Progress in Railway Mechanical Engineering, 1967–1968

Introduction

Developments in the carbuilding field continued at a brisk pace even though there was a sharp decline in the purchasing of new equipment by the railroad industry. The trend to produce specialized equipment designed to help the consignor and consignee in the loading and unloading of a specific commodity continues to dominate the development of new equipment. As the users of the railroad's service continue to approach their physical distribution problems on a total cost basis, this trend toward specialized equipment can be expected to continue, and perhaps accelerate, in the near future.

New Freight Cars

Several new freight cars designed to facilitate the handling of a specific commodity were introduced. Pullman-Standard, the Canadian National Railways, and the Chicago, Burlington, and Quincy Railroad have all introduced foam insulated freight cars designed to facilitate the handling of commodities requiring a specific temperature while in transit. The Pullman-Standard built, 60-ft, insulated boxcar (Fig. 1) uses foamed-in-place polyurethane insulation. The polyurethane insulation is essentially a 5-in. blanket capable of holding a specific temperature within specified limits for seven days [1].

The Canadian National's version of a foam-insulated refrigerated car (Fig. 2) also uses foamed-in-place polyurethane insulation to envelop the car. Because the floor is predominantly supported by the polyurethane insulation, the foam becomes part of the car's structural support system allowing the use of wood and other heat loss material to be held to a minimum. The temperature control system can maintain temperatures ranging from −10 deg F to 70 deg F, no matter what the outside temperature. The heat saving feature of the car will enable the car to operate long distances without servicing even if a mechanical failure should occur en route. The car is so well insulated it may eliminate the need for refrigeration or heating units for many types of traffic [2].

The foam-insulated car developed by the Burlington Railroad (Figs. 3 and 4) is a refrigerator car using liquid nitrogen as a coolant. The Polarstream process uses liquid nitrogen in carefully regulated amounts to both cool the car and induce a low oxygen atmosphere designed to impede product deterioration. Equipment installed in the car's engine compartment includes a 1200-gallon 8100-lb capacity liquid nitrogen storage tank, a flow regulator, and temperature control devices. Nitrogen is released into the car through small perforated pipes attached to the center beam rail running the full length of the car. The nitrogen supply will last from origin to destination mainly because the car has a low heat loss. The low heat loss is possible because 5 in. of polyurethane insulation enclose the car. Also there are 48 percent fewer conductive parts in the walls, roof and floors because


2 Numbers in brackets designate References at end of paper.

second deck hinged so that it may be raised to produce clearances for automobiles being loaded or unloaded from the first level [7].

During the year, several new railcars were introduced for the efficient handling of bulk commodities. The Hawker Siddeley Limited of Canada has designed a 100-ton open hopper car specifically conceived to haul coal (Fig. 11). The “bathtub” design is of stressed skin construction. The sides of the car contain the load and function as an underframe and reduce overall tare weight of the car. Additional features include a new bi-directional automatic dump gate [8].

The Seaboard Coast Line has received a prototype covered hopper car from Bethlehem, equipped with Staury’s hinged roof. The car, designed to go through a rotary dump, features a hinged roof which can be entirely removed when unloading phosphate rock or sugar.

ACF Industries has developed a new type of pressure differential car (Fig. 12) designed especially for combination rail-highway method of physical distribution. Although this car is similar in basic design to ACF’s center flow dry bulk commodities car, this new car uses low-pressure air (5 psi versus 15 psi of previous models) to discharge its cargo into local delivery trucks or into a plant storage system. This low pressure differential car is lighter in weight and can better accommodate a greater variety of bulk commodities such as flour and dry chemicals. Materials can be discharged by vacuum and gravity as well as by pressure [9].

A new composite steel and aluminum triple-hopper covered hopper car has been designed by Major Railcar Division of Fruehauf Corporation (Fig. 13). The principle used in developing this design has been to have an aluminum container mechanically fastened to a steel underframe. Additionally, the interior of the car has been improved by curving intersecting surfaces to prevent lading retention in corners and valleys.

National Steel Car has built 120 covered ore cars to transport iron ore for the Canadian National and Ontario Northland railways (Fig. 14). These 100-ton ore cars have no center sills, transmitting draft and buffing forces through the tubular steel bodies. At the mine the cars are fed by gravity under loading silos where “trip” levers operate the roof hatches, opening and closing them automatically. At destination the lading is dumped through drop doors—six cars being unloaded in 60 sec [10].

Several new concepts of tank car equipment were introduced last year. Union Tank Car has developed and plans to produce 40 basic designs of a “Changeable” tank car which will have flexibility and versatility to meet specific lessee requirements (Figs. 15, 16, 17, and 18). These Changeable tank cars are designed so that ring sections can be added to, or removed as needed, to change its size and capacity with relatively few mechanical steps. Rings are inserted at predetermined points on the car’s length in sizes to match new capacity objectives. The “Funnel-Flow” design has a built-in slope or pitch to the center, at a rate of one-quarter in. per ft, to facilitate the unloading of the car. The car’s ability to accept larger trucks without structural change permits conversion to heavier product densities with less downtime for modification. Loading and unloading fittings
may be switched at any time to give the lessees maximum operating latitude.

Union Tank Car has also designed and built for the Dundee Cement Company 50 pressure differential tank cars (Fig. 19). Each 3000-cu ft car is capable of carrying 530 barrels of cement in five conical hoppers. Unloading is accomplished by the pressure differential process which fluidizes the cement, causing it to move as if it were a liquid [11].

Procor Ltd. of Canada has developed a highly specialized version of a pressure flow car for handling asbestos fiber. In the past, asbestos fiber has been shipped in bags because vibration of the railcar during transit so compacted the fiber that it was difficult to handle pneumatically. With the development of this pressure flow car, asbestos fiber may now be handled in bulk [12].

Twenty-eight tank cars with 150-ton (six wheel) trucks have been built for Mobil Oil by ACF Industries (Fig. 20). These tank cars, the largest ever built to transport lube oil, are 70 ft long and have a capacity of 38,000 gallons. The increase in payload is obtained by reducing the deadweight of the car by using a stub-sill (no underframe) design [13].

The continued growth in the movement of containers and trailers on flatcars has resulted in the development of a new all-purpose flat car for carrying trailers or containers with equal facility (Fig. 21). These latest TTX all-purpose cars were developed from prototypes built by Pullman-Standard, ACF, Bethlehem, and General American and feature uncushioned tractor-operated hitches and adjustable pedestals which fold into the floor when not used. The all-purpose cars are well suited to handle trailers and/or containers interchangeably. Typically, the TTX car will accommodate a highway trailer and a container, each 40 ft long. They are designed to carry a 45-ft and a 40-ft trailer, or containers in combination ranging from 20 to 40 ft in length. The inside rub rails allow for growth in trailers without restriction [14].

For trailer on flatcar service Pullman-Standard has adapted an automatic trailer hitch to a car with an end-of-car cushioning (Fig. 22). The wider hitch and top plate give the trailer a better roll stability while the trailer is in transit. A tractor or a crane can be used to raise and lower the hitch.

ACF Industries has developed an 89-ft 4-in. multipurpose flatcar designed to carry highway trailers and containers separately or interchangeably as well as bulk materials, such as pipes,
poles, lumber, and steel extrusions or beams (Fig. 23). The car is designed so that each of the twin inside guide rails is composed of separate units that can be pivoted either longitudinally to accommodate highway trailers and containers, or laterally to support bulk materials. Reportedly, one person can convert the car from piggyback to bulk service in 15 min. The car is equipped with heavy duty side sills incorporating stake pockets and a low silhouette hand brake. Accessories include retractable trailer hitches, a container trackway system with adjustable and retractable pedestals, and lading strip anchors [15].

Magor has also developed a multipurpose flatcar for handling of trailers and containers (Fig. 24). Pop-up container adapters accept the vast majority of domestic and foreign built containers, and they fold flush with the floor when not in use. Pull-up, knockdown stanchions provide trailer stability and adapt to lift-on, lift-off loading. Optional Flexi-Van equipment permits the car to handle containers, trailers, and Flexi-Van containers interchangeably.

Pullman-Standard has developed a new standard boxcar equipped with built-in dollies, or platforms, which can be moved from the ends of the car to the doorway area for loading or unloading and then rolled back to the end and automatically backed in place (Fig. 25). With the use of the dollies, this HELLO DOLLY® car, in effect, is completely loaded and unloaded in the extra wide doorway area permitting the lading to be loaded and unloaded more quickly, more economically, and more safely.

The all-door boxcar (Fig. 26), designed by Thrall Car, is operating on the McCloud River Railroad. The patented truss roof and bulkhead end are designed to insure that all doors open and close easily to protect a watertight interior. A 25-ft wide door opening on both sides of this 50-ft boxcar makes it easy for fork trucks to load or unload bulky commodities. Since
1. Add Trucks

2. Add rings with pre-determined splice lines (a), tubes with interchangeable center plate, and bolster

3. Later add more rings (or remove them) as needs dictate

**Fig. 16**

UNIFORM PRODUCT LOAD

Larger diameters result in shorter tanks that are stronger for supporting product loads. Stresses at top and bottom of tank due to product loading are low.

Straight bottom "HO" cars have tendency to deflect upward under compressive end-load.

"Funnels-Flow" cars, under compressive end-load, resist upward deflection because of hinged cylinder design.

**Fig. 17**

**Fig. 18**
all doors, four on each side, are "plug" doors, they move out and away from the car as they open preventing cargo from shifting and jamming. The 70-ton car also features end-of-car cushioning, and there are no interior posts or pillars to interfere with fork trucks during loading. Although the car was designed to handle lumber, there is a variety of merchandise it can haul [16].

Miscellaneous Freight Car Parts

A new trouble-free outlet valve designed to unload all forms of plastic has been developed by Pullman-Standard (Figs. 27, 28, and 29). The outlet valve has large clearances between operating parts eliminating chances of jamming or binding because of product or by deflection. The straight pneumatic outlet can unload with both high and low vacuum systems with or without probes, and the unloading rate can easily be adjusted to accommodate both large and small unloading systems. The valve can easily be disassembled and assembled by one man in minutes, making the outlet valves easy to clean.

A new freight car truck, named the "Super C-1 with Wedge lock," has been developed by the National Castings Division of the Midland Ross Corporation, for high capacity roller bearing cars in high mileage service (Fig. 30). Major modifications of the "Super C-1 Wedge lock truck" are in the vertical columns for friction wedge applications. The Bolster is conventional except where the wear plates are applied. Bolster antirotation protection is provided by eight bearing areas instead of four, resulting in less surface wear and decrease in side-frame stress during end impact and braking. These changes give the car an improved ride through better car control [17].

A tapered roller bearing (Fig. 31) having a rated B-10 life of 500,000 miles under an 80 percent load has been introduced by the American Kayo Corporation. A patented upset forging and rolling process alters metal grain density and alignment to insure the life and reliability of the races. Vital bearing components are produced from vacuum-degassed, case-hardened steel. Special synthetic rubber oil seals are encased in a steel cover to prevent damage and reduce maintenance [18].

Akers Manufacturing Company has a torsion bar lifting arrangement which employs a cylinder containing a strong spring mounted on the end of the car directly under the bridge plate. The torsion bar extends from the cylinder to bear against the underside of the plate to achieve an equivalent weight of 24 lb on the plate end. The device, which is said to ease raising and lowering of the plate, will hold the plate in an upright position without looking at impact speeds approaching 10 mph and may eliminate vibration and retard wear in hinges and locks [19].

Railroad Dynamics has designed a double-acting, hydraulic damping device to control the roll stability of high center-of-gravity cars (Fig. 32). Four units are applied to each car with clevis and side-frame brackets designed for 8.3 deg rotation of the truck, permitting traversing of 125-ft radius curves. The clamping device clamps both relative motion between truck and body and the motion of the truck bolster on its supporting springs [20].

An end-of-car cushioning device (Fig. 33) has been developed by the Cushion Coupler Corporation which uses elastomer pads for cushioning and clamping. The pad arrangement inside the coupler is such that shock forces are expanded as various elastomer pads are deflected in shear or in compression or through frictional resistance to the travel of the coupler's head shank. Energy absorption is about 220,000 ft-lb at full travel [21].

During the year various new materials were used as freight car construction (Fig. 34). The Burlington Railroad put into service two insulated boxcars containing plastic roofs. The roof, applied to two of the Burlington's polyurethane foam-insulated 70-ton boxcars, is made of 5 in. of polyurethane foam sandwiched between two layers of fiber-glass reinforcement. The three-piece roof, which has tongue-and-groove ends which interlock with each other, are secured to the side plates and ends by Huckbolts and cold rivets. Joints are covered by batten strips which are sealed with an epoxy compound. Beneath the roof polyethylene car liners are used to support the Evans bulkheads. The use of the plastic is expected to greatly improve the insulating qualities of the cars, and in addition the plastic roof weighs 2100 lb less than a steel roof of equal strength [22].

A line of molded fiber-glass hatch covers for covered hopper cars, designed to save weight, ease opening and closing, reduce maintenance, and improve cargo protection, was introduced by the Molded Fiber Glass Body Company. The covers, which come in trough type and round models, are of all-pressure molded fiber-glass reinforced polyester which cannot rust and are corrosion-resistant. A typical installation of four 11-ft fiber glass covers and attached hardware weighs 624 lb as compared to 1414 lb for a similar set of steel covers [24].

A new type of stainless steel has been developed by the Allegheny Ludlum Steel Corporation which has the mechanical properties of the best carbon or low alloy structural steel and the corrosion-resistance of stainless steel. In addition, no post-fabricating heat-treatment or stress-relieving treatment is
necessary. This new stainless steel has been used in covered hopper cars designed to carry plastic without fear of contamination [24].

An all steel flooring made of columbium-bearing steel which "won't turn nails away" has been developed by Armo Steel Corporation. The floor consists of hat and channel members laid alternately across the width of a car forming grooves into which nails can be driven. Nails follow the curved groove to automatically clinch and pull easily because they curve only once. Besides remaining flat and smooth under loading and unloading conditions, the steel floor distributes the load evenly and adds strength and stiffness to the car [25].

A new three-section telescopic cover has been developed by Shunk Manufacturing Company, Inc., a subsidiary of Chromalloy American Railroad, for permanent installation on flatcars, steel railcars, and gondolas (Fig. 35). The complete cover telescopes into one third its length, leaving two thirds of the car open for easy loading and unloading, and eliminates the need for stacking space required by lift-off type hoods. The cover section can be opened and closed manually, moving on rollers equipped with anti-friction bearings. Automatic locking devices secure each section in closed position for payload protection from weather and dirt [26].

Evans Products Company has introduced a new system of freight car lading controls which was developed by General Foods Corporation (Fig. 36). The device consists of a single movable bulkhead with two outer panels that expand when attached rubber bladders are inflated and maintain constant pressure against the load, preventing shifting of the lading. The pneumatic feature of the bulkhead eliminates the need for side fillers [27].

Removable A-frames that can be set up or taken down in minutes are features of a new design lumber flatcar developed by RSP Railway Equipment Corporation (Fig. 37). The use of A-frames speeds loading and permits the unloading of packaged lumber products from the same side of the car. Lumber loaded in layers on the A-frames are secured with built-in cables and winches; no metallic strapping is needed. Special "chair" bases on the frames slant inward to keep weight of cargo toward the center of the car and prevent shifting in transit [28].

A trailer hitch with yoke release has been patented by Bethlehem Steel Corporation. The trailer hitch, mounted on a railway flatcar for trailer-on-flatcar service, permits the passage of tractors and trailers over it since it has folding legs. Buffeting forces during transportation are minimized by shock absorbers in one or more legs of the hitch [29].

The Buffalo Brake Beam Company has a new fold away metal pedestal which permits rapid conversion of a flatcar from piggyback to container to piggyback handling. The pedestal can be raised or lowered in seconds without using tools. In an upright position four pedestals support the container with 5-in. clearance beneath container for crane feet to pick it up. When folded down, the pedestals lie flush with the deck [30].

A single-handle, cam-operated plug door has been designed by CoManCo, Inc. The doors, easily operated by one man, are continuously seam-welded, and gaskets give positive sealing under adverse weather conditions [31].

Passenger Cars and Parts

The Southeastern Pennsylvania Transportation Authority has acquired 20 new air-conditioned, humidity-controlled electric MU commuter cars to be operated by the Penn-Central Transportation Company. The St. Louis Car-built cars are 85 ft long, have a speed of 85 mph, with a rated acceleration of 2.2 mph per sec. The improved ride is attributed to GSI's General-70 trucks which feature a double suspension system of coil equalizer springs and air bolster spring which smooths the ride. In addition, lateral shock absorbers and vertical friction snubbers provide added stability [32].

The Budd Company has recently delivered 75 high speed transit cars for service between Philadelphia, Pennsylvania, and Lindenwald, N. J. (Fig. 38). The 67-ft 2-in. cars are air conditioned, and special attention has been given to noise suppression. Initial acceleration of 3 mph per sec. with a top speed of 75 mph will be provided. The cars are equipped with an automatic train operating system where the only manual operations will be closing or opening doors and pushing the start button.

Also under construction at Budd are 270 suburban cars for the MCTA for service on the Long Island Railroad (Fig. 39). These 85-ft cars will operate in pairs which will share air compressors, motor alternator, and toilet facilities. "A" cars seat 122 passengers, and "B" cars, 118, using three and two seating and are capable of speeds of 100 mph operations. The cars are built of stainless steel and have rounded sides.

Corning Glass has introduced a chemically strengthened laminated glass, said to be four times stronger than annealed 1/8-in. plate glass and equal to 1/4-in., air-tempered glass, and offers greater protection from flying objects to passengers and train operators than standard laminated safety glass previously used in transit car windows. If broken, the glass does into blunt particles with no jagged edges. The glass weighs only 2.26 psf compared to 3.18 psf for a single thickness of 1/8-in. plate glass. The tinted polyvinyl interlayer reduces the visible light transmission in cars up to 38 percent [33].

Boron deoxidized copper has been developed for use in braking equipment for high speed railroad and rapid transit service by the Anaconda American Brass Company. The brakes operate as much as 1500 deg F cooler than conventional air-cooled brakes. The function of the copper plate is to produce friction and conduct heat [34].

Foreign Developments

The Gresham & Craven Limited has developed a braking system for the Angola Railways designed to maintain full brake power during applications of up to 2 hr while an ore train transverses an almost continuous descent of 6000 ft (Fig. 40). The braking system has a two-pipe vacuum brake which maintains a continuous top-side connection from all ore cars in the train directly to the locomotive exhaustors during brake applications. It thus compensates for any leakage tending to reduce brake power over long periods, and also eliminating the normal small initial drop in top-side vacuum due to reduction in volume...
1. Doors of the Hello Dolly car, which has just arrived at Champion Home Builders plant at Dryden, Mich., are opened.

2. Perfect condition of the particle board consignment is due in large part to proper loading at Boise-Cascade plant.

3. Dunnage bag, one of four in car, is deflated and removed.

4. Next comes plywood sheets which allow bag to exert even pressure on cargo.

5. Bundles in doorway area are removed easily and quickly by a fork lift.

6. When doorway has been emptied, the lift truck takes 20 seconds to pull out a dolly (platform on rollers) carrying 12,600 pounds of particle board.

7. Bundles are removed from first dolly. Watching is William Plumb, Champion Home Builders purchasing agent.

Fig. 25 (Continued on opposite page)
8. Another dolly is pulled into unloading position at doorway by lift truck.

9. Cable is pulled against locked far platform to draw a dolly into door area.

10. Two bundles are removed from last dolly. Note good arrival condition.

11. Part of shipment is visible as operator takes last of material from car. Elapsed unloading time: one hour.
when the piston moves up. Both the brake pipe and the exhauster pipe are provided with valves which automatically maintain the correct vacuum above and below the pistons irrespective of altitude [35].

The R. Y. Pickering & Company, Ltd., has built for the British Railway Traffic & Electric Company, Ltd., 42 100-ton tank cars. These cars are designed to run at speeds of 65 mph and have an actual payload of 20,079 gallons. Outlets for the fuel are equipped for use with quick action couplings [36].

Sprayed asbestos protection has been used in Spain for the first time in railway vehicles to reduce the effects of solar heat passing through the roof of passenger coaches and goods vans. The material used, Silbestos, is a mixture of crocidolite asbestos fibers and cement and is applied by spraying with jets of atomized water. Thicknesses of up to 6 in. have been achieved, but 1/16-2 in. is normal [37].

**Locomotives**

New locomotive models in all countries show a continued emphasis in three areas, namely; high horsepower ratings, im-
provement in adhesion, and use of static component (thyristor) control. One exception to the horsepower race has been the introduction by two builders in the United States of new medium power locomotives. During this period the United States builders have continued the maximum ratings at the level established by the end of 1967.

Adhesion control appears in most new European and Japanese built locomotives by some means of low-level traction transmission between truck and carbody. In this country EMD has introduced a new slip control system for detecting and correcting slips by very rapid action in the excitation control system. Also in the United States, a new 2-axle truck by Alco used the low traction principle with reported improvement in adhesion [38, 39].

Reports from Britain, Sweden, Japan and Switzerland tell of installation of silicon diodes (thyristors) to provide stepless control of tractive effort with automatic response to the load demand. In the United States the newly delivered 25 kv, commercial frequency electric locomotive for Muskingum Electric Railway, to be described later, is the first application of thyristor control in this country.

Motive Power Distribution in the United States

The year 1967 saw a decrease of 190 diesel-electric units in the total owned or leased by Class I railroads. The available steam roster has been reduced to 1. The distribution as of January 1, 1968, was reported in AAR Report CS-56A, No. 607 as follows:

<table>
<thead>
<tr>
<th>Locomotives of Class I railroads of U.S.</th>
<th>Diesel</th>
<th>Steam</th>
<th>Electric</th>
<th>Gas</th>
<th>Turbine</th>
<th>Total</th>
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<tr>
<td>Units owned or leased</td>
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<td>1</td>
<td>321</td>
<td>31</td>
<td>27,670</td>
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<td>Units serviceable</td>
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<td>294</td>
<td>23</td>
<td>25,810</td>
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<td>Units stored-serviceable</td>
<td>267</td>
<td>1</td>
<td>17</td>
<td>8</td>
<td>293</td>
<td></td>
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<tr>
<td>Units awaiting repairs</td>
<td>1,825</td>
<td>0</td>
<td>27</td>
<td>8</td>
<td>1,860</td>
<td></td>
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</tbody>
</table>

Locomotive Developments. A 4000 gross hp prototype diesel electric locomotive named the "Kestrel" began high speed passenger service trials on the British Railways last spring. (Fig. 41.) De-
signed and produced by Brush Engineering Company, the locomotive is powered by a single Sulzer, turbocharged V-16 engine running at 1100 rpm. The traction alternator and an auxiliary 530 kVA alternator for train heating are both of the “brushless” design which means the exciters have rotating armatures and integral silicon diodes on the end of the main shafts. Thyristor control provides continuously variable tractive effort control. These locomotives also feature automatic proportioning of the dynamic brake and the friction brake according to speed, under control of a single brake handle. The cab is pressurized for cleanliness, air cleaning is by dry inertial type cleaners instead of conventional oil panels. The 6-axle double ended locomotive is 66 ft 6 in. over buffers and weighs 252,000 pounds with 1200 gallons of fuel. It appears to be a very comprehensive attempt to develop the next step in British Railway power with advances based upon proven mechanical design, machines and systems [40, 41, 42] (see item 9, Table 1).

Fig. 41 pictures a French 2-engine hydromechanical drive prototype, Class CC 80,001, which is 70 feet long over buffers and weighs 256,000 pounds with 1000 gallons of fuel. It is powered by two V-12 engines running at 1550 rpm by Chantiers de L'Atlantique. The 2 engines drive through fluid couplings into central, body-mounted, 8-speed transmissions from which cardan shafts drive to axle boxes on each of the 3-axle trucks. During gear changes the input shaft is declutched and braked and the output shaft can freewheel so the internal shafts are stationary. The locomotive rating is 3100 gross horsepower and maximum

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**Table 1 Diesel locomotives**

<table>
<thead>
<tr>
<th>Item No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>7</th>
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<td>END</td>
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<td>English Electric</td>
<td>Krupp</td>
<td>Mitsubishi</td>
<td>Alsthom</td>
<td>Brush</td>
<td>H.-S.</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>Number of cylinders</td>
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<td>Bore and stroke, in.</td>
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<td>Total locomotive wgt., lb.</td>
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<td>Fuel capacity, ft3, gal.</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
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<td>1000</td>
<td>1000</td>
<td>1000</td>
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<tr>
<td>Driving wheel dia., in.</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
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<td>60</td>
<td>60</td>
<td>60</td>
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<tr>
<td>Number of axles</td>
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<td>6</td>
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<td>6</td>
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<tr>
<td>Locomotive rating</td>
<td>3100 gross horsepower</td>
<td>3100 gross horsepower</td>
<td>3100 gross horsepower</td>
<td>3100 gross horsepower</td>
<td>3100 gross horsepower</td>
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<td>3100 gross horsepower</td>
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By permission of the publisher, the data are reproduced from Table 1 of the Transactions of the ASME, Volume 91, 1969, page 817.
speed is 80 mph. It is undergoing trials on the French National Railways [43] (Table 1, item 1).

The first electric locomotive in the United States to be powered from a 25,000 volt, 60 cycle catenary was delivered by General Electric this year (Fig. 43). Two locomotives are to be used on automated coal haulage of the Muskingum Electric Railroad. The locomotive uses solid state silicon rectifiers to convert the commercial frequency a-c to d-c for the standard traction motors. The control system is the first U. S. application of thyristor control on locomotives.

In addition the locomotives will be automatically controlled from loading to unloading with on-board speed-distance regulation directed by wayside signals. No operating crew is required. The operation is expected to show developments of power and control equipment applicable to U. S. railroad electrification and automation.

The locomotive is rated at 5000 hp, weighs 402,000 pounds, and is 69 ft 6 in. long. Its mechanical design is very much like the Pennsylvania E44 locomotives except as the new equipment has dictated changes. Details are given in Table 2, column 1 [44, 45].

**Diesel Locomotives.** Early in the year General Electric introduced the U23C locomotive of Fig. 44 powered with the General Electric V-12 engine of the same basic design as its V-10. The locomotive has the same structure as the U33C and is described in Table 1, item 2. It uses a d-c generator for traction instead of the ac/dc transmission of the higher power units. Four axle units of this rating were also produced [46].

A new turbocharged, 12 cylinder version of the EMD 645 engine was used to power a new model SD/39 by EMD with a 2300 hp rating, Fig. 45. The new engine model produces 300 more horsepower than the nonsupercharged 16-cylinder engine previously offered in this range. EMD also offers a 4-axle model and both have d-c transmission. See item 3 of Table 1 [47].

Fig. 46 shows General Electric's 3300 hp U33B (item 4, Table 1) which began delivery in this period using the GE 16 cylinder engine and ac/dc transmission. Six axle models are also being produced.

Late in 1967 the Santa Fe received the only recently produced full width or “streamlined” cab design locomotives. Both General Electric and EMD furnished units, which, except for steam generators, passenger speed gearing, and the special cabbody designs, include the standard power plants of the conventional hood type units. Fig. 47 illustrates the EMD unit FP45 which is rated at 3600 net hp with the 20 cylinder version of the EMD 645 engine. The General Electric U30CG of Fig. 48 uses the 16 cylinder engine and rates 3000 net horsepower.

### Table 2 Electric locomotives

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<td>Pantograph</td>
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<td>Silicon</td>
<td>Pantograph</td>
<td>54 7/8</td>
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<td>62/16</td>
<td>Floating Ring</td>
<td>30,000</td>
<td>27,300</td>
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**Fig. 44** General Electric U23C diesel-electric locomotive

**Fig. 45** SD/39 diesel-electric by General Motors

**Fig. 46** General Electric 3300 hp U33B

**Fig. 47** General Motors FP45 for Santa Fe Railway

### Notes

- **AEI** - Associated Electrical Industries, Manchester, England
- **GE** - General Electric Company, Erie, Pa., U.S.A.
- **Italy** - Italian State Railways (F.S.)
- **M-C** - Metropolitan-Cammell Ltd., Birmingham, England
- **Muskingum** - Muskingum Electric Railway, United States
- **Turin** - Istituto Nazionale delle Officine di Savignano di Torino, Italy
Electro-motive also produced a second order of similar design designated F45 without steam generators for high speed trailer train service on the same railroad [48].

Fig. 49 shows one of the 2700 hp diesel electrics, part of an order for 50 being supplied to British Railways by English Electric. The 16 cylinder English Electric 16CSVT engine drives a train heating generator as well as the traction generator and auxiliaries. The heating load may be 455 hp. An automatic tractive effort control system using thyristors and other components developed on M-U train set equipment provides for regulating the tractive effort, including wheel slip control, to meet the requirements.

Another feature is the use of primary inertial filtration and disposable dry element secondary elements.

The units have dynamic brakes, slow-speed, and are equipped for multiple unit operation. See Table 1, item 5 for details [49].

English Electric has an order of 10 locomotives very similar to these to be exported to the Portuguese Railways [50].

The German Federal Railway (DB) have acquired 22 diesel-hydraulic locomotives, Class 218, Fig. 50, built by Krupp and powered by the M.A.N. turbocharged 12 cylinder V6V23/23 TL engine. See Table 1, item 6 [57].

An interesting class of Japanese built diesel electric locomotives have begun service on New Zealand Railways. The locomotive, Fig. 51, is powered by the Caterpillar D398 engine and produces 1050 gross horsepower with an ac/dc transmission, being probably the lowest powered unit with a silicon rectifier ac/dc system. The engine drives the main alternator through a flexible coupling, drive shaft, and universal joint instead of the usual frame mounted, close coupled design.

The wheel arrangement is B-B-B with the center truck carrying its load through rollers allowing lateral movement. This arrangement was chosen for ability to negotiate sharp curves on the lightest rail in the system. Tractive effort is transmitted from each truck to the underframe at a point almost on the axle center line by a non-load-carrying resilient center pin. Swiveling of the trucks forces the secondary system of coil springs between truck frame and carbody into a shear deflection (Table 1, item 7) [51].

Alsthom has delivered production units of a 3600 gross horse-

Fig. 49 British Railways 2700 hp diesel-electric by English Electric

power, 6-axle, diesel electric, series CC 72,000, for the French Railways. The prototype of this design was announced in the 1966 issue of this report. The power plant is the turbocharged 16 cylinder ARO-V16 by SACM driving a 3-phase traction alternator. Silicon rectifiers convert the power to d-c for the 3-axle monomotor trucks. The locomotives have two power ranges attained by manual gear changing at standstill to suit the type of service. The locomotives have operating compartments at each end, are 65 feet 11 1/2 inches over all and weigh 242,000 pounds with 1350 gallons of fuel (see Fig. 52 and item 8, Table 1) [52].

A locomotive nearly identical to the above has been delivered to the Moroccan Railways under designation D4101 with only a slight reduction in weight and speed rating due to wheel diameter.

Fig. 53 illustrates a locomotive with combined diesel-electric and straight-electric power systems for the Rhaetian Railway in Switzerland. The diesel power is supplied by Cummins engines providing 1040 rail horsepower. The locomotive can also collect 1000 volt d-c by pantograph from a catenary system for a 940 rail horsepower rating.

The same builders, Brown Boveri and SLM produced two diesel-electric locomotives (Fig. 54) for rack and adhesion operation, also in Switzerland. Two supercharged Cummins 12 cylinder engines produce a gross horsepower rating of 660 hp each.

A new general purpose locomotive was built by Brush Engineering for the Philippine Railway. It features two underframe mounted d-c traction motors, each driving to an axle box on one truck through a cardan shaft. Additional cardan shafts couple the two axles of each truck. The power plant is a Caterpillar D398 turbocharged V-12 engine developing 1050 gross horsepower at 1300 rpm. The trucks are standard car type with coil spring
suspension and fixed roller bearing journals except that the bolster is arranged to hold the axle box torque arms. This locomotive is intended to be one of a series from 450 to 1050 hp for narrow gauge use when the small unsprung weight and narrow dimensions of the axle gear boxes are desirable. The design is reminiscent of one by EMD reported by this survey in 1959 [53].

The Italian State Railways have acquired the Type D343 diesel-electric locomotives powered by Fiat V-8 engine reported in 1966. The 4 cycle, turbocharged engine rates 1350 gross hp at 1500 rpm. The 4 axle, 06 ton unit is intended for mixed service. See Fig. 55 and Table 1, item 10.

Electric Locomotives. The British Consortium for Electrification of Pakistan Railways began shipment of 29 3070 hp a-c electric locomotives for the Pakistan Western Railways. The power supply is 25 kv, 50 cycles rectified by silicon rectifiers. The locomotives will incorporate a static control system with thyristors to provide infinitely variable tractive effort control following developments on British Railways. The construction is of conventional double end, full width body design with B-B wheel arrangement. Low level tractive effort transmission to the underframe minimizes weight transfer (Table 2, item 2) [54, 55].

The electrification program in Italy has been advanced by delivery of 4, Class E444, 3000 volt d-c electric locomotives. They have an hourly rating of 3500 hp, a maximum speed of 110 mph, and a total weight of 174,000 pounds. They have an automatic acceleration control using resistance steps. Dynamic braking is proportional with the air brake dependent upon speed using a single brake handle.

Weight transfer precautions have been taken by both mechanical and electrical means. Low level traction cables, connected to the trucks 10 inches above the rail transmit tractive effort to the carbody. In addition, the traction motors on the leading truck are 1 electrical resistance step behind the trailing truck during series connection acceleration. These precautions eliminate most of the weight transfer both within the truck and between the two trucks, see Table 2, item 3.

A fifth locomotive of this series will be built with a thyristor chopper control feeding pulsed power to the 4 motors permanently in parallel connection. The voltage applied to the motors can be varied from 0 to 1550 volts by the circuitry automatically to reach and hold the speed called for by the controller handle. Electric braking will also be automatically controlled. These developments make automation or remote control much more attainable [56].

The Survey Committee wishes to thank all of the people who made a contribution by supplying information to be used in this paper, and for the assistance and cooperation extended by builders, equipment suppliers, railroads and trade journals in providing the information for this report.

References

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