PROGRESS IN RAILWAY MECHANICAL ENGINEERING
1996-1997 SURVEY-LOCOMOTIVES

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ABSTRACT

This survey reports on motive power developments for the previous year ending August 1997. Invitations to participate were sent to a large number of locomotive builders throughout the world. Although the response this year was limited, railway industry trade journals and other rail magazines provided additional input.

General information is presented on five diesel locomotives and six electric locomotives. For further details on any given design, the reader is urged to contact the builders.

INTRODUCTION

AC traction continues to be in the spotlight for North American freight locomotives and now it accounts for a majority the new locomotive orders. Surprisingly however, has been the continued demand for high horsepower DC locomotives. As railroads make their economic decisions on which type of propulsion system to order, they have to be convinced that the benefits to their operation justify the increased cost of an AC locomotive. Increased adhesion has convincingly been demonstrated resulting in the expected unit reductions, generally on the order of 3 for 5 and 2 for 3. A reduction from two high adhesion DC units on a tonnage train to one AC locomotive is not always achievable. Operating crews have also become enthusiastic proponents of AC traction locomotives, the high adhesion capability being well recognized but more importantly they like the flexibility to dynamic brake almost down to a standstill with no loss of effort.

GE and EMD continue their 6000 hp locomotive developments on several railroads. Railroads that have the opportunity for effectively utilize locomotives in this horsepower range are anxiously awaiting their arrival. Fewer units on the head end of most mainline trains is a clear indicator of the builders ability to deliver productivity to the railroad industry.

Railroads continue to look to the builders to supply locomotives with:

1) Increased performance (productivity)

2) Improved reliability (greater single unit operation)

3) Lower life cycle costs

4) Reduced emissions

5) Better working environment for the operating crew

6) Improved crashworthiness

7) Spill resistant fuel tanks

A number of these initiatives are the focus of existing and/or future government regulations. It behooves the locomotive manufacturers to stay ahead of the power curve.

Recent mergers continue to challenge North American locomotive manufacturers to adapt to a climate of fewer but larger and more demanding customers. Competition among the suppliers continues as fierce as ever combined with ups and downs on the order books. Nineteen ninety six was a banner year for domestic locomotive builders, 1997 and 1998 promises to be very good as well. Mergers have resulted in fewer but much larger orders, a positive development for builders. The challenge is to continue to manufacture at a much higher rate, introduce new technology while at the same time holding costs in line and not sacrificing quality. A tremendous challenge, but it sure beats the alternative.

Highlights of new locomotives and features is by country rather than by manufacturer.

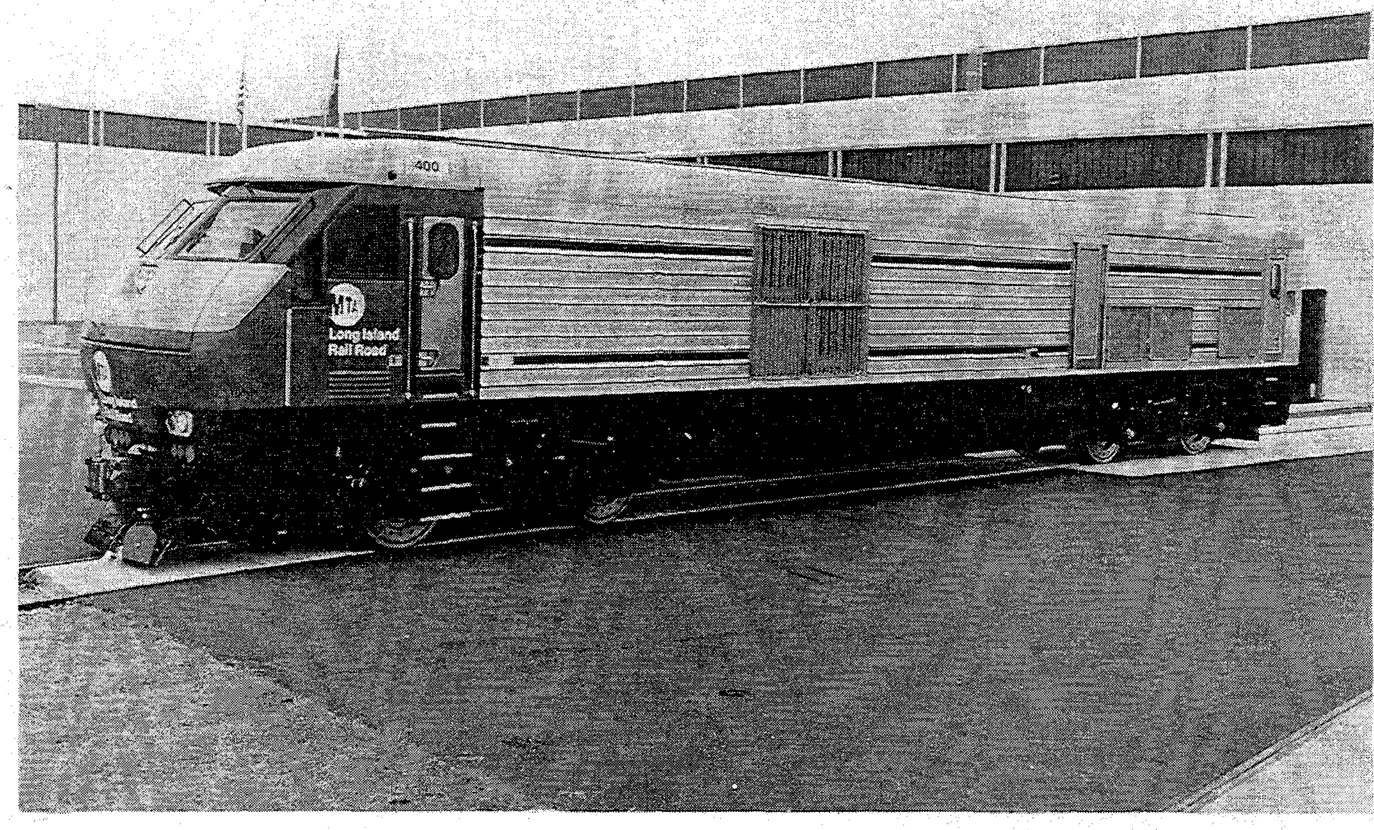


Figure 1 - DE30AC, Diesel electric passenger locomotive

LOCOMOTIVES

United States

EMD - DE30AC Passenger Locomotive

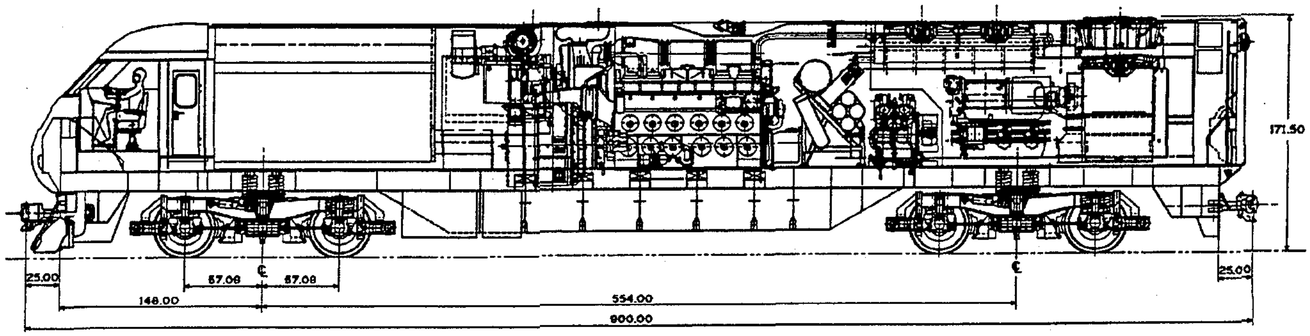
During 1997, EMD introduced the DE30AC passenger locomotive, the first of an order for 23 locomotives for the Long Island Rail Road. See Figure 1. This four axle, monocoque locomotive is rated at 3000 hp is geared for 100 mph. It is 75 ft long between coupler pulling faces and is 14 ft 3.50 in high. Propulsion equipment is supplied by Siemens using the inverter per truck concept with an additional inverter is supplied for 600 kW, 480 VAC, 3 phase, 60 Hz head end power (HEP). The HEP inverter is capable of utilizing dynamic braking energy to provide power for auxiliary and HEP loads. One of the traction inverters can be used for HEP should it be needed.

The carbody is a monocoque design with an integral 3000 gallon fuel tank. The structure exceeds the AAR S580 crashworthiness requirements. Nose pieces are made of high strength vinyl ester glass fiber composite material. The upper part of the carbody is stainless steel.

The trucks are a bolsterless 2 axle design incorporating 44 in. wheels. Braking is accomplished with a combination cheek and tread brakes, with the majority of braking effort provided by the cheek brakes. The braking system is designed to provide a brake rate of 2.3 mph/sec from 80 mph without dynamic assist. The trucks designed by Siemens at their facility in Kiel, Germany are very similar to those used on Amtrak's P40 and P42 locomotives.

To improve crew comfort, the DE30AC incorporates an isolated engine/generator package to reduce noise and vibration. In addition a central HVAC is provided. Integrated Cab Electronics combines gauge functions, event recorder and train control features. There are additional abatement measures to reduce noise exposure on passenger platforms.

The general outline is shown in Figure 2.



The "DE30AC" general outline: Basic Locomotive Features

Figure 2

Additional features include:

Advanced EM2000 computer

- Utilizes 32-bit microprocessor
- Reduction in number of modules and components
- Download capability to a laptop computer

Air System

- Electronic air brake
- Motor driven air compressor
- Air dryer package

EMD - SD90MAC

EMD in cooperation with Siemens is continuing the development of the SD90MAC. Figure 3. This 6000 hp locomotive incorporates EMD's new model GM16V265H model engine (described later in this paper). It is 80' 2" long with a 5,800 gallon fuel tank and weighs 425,000 lbs. Maximum speed at full horsepower is 75 mph. It incorporates the following additional features

- Higher tractive effort and braking effort capability
  170,000 lbs continuous TE
  200,000 lbs starting TE
  115,000 lbs braking effort
- 16% improvement in fuel economy over SD40-2
- AC traction technology
  New ITB2830 AC traction motors
  Heavy duty inverter per truck
  Single inverter cabinet
  New TA20 traction alternator
- Integrated Cab Electronics
- EM2000 advance computer
- Isolated operators cab
- Radial truck

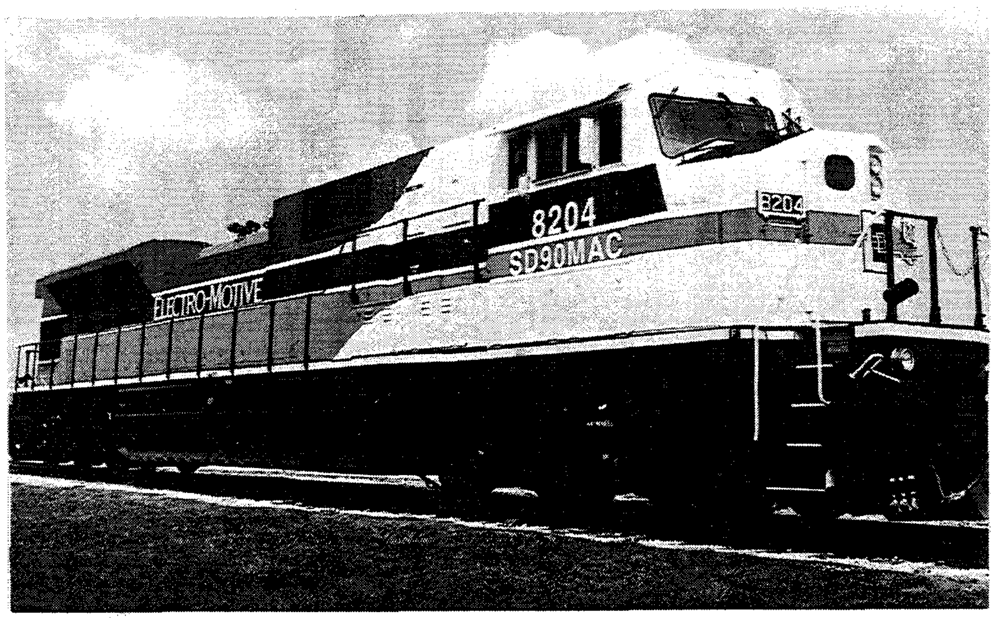


Figure 3 - SD90MAC, Diesel electric freight locomotive

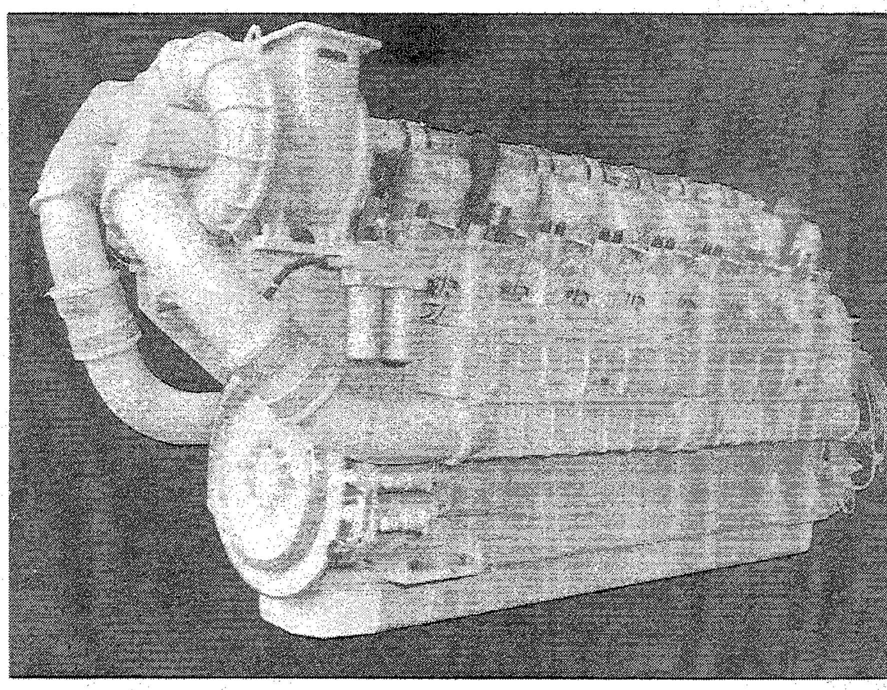


Figure 4 - EMD-GM16V265H, Engine

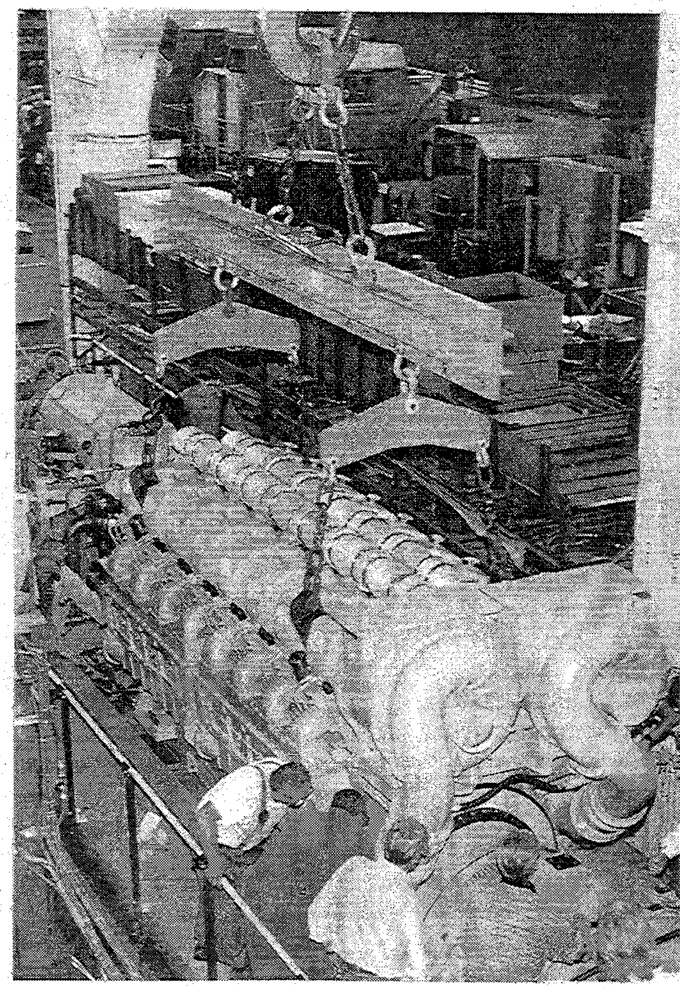


Figure 4 - EMD-GM16V265H, Engine installation

EMD - GM16V265H Engine

EMD has designed and is now producing a new 4-cycle, 6300 bhp diesel engine for use in their SD90MAC locomotives. Figure 4. The Union Pacific Railroad will be the first to add locomotives with this engine to its high horsepower fleet. The engine features:

- 6300 bhp at 1000 rpm
- 265 mm bore x 300 mm stroke
- Single inboard sectioned camshaft
- Ductile iron cross flow cylinder head
- Cast ductile iron crankcase
- Twin turbochargers
- Hydraulic tensioning of fasteners
- Antifreeze cooling system

Figure 5 shows the engine being installed in one of the first locomotives.

Germany

Siemens - ICE2

The ICE (InterCity Express) trains in Germany have been very successful in attracting additional riders to the Deutsche Bahn's extensive railway network. A total of over 100 runs are made daily. Each train of the original fleet, now known as ICE1s, consists of two locomotives and 14 cars which stay together as one consist and are serviced between runs without any rearrangement. The maintenance facility at Eidelstadt (near Hamburg) can service several complete trains on parallel tracks within the same building.

The success of the original concept led the German government to look at ways in which the ICE concept could be expanded to routes that are less heavily traveled but never the less worthy of inclusion in the ICE system. In addition they were interested in developing trains that would allow flexibility in their operation and thus was born the ICE2 concept. The ICE2 train consists of one locomotive, six cars and a cab car which can operate in a push-pull mode as well as in trainset pairs. The ICE2 locomotive is identical to an ICE1 with one major exception. The front of the locomotive has been modified to include swing away nose panels and the addition of an automatic coupler (ICE1s have an emergency coupler used only for rescue), see Figure 6.

Operational flexibility is achieved by using a single ICE2 trainset on lower density runs or on runs where two coupled trainsets are used initially and subsequently separated at a major division point. Each single ICE2 trainset then continues on to a separate destination. This operation is repeated in reverse order for the return trip. Coupled trainsets will typically operate with cab car coupled to cab car and the locomotives at each end of the train. In addition, flexibility is further enhanced by removing the cab car from each train and coupling coaches together to from one longer trainset. As trainsets are separated or combined, trainline functions are handled automatically within the couplers regardless of the train configuration.

The location of apparatus as well as the locomotive outline is shown in Figure 7. The only significant difference to be seen in an ICE2 location of apparatus compared to the ICE1 is the addition of a pneumatic section to operate the swing away nose doors. The cab end of the cab car is configured identically to that of the locomotive cab and it too has swing away nose panels and an automatic coupler.

ICE1 development included extensive aerodynamic studies to minimize drag, evaluate aerodynamic performance of two passing trains as well as that of entering, passing thru and exiting from tunnels. The ICE2 presented the additional challenge of evaluating these same performance criteria while running in the coupled trainset mode.

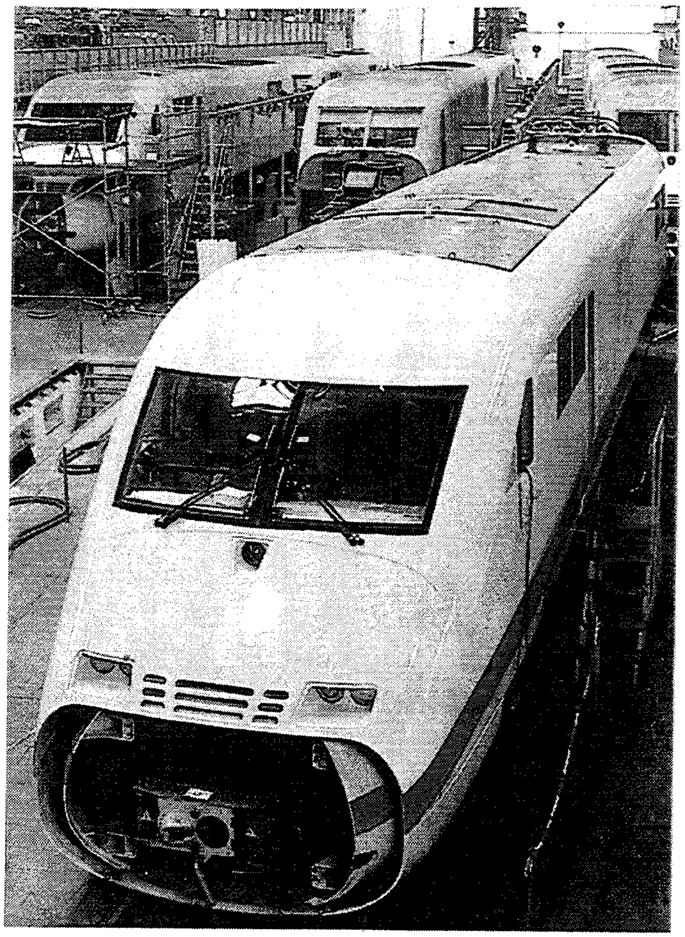


Figure 6 - ICE2, Coupling arrangement

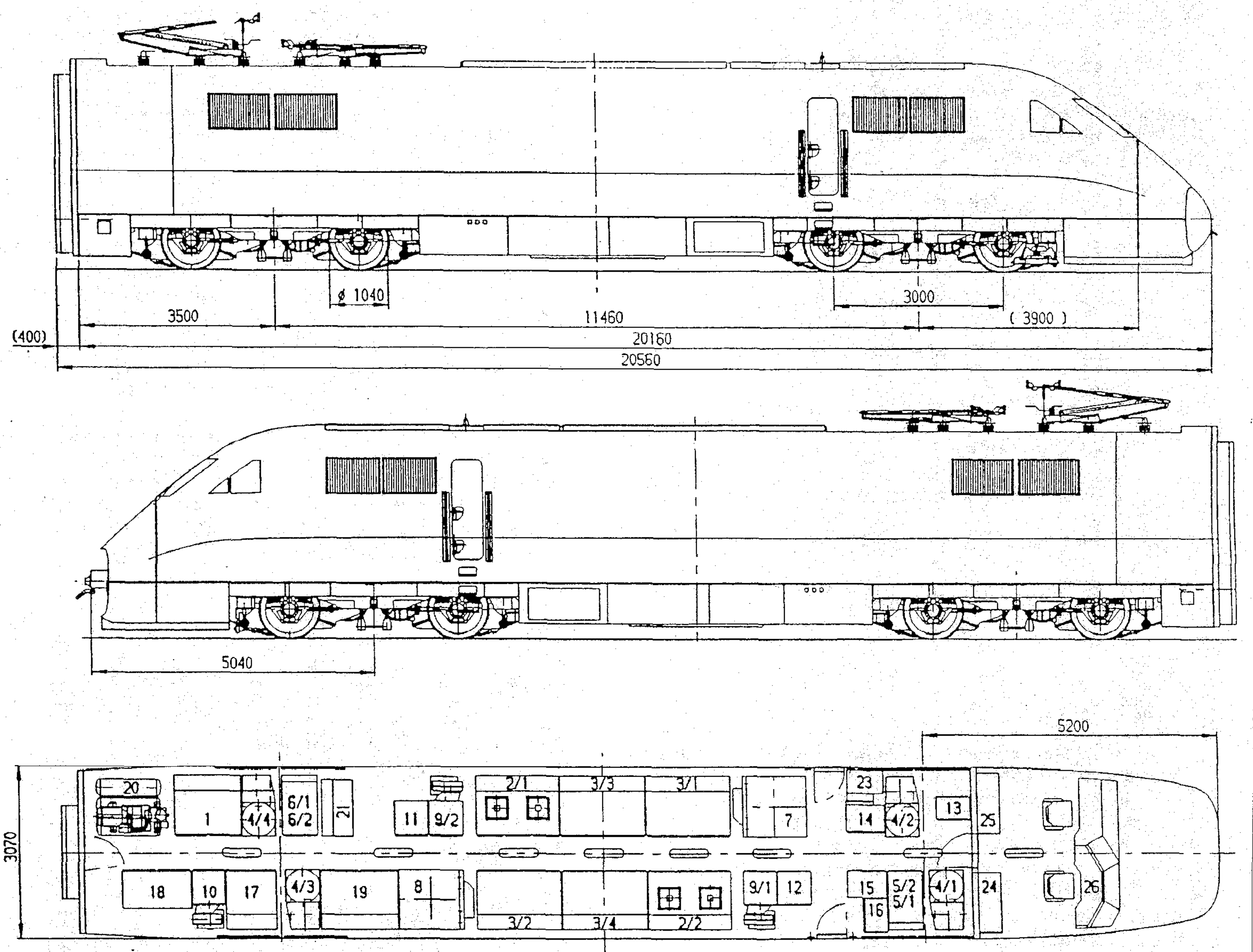


Figure 7 - ICE2, Outline and location of apparatus

ADtranz/GE - DE-AC33C

In November 1996, ADtranz/GE unveiled the prototype DE-AC33C locomotive, also called the Blue Tiger. This is the first of a family of lightweight, high horsepower, AC diesel electric locomotives designed for countries outside of the North American continent. It was jointly developed by ADtranz of Germany and General Electric's Transportation Systems division in the United States. The prototype has been extensively tested at the ADtranz facility in Kassel, Germany and is now in service on the Deutsche Bahn gaining field experience. This locomotive series is designed for main line freight and passenger service with speeds up to 100 mph (160 kph). Figure 8 shows a completed locomotive outside the manufacturers workshop.

The basic locomotive series uses standardized modular components permitting adaptation to special customer requirements. In addition to the standard full width operator's cab, double cabs are an option. Full width equipment hoods and various loading and track gauges are available as well. The family has been designed for meter gauge (39 3/8") up to 1.676 meters (66") and axle loads ranging from 28,000 lbs to 50,000 lbs with engine power ratings form 1640 kW (2200 hp) to 3280 kW (4396 hp). The standard gauge (56 1/2") prototype weighs 238,000 lbs with an axle load of 39,667 lbs

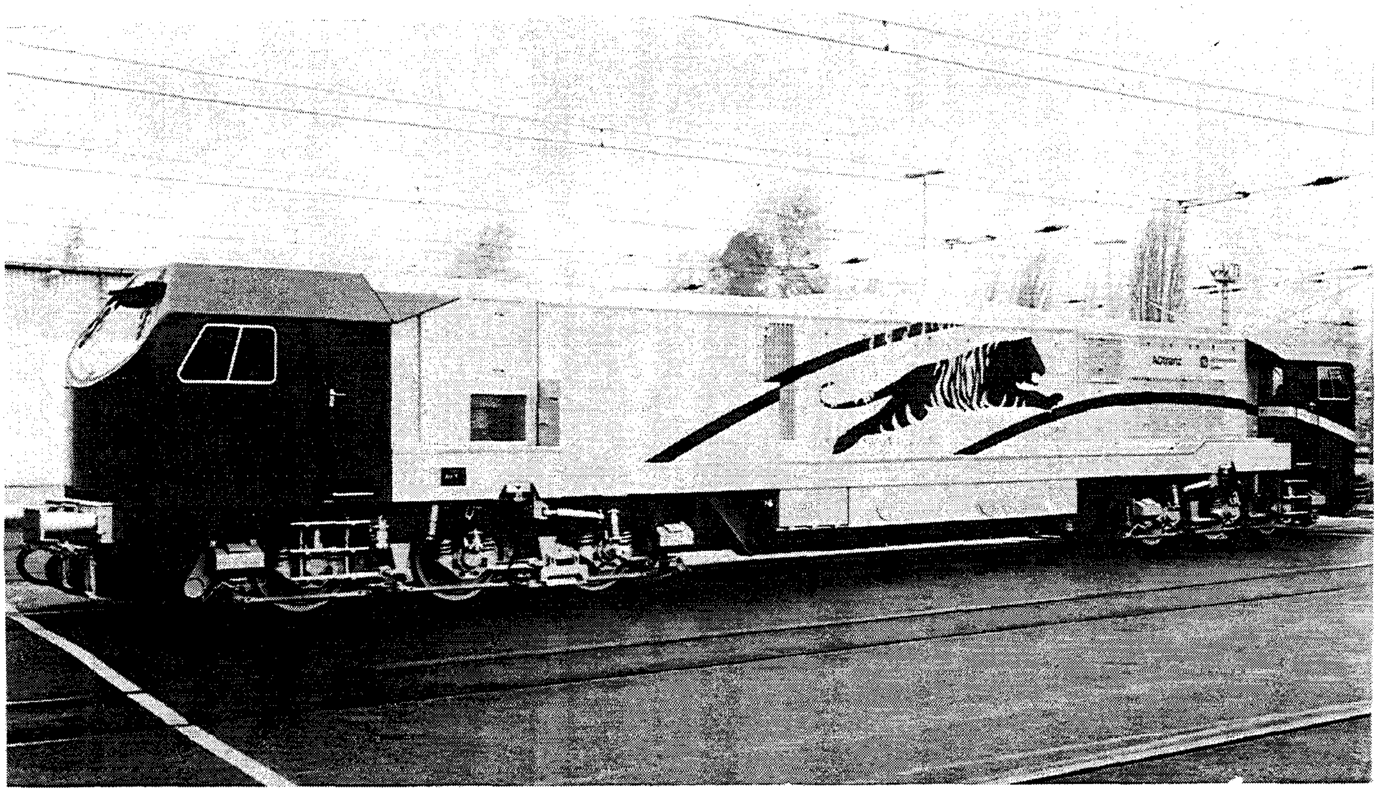


Figure 8 - DE-AC33C, "Blue Tiger" Diesel electric locomotive

and has an engine rating of 3200 hp. A location of apparatus is given in Figure 9.

GE Transportation Systems provides the complete three-phase propulsion system with diesel engine, generator, traction motors including controls, the cooling systems and the electronic components for diagnostic and display systems. The propulsion equipment has one air cooled traction inverter

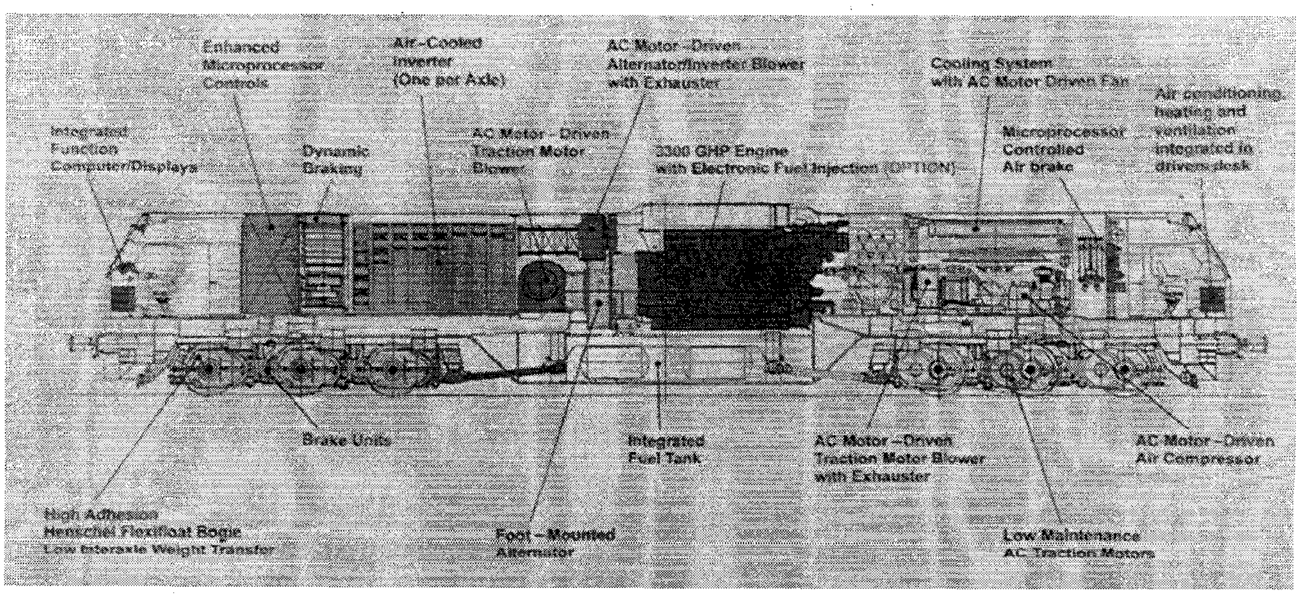


Figure 9 - DE-AC33C, Location of apparatus

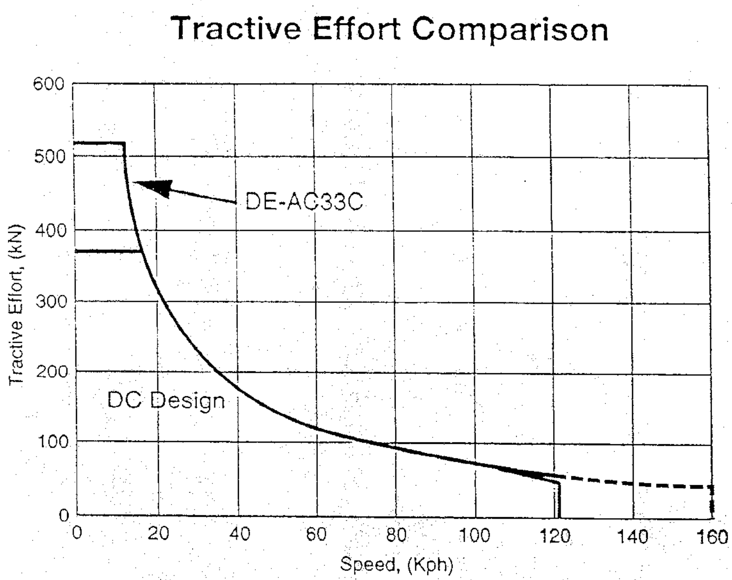


Figure 10

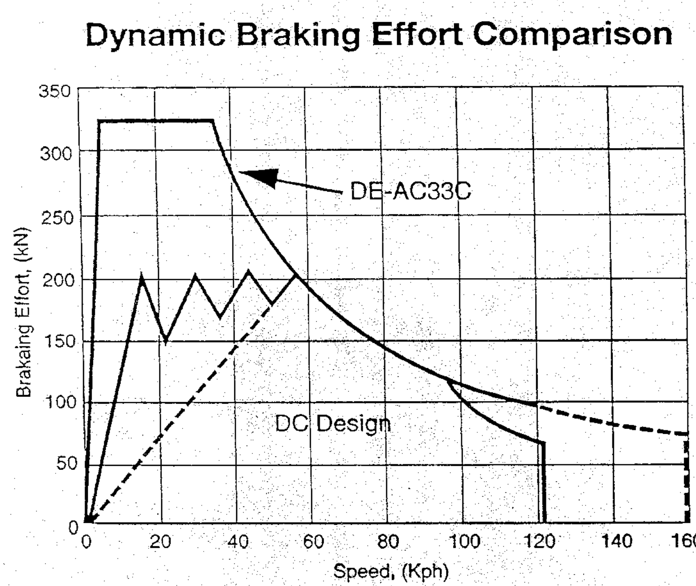


Figure 11

per axle, integrated function computer and displays, dynamic braking, computer controlled air brake system, microprocessor controls and AC motor driven auxiliary equipment.

ADtranz developed and manufactured all of the mechanical components. The locomotive features a separate platform structure supporting all major components with a full width operators cab at one end. The machinery is housed in a narrow hood superstructure with walkways along side, permitting ready access to equipment for maintenance. Henschel Flexifloat trucks provide excellent ride quality with minimum wheel wear and reduced weight transfer.

Figures 10 and 11 provide tractive effort and dynamic braking effort curves respectively.

ADtranz - LOCO 2000

The modularized family of locomotives developed by ADtranz continues to gain additional acceptance within many countries. Locomotives of this family include SBB class 460 and BLS class 465 in Switzerland, VR class Sr 2 in Finland and derivatives powering the Euroshuttle trains described in previous survey papers. Figure 12 shows the basic modular concept.

ADtranz - Prototype 12X

The 12X prototype locomotive, shown in Figure 13 continues ADtranz's development efforts. It recently completed over 100,000 km of revenue service on the Deutsche Bahn (as Class 128 001) and is now equipped with a high speed pantograph and associated measuring equipment for operation up to 280 km/h. New technologies in

the area of transformers, traction power converters and controls are also being evaluated. It is now a multi-system locomotive demonstrating its capabilities to various customers.

ADtranz - Class 101

The Deutsche Bahn (DB) is starting to receive class 101 high speed electric locomotives from ADtranz Germany for use on their InterCity (IC) network trains. See Figure 14. These locomotives, based on the ECO 2000 family have single axle control, pressure proof, air conditioned operators cab and a machine room with a center aisle.

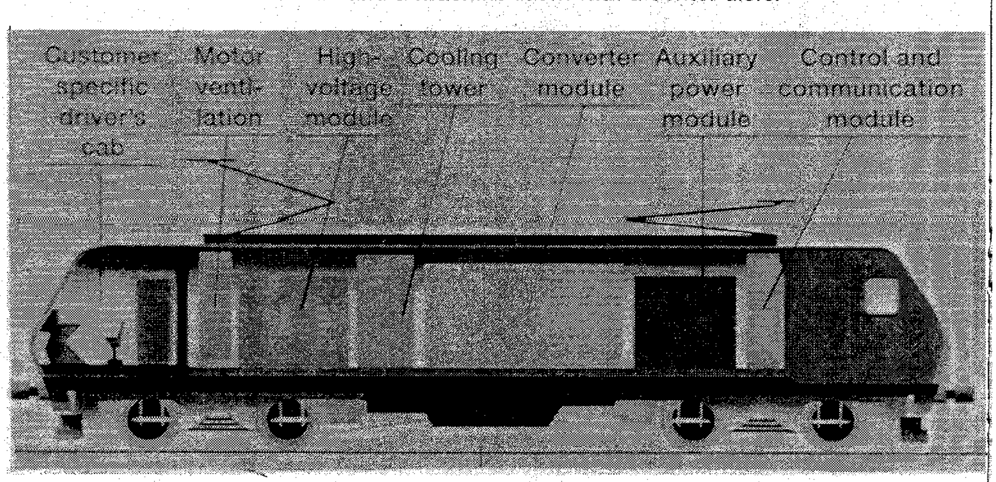


Figure 12 - LOCO 2000, Modular concept

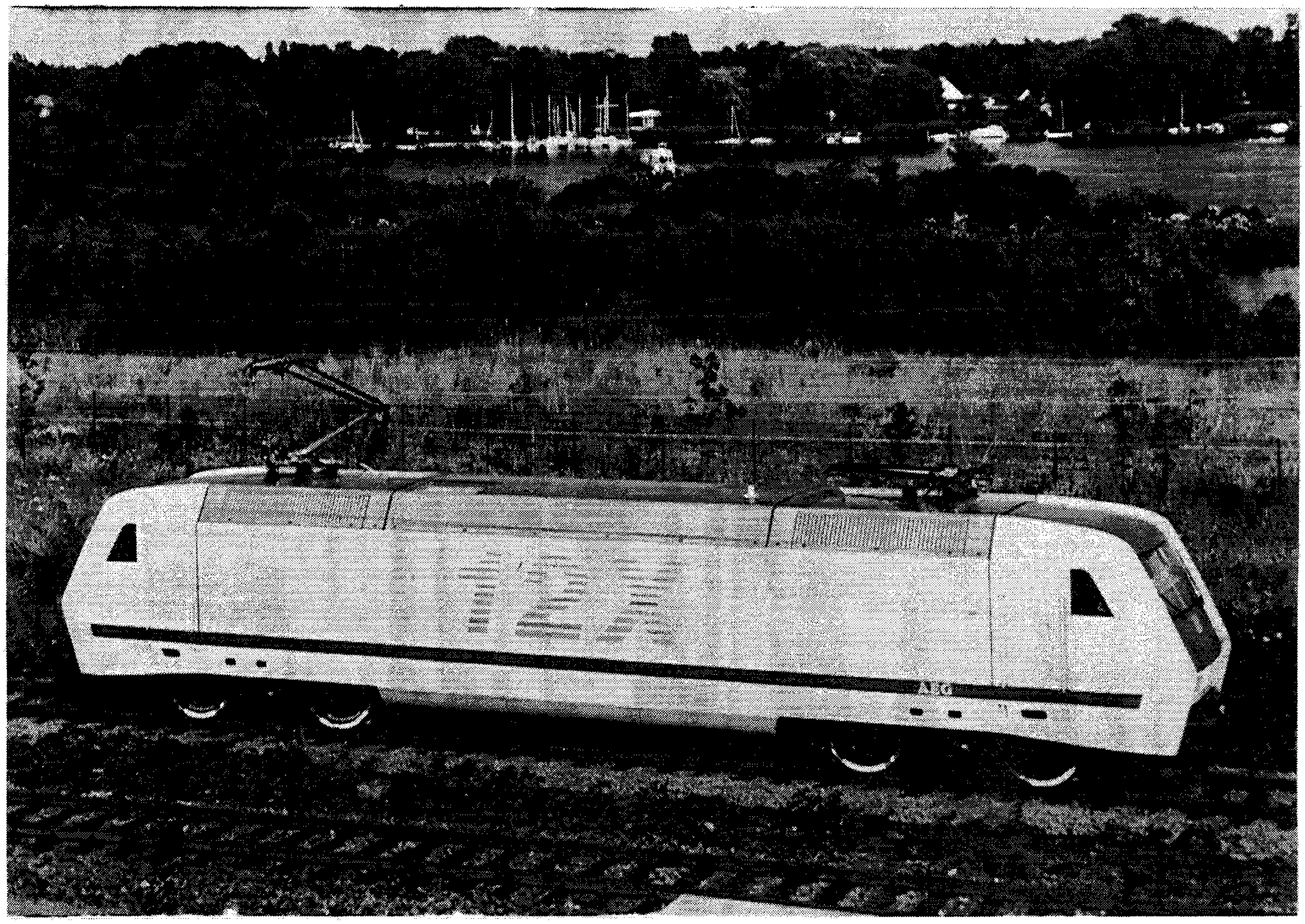


Figure 13 - 12X, Electric locomotive

Figure 14 - Class 101, Electric locomotive

This four axle Class 101 locomotive has a maximum power rating of 8847 hp (6600 kW) with a maximum starting tractive effort of 67,500 lbs (300 kN). It is designed for a maximum speed of 137.5 mph (220 kph) and draws its power from a 15 kV, 16 2/3 Hz catenary supply. It is 62 ft 2 in long and weighs 190,953 lbs (86.6 tonnes)

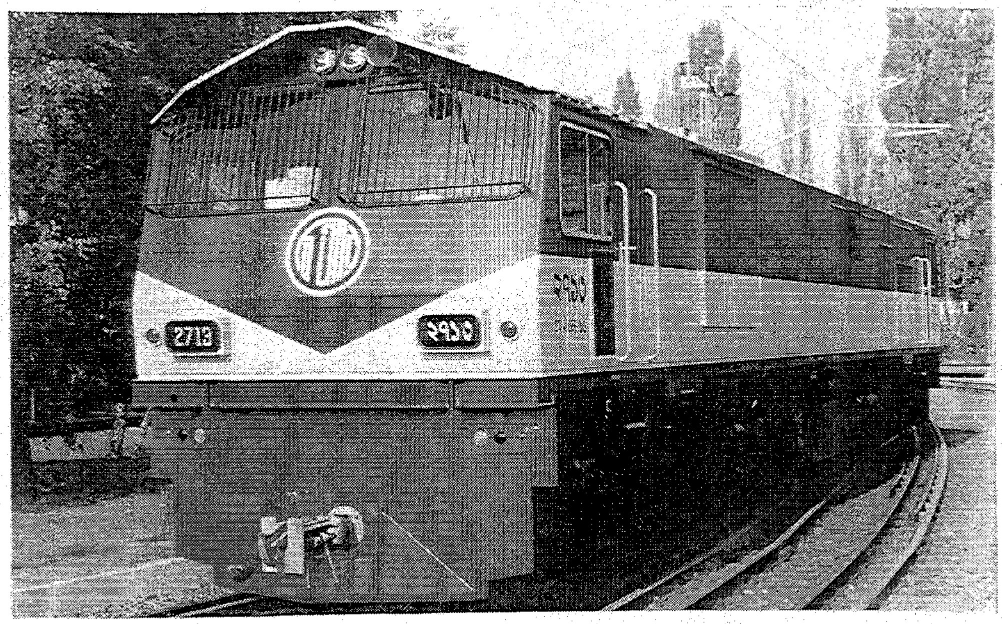


Figure 15 - DE 1650 Diesel electric locomotive

Bangladesh

ADtranz - DE 1650

Bangladesh Railway (BR) contracted with ADtranz Germany for 12 diesel electric, meter gauge six axle locomotives, class DE 1650. Figure 15. These locomotives designed for operation up to 62.5 mph (100 kph) will be used to power passenger and freight trains between the cities of Dhaka, the capital, and Chittagong. The locomotives have full width hoods to prevent stowaways from riding on exposed walkways.

Egypt

ADtranz - DE 2550

ADtranz is supplying a total of 68 class DE 2550 locomotives to Egypt Figure 16. These locomotives, manufactured at Kassel, Germany feature a modular design suitable for various customer needs. These locomotives with an EMD 12-645 E3 engine are rated at 2473 hp (1845 kW) and have a single operator's cab with windshield protection. They weigh 291,060 lb (132 tonnes) and have a maximum speed of 50 mph (80 kph).

Hong Kong

SLM/ADtranz - KCRC

The Kowloon-Canton Railway Corporation (KCRC) is receiving two electric locomotives and 12 bi-level passenger cars from the consortium ADtranz/ITOCHU. These locomotives, Figure 17, except for the track gauge, communications and safety equipment, are very similar to the Finnish Railways class Sr2 described in the 1995-1996 survey paper.

The locomotives will receive power from a 25 kV / 50 Hz catenary and have a maximum power rating of 8043 hp (6000 kW). Maximum speed is 100 mph (160 kph) with possibility to increase to 125 mph (200 kph). They feature MICAS microprocessor control electronics using fibre optic links as the communications medium. Regenerative braking is provided along with optimal power factor.

SLM is providing self steering radial wheelset trucks with a computer designed lightweight carbody. The overall

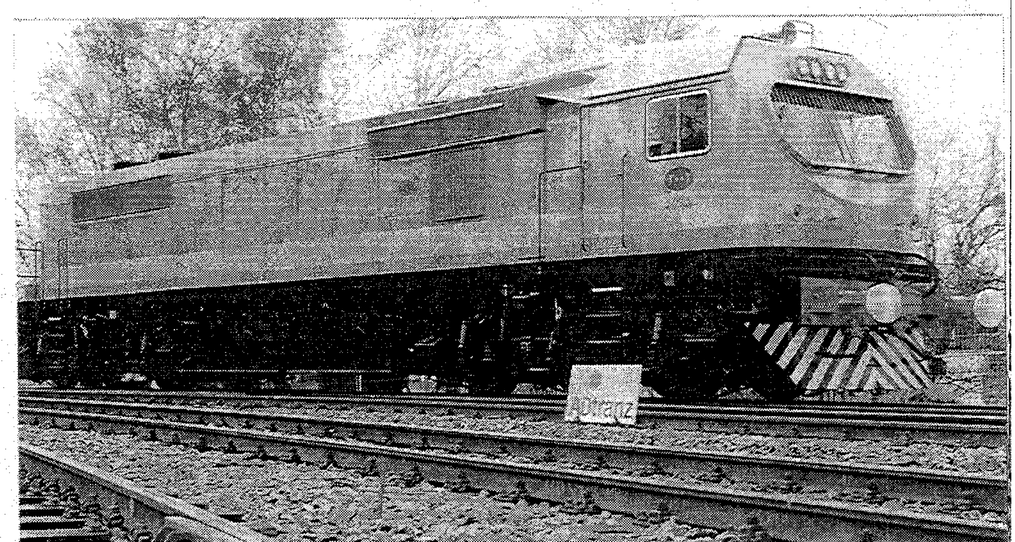


Figure 16 - DE 2550 Diesel electric locomotive

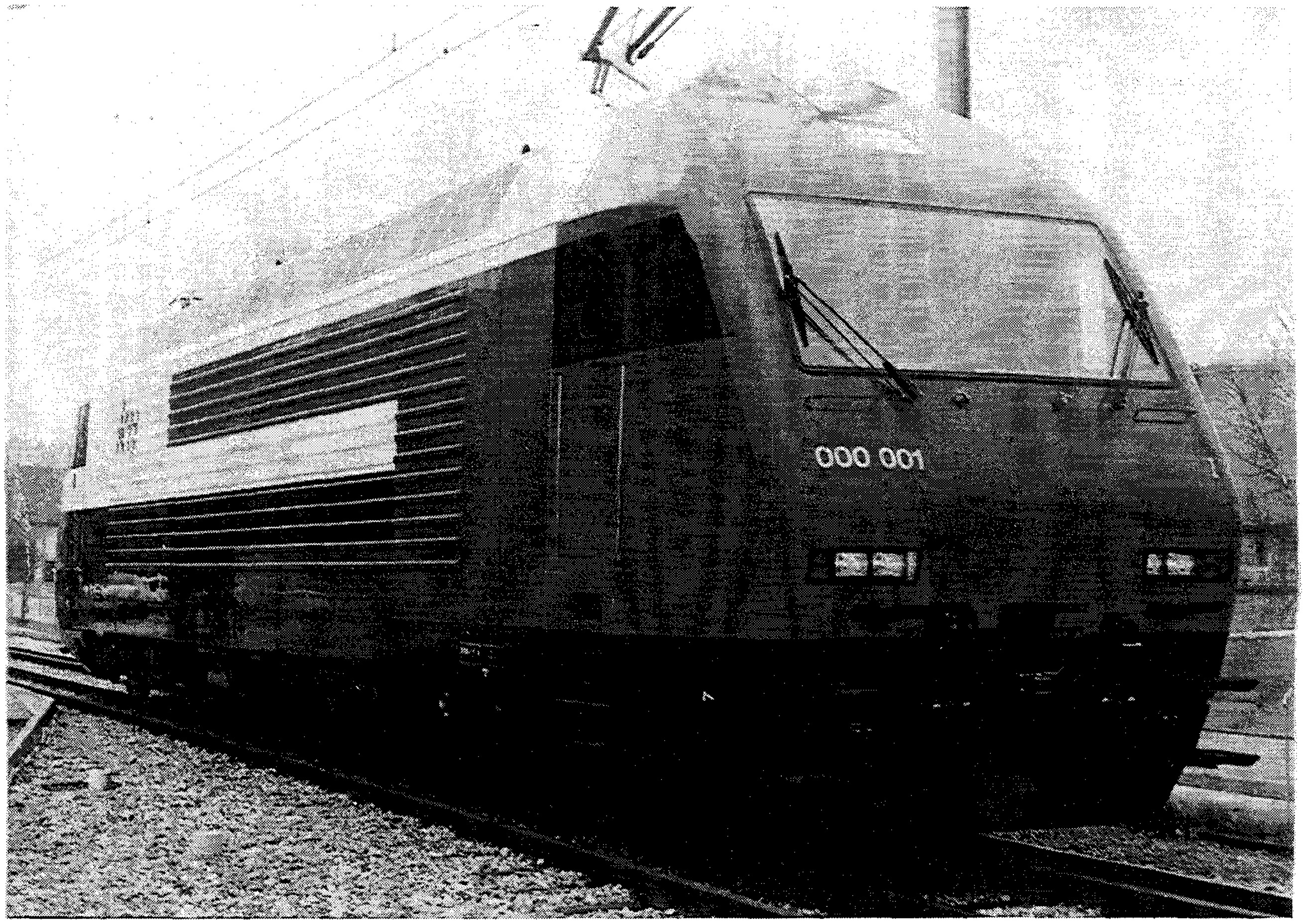


Figure 17 - KCRC, Electric locomotive

configuration was tested in a wind tunnel. The air conditioned and pressure sealed operator cabs are made of a fibre reinforced plastic sandwich construction.

They were manufactured and assembled by SLM/ADtranz in Switzerland.

<u>Norway</u>

<u>SLM/ADtranz - EL 18</u>

SLM/ADtranz is supplying 22, class EL 18 electric locomotives to the Norwegian State railways (NSB), Figure 18. These locomotives, based on the Swiss Loc 2000 concept are being manufactured by a consortium consisting of ADtranz Switzerland, SLM Swiss Locomotive and Machine Works Ltd and ADtranz Norway.

These locomotives with a maximum speed of 125 mph (200 kph) are rated at 7239 hp (5400 kW) and weigh 185,220 lbs (84 tonnes). Weight of the electrical equipment is 85,995 lbs (39 Tonnes) whereas the mechanical equipment weighs 99,225 lbs (45 tonnes). Power is from a 15 kV, 16 2/3 Hz catenary. Each traction motor is powered by a separate inverter to maximize tractive effort. The locomotive is designed to minimize pressure waves, particularly when passing other trains in tunnels.

ACKNOWLEDGMENT

The Survey Committee expresses its appreciation to the builders and other rail organizations who supplied information for this report. More material and details were received and so only new locomotives and/or significant additional information was highlighted.

Special thanks goes to the rail oriented trade journals and other rail magazines as sources of general information on locomotive developments.

Figure 18 - EL 18, Electric locomotive