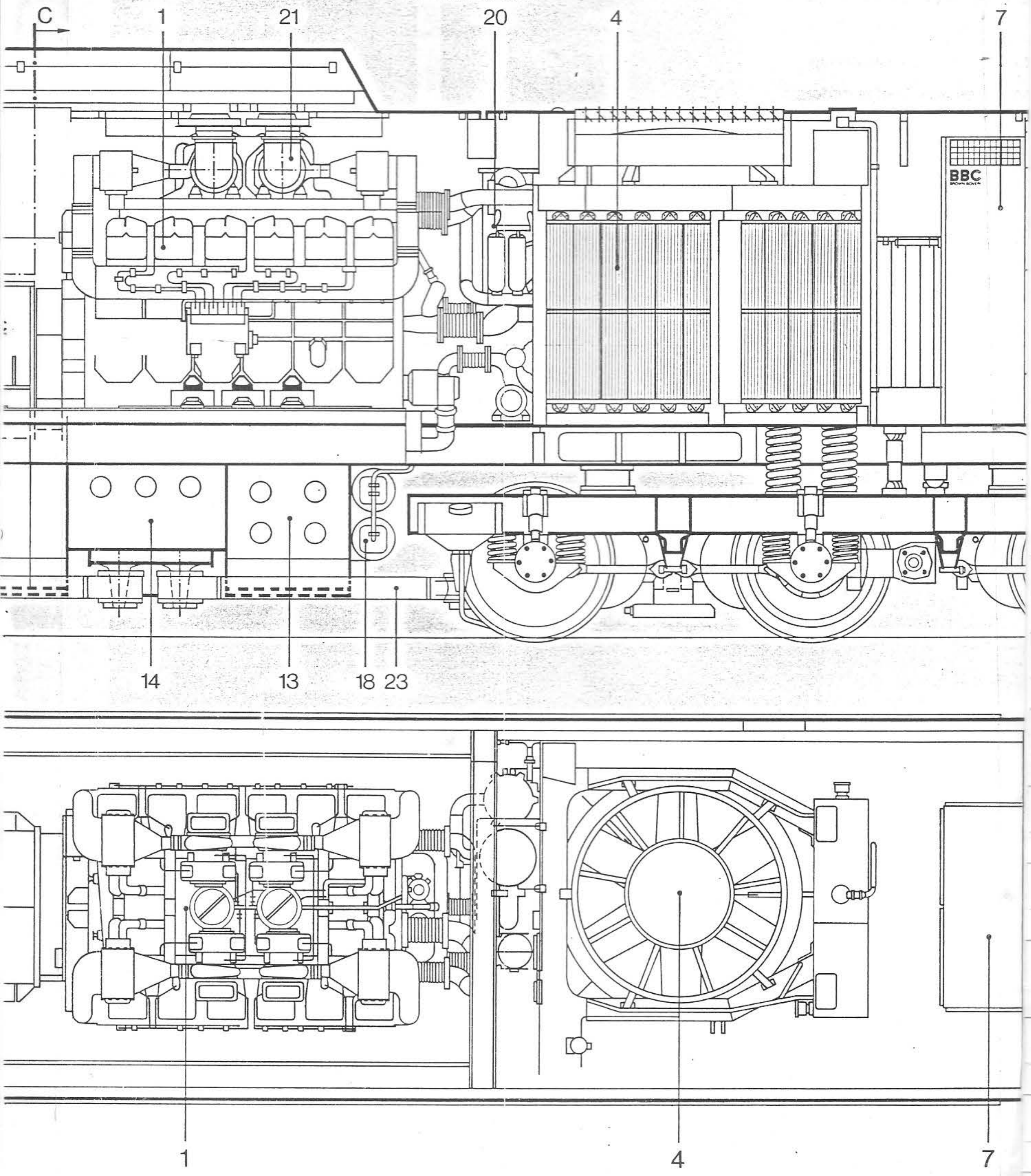
Braking effort diagram
A special feature of the three-phase power transmission is the possibility of providing a high braking effort down to zero speed. Trains can thus be slowed down to standstill without causing wear to one part or the other. The maximum braking effort according to Metzkow is 12 Mp. However, the three-phase power transmission is basically capable of achieving during braking the same characteristic as during traction.

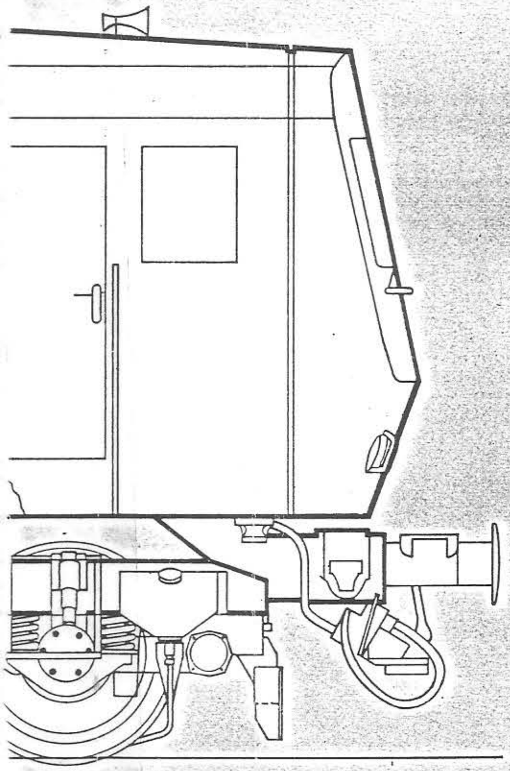
ᶠ the line pressure falls below 4.7 kg/cm^2, brake step 1 (3.2 Mp) is switched on automatically to assist ɿe compressed-air brake.

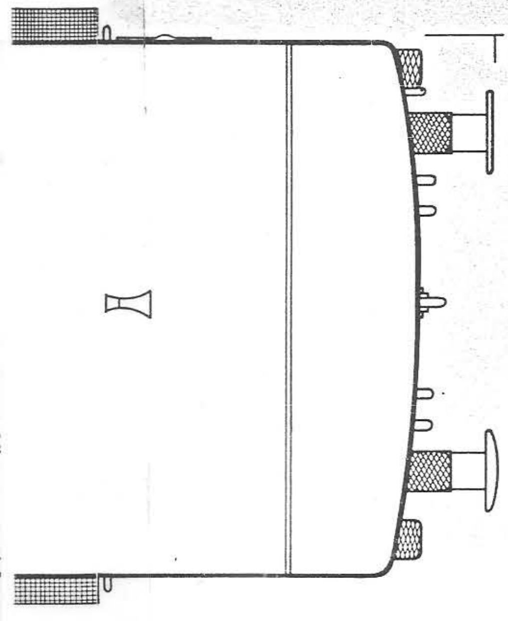



19
17
8
9
9a
A
11
15
12
10
6
5
BBC
3a
3
16
3b
B
D
17
8,9,9a
11
12
22
10
6
5

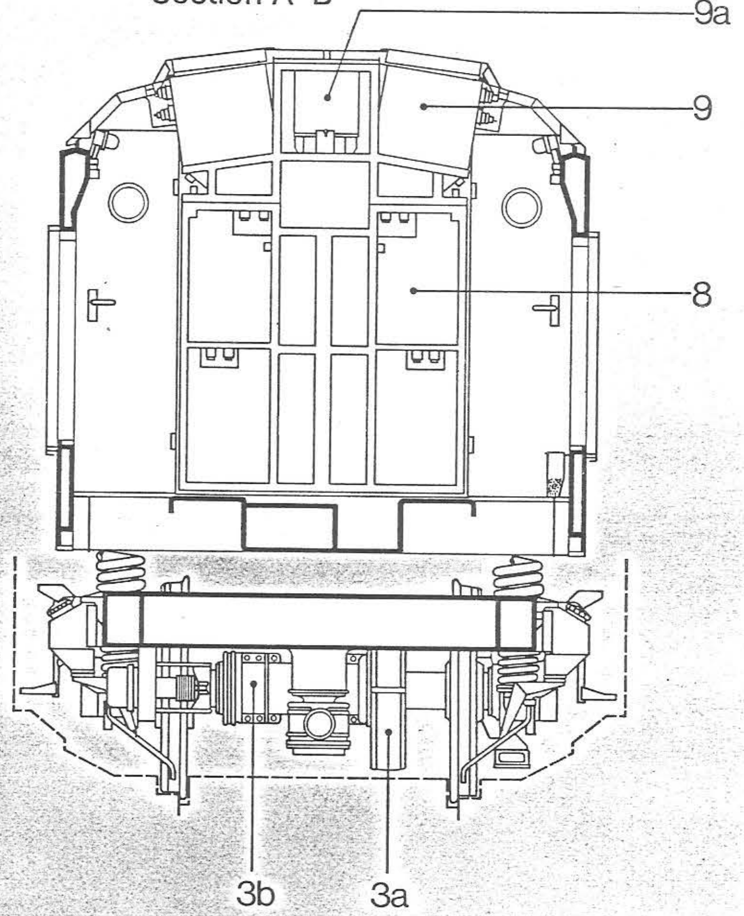
1 diesel engine
2 alternator
3 traction motor
3a gear
3b nose bearing
4 cooler
5 central blower
6 H. P. compressor
7 inverter for heating
8 inverter for traction
9 brake resistors
9a blowers for cooling the inverters and brake resistors
10 alternator for power supply to electronic control system
11 cabinet accommodating the electrical equipment
12 braking air compressor
13 fuel tank
14 battery
15 main air tank
16 automatic signal control
17 inverter control, traction control
18 H. P. tank for diesel starting
19 driver's cab
20 motor lube oil heat exchanger
21 turbocharger
22 frame accommodating the air brake devices
23 bogie link rod



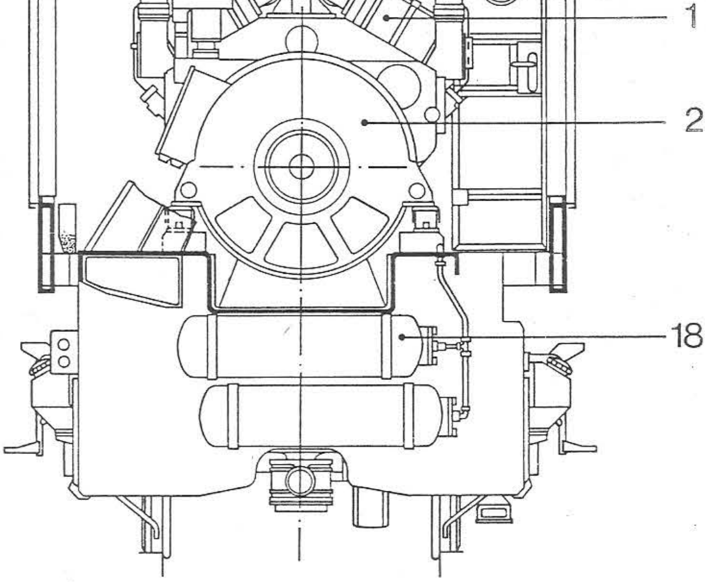




Section A–B



Section C–D



Locomotive body and layout of the equipment

The Henschel-BBC-DE 2500 locomotive is designed in such a way that the sides of the body are the supporting structure proper. They are of the sheet-metal-frame type.

Instead of the usual bridge girder, this new locomotive design uses a system of longitudinal beams and cross beams between the two side plates. The overall height of this system is considerably less than that of the bridge girder and allows thus the floor sheet above this system to be placed relatively lower than usual with other Diesel locomotives. This method gives sufficient hight to the engine room even if for the locomotive body only a low overall height is available due to a limited profile.

At either end, the U-shaped body is provided with a driver's cab with welded-in backplate and welded-on roof. The front portion of the driver's cabs is put in front of this tubular locomotive body part like a mask.

The support for the removable buffer beam is not directly connected with the mask-shaped front portion but is hinged from below to a very sturdy cross tie behind it. In the case of a light head-on collision this design prevents folds in the front portion of the locomotive body even if the buffer beam is forced backwards. The damage occurred can easily be repaired by adjustment or replacement of the buffer beam support.

The buffer beam portion can be adapted to suit the mounting of all automatic coupling types available.

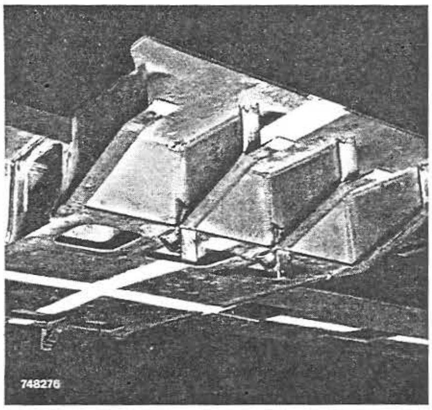
The entire portion of the locomotive body between the two cabs is U-shaped. The removable roofs have the same width as the locomotive body. By their removal the locomotive body is uncovered at the top over its entire width between its longitudinal plates.

Between the driver's cabs, the locomotive body consists of engine room and cooler room.

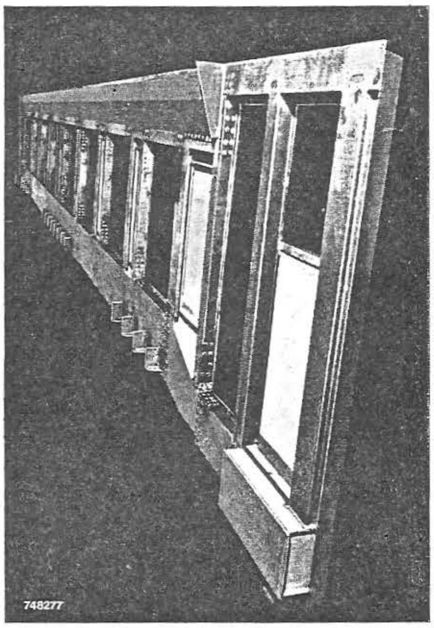
Our experience with the first prototype locomotive Henschel-BBC-DE 2500 has shown that oil leaks in the diesel engine area, which cannot be avoided in the long run, will result in oil mists which may be sucked in with the cooling air for the inverters. For this reason, the design of the Henschel-BBC-DE 2500 locomotives following the prototype locomotive is such that the inverter unit is isolated from the remaining engine room so that the latter consists of two parts.

One part, the diesel engine room, accommodates the diesel engine/alternator unit, the blower for the alternator and the traction motors, the air compressor for the braking system and the air compressor for the diesel starting device. The other part houses the inverter cabinet with rectifier and auxiliary equipment. This room receives only fresh air and is well isolated from oil mists which might occur in the diesel engine room.

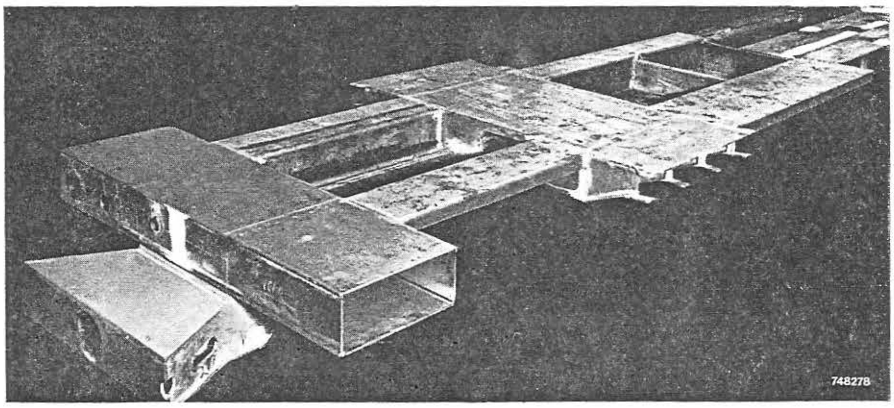
The auxiliary unit associated with the diesel engine and completed outside the locomotive is placed in the cooler room. However, the equipment fitted to the front portion of this unit, such as lube oil and fuel pumps, all the filters and the oil coolers, project into the engine room towards the diesel engine through an opening in the partition.



748276



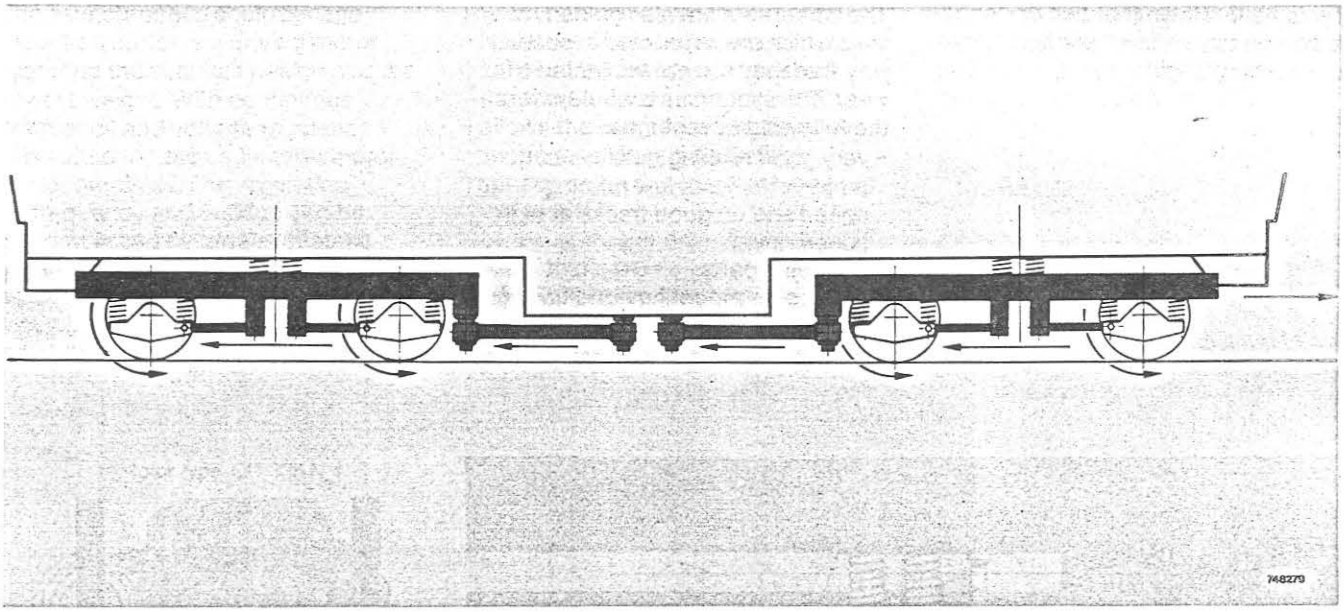
748277



748278

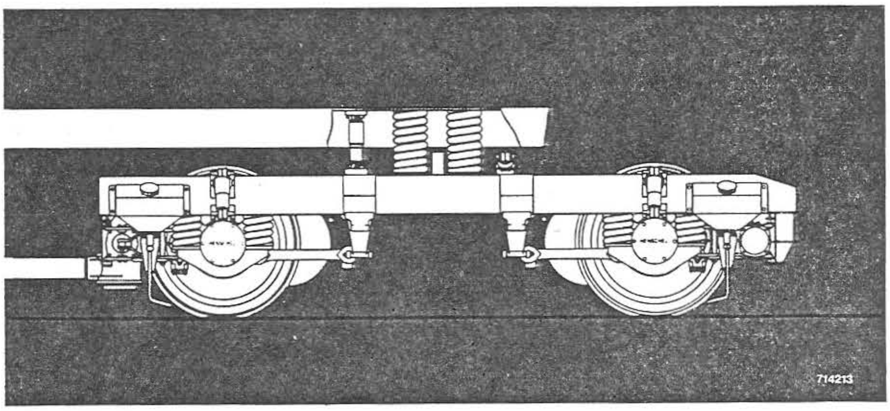
Running gear

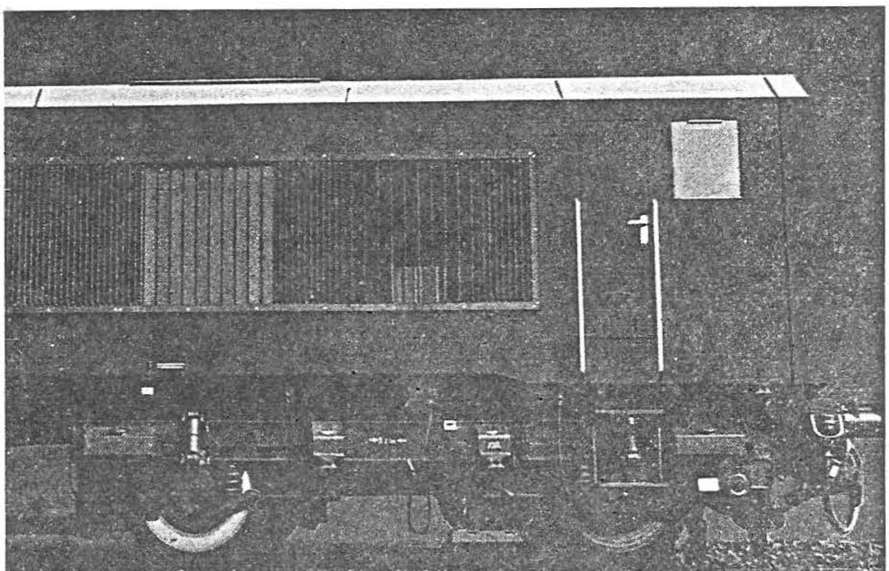
Transmission of tractive and braking efforts



The bogies have a very simple and clear design of rectangular profile. They use no pivots.

The tractive and braking efforts are transmitted by means of non-wearing sturdy links which are hinged to the interior bogie end girder.

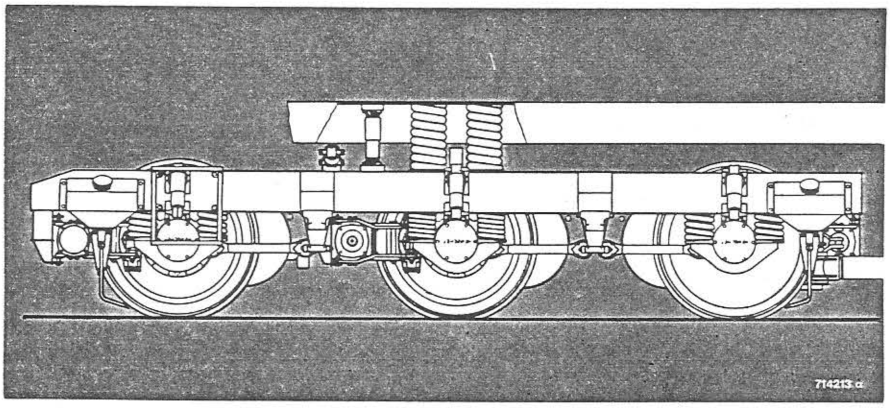




Tests have shown that this design is completely satisfactory also for the pushing bogie.

The wheel sets are also guided by links which are supported in such a way that they are not subjected to wear. The system as a whole offers the following advantages:

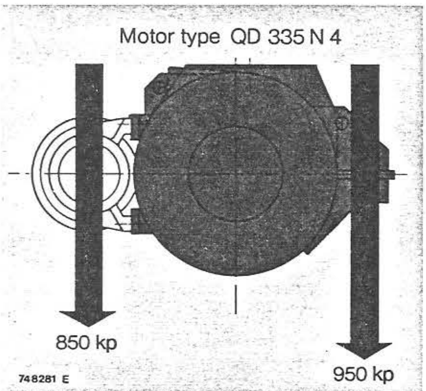
- very good running qualities both on poor tracks at low running speed and on good tracks at high speed
- no sliding parts
- favourable mounting conditions for the traction motors.



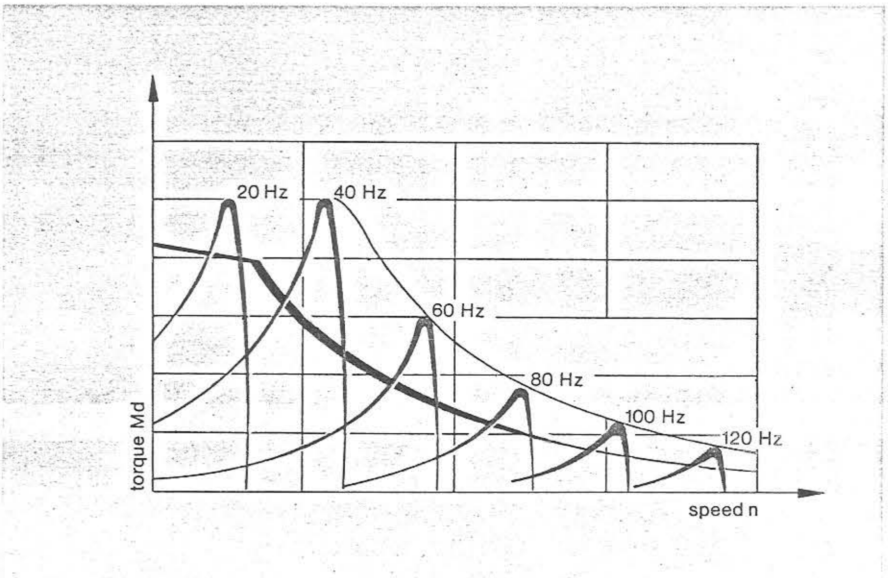
Asynchronous motor drive

The asynchronous squirrel-cage induction motor is a driving motor featuring the simplest design and the lowest weight. With continuous frequency and voltage regulation it is suited for use as traction motor for locomotives. The regulation of frequency and voltage can be accomplished by means of static inverters. With an infinity of torque-speed curves a stable operating point is always obtained with the traction resistance curve.

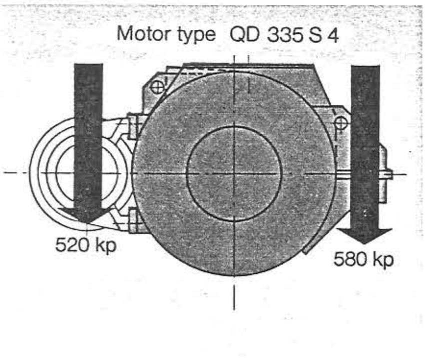
The asynchronous traction motor
- is always operated at an economical point on the steep branch of the torque-speed characteristic
- allows the use of the simple nose-suspended drive also for high speeds since the unsprung masses are small
- allows optimum drive designs since there are no speed limitations by commutators at all
- consists of non-wearing components, with the exception of the armature bearings, and is thus extremely sturdy
- allows simple bogies and ensures good running qualities.



748281 E

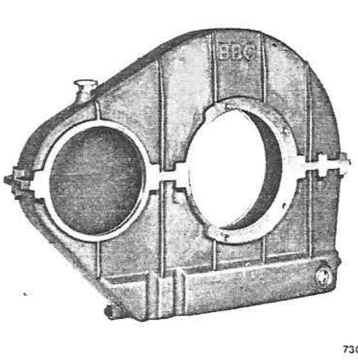


748282 E



748280 E

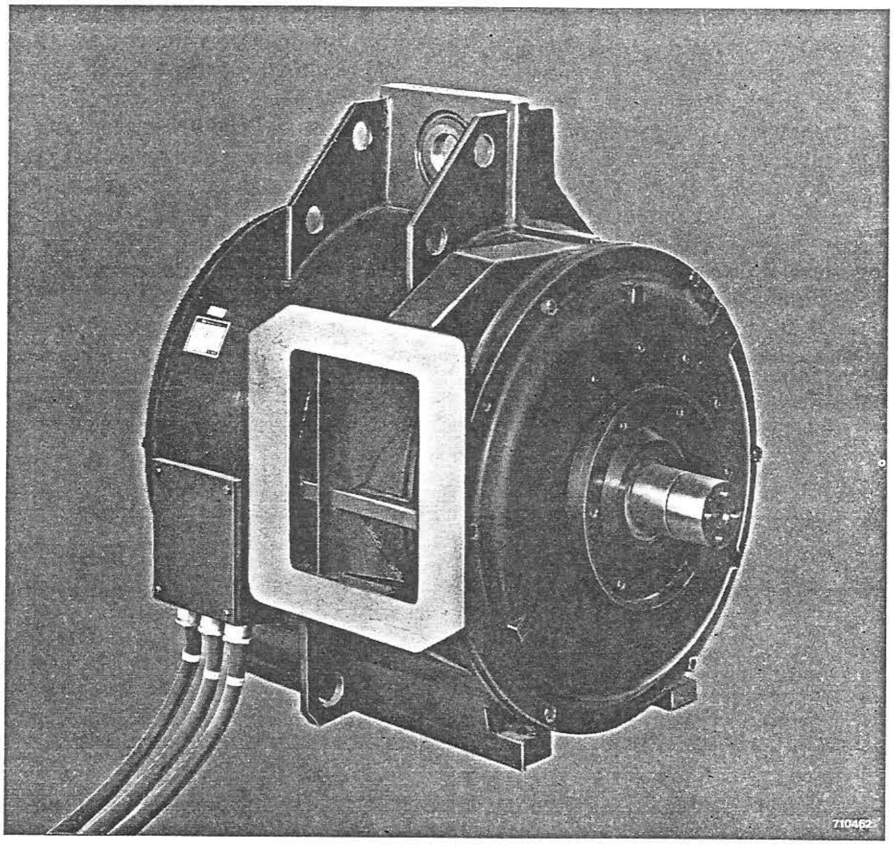
The design of motor casing with suspension and nose-bearing fitting allows
- the complete prefabrication of the driving axle with axle suspension without motor
- very simple mounting and, if required, dismounting during operation.


730351

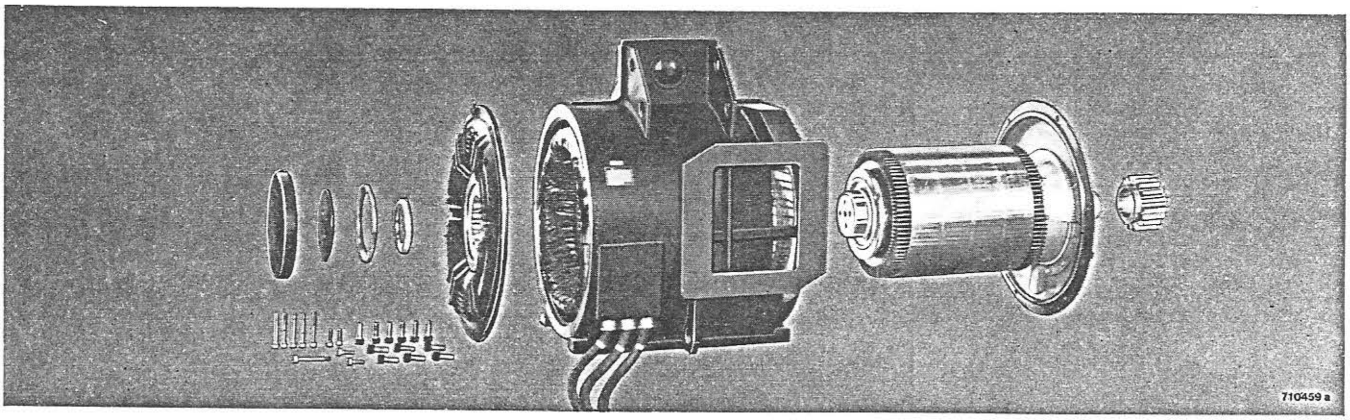
The simple spur gear between traction motor and driving axle
- is designed for oil lubrication
- is accommodated in a light-weight box consisting of two silumin castings. The oil level can easily be controlled from outside through an inspection hole.

The space within the driving wheel set can be better utilized by the designer when an asynchronous motor is used since

- there will be no limitations imposed by a commutator, such as peripheral speed, temperature rise, dielectric strength, accessibility to carbon brushes, etc.
- due to the absence of the commutator there will be more overall length available for the active motor power to be installed
- the electrical data for current, voltage and frequency can be selected under consideration of overall optimization.



Motor type QD 335 S 4 for gauges of 1000 mm and up



For production and maintenance it is always good practice to satisfy a maximum of demand with a minimum of parts. With proper type selection the asynchronous motor is an ideal element for a modular system since

- several winding versions can use the same sheet-steel lamination
- different type ratings can be obtained by various lengths of the core (motor length).

The main data of the two traction motor types of locomotive power class 2500 HP, corresponding to the DE 2500, are as follows:

Motor	Suited for gauges of and above	Rating	Voltage	Speed	Weight	Outer dia.	Length
Type	mm	kW	V	rpm	t	mm	mm
QD 335 S 4	1000	250	1250	3750	1.1	660	857
QD 335 N 4	1435	375	1250	3750	1.8	660	1187

The data stated apply to the use in the DE 2500
The actual motor ratings are considerably higher.