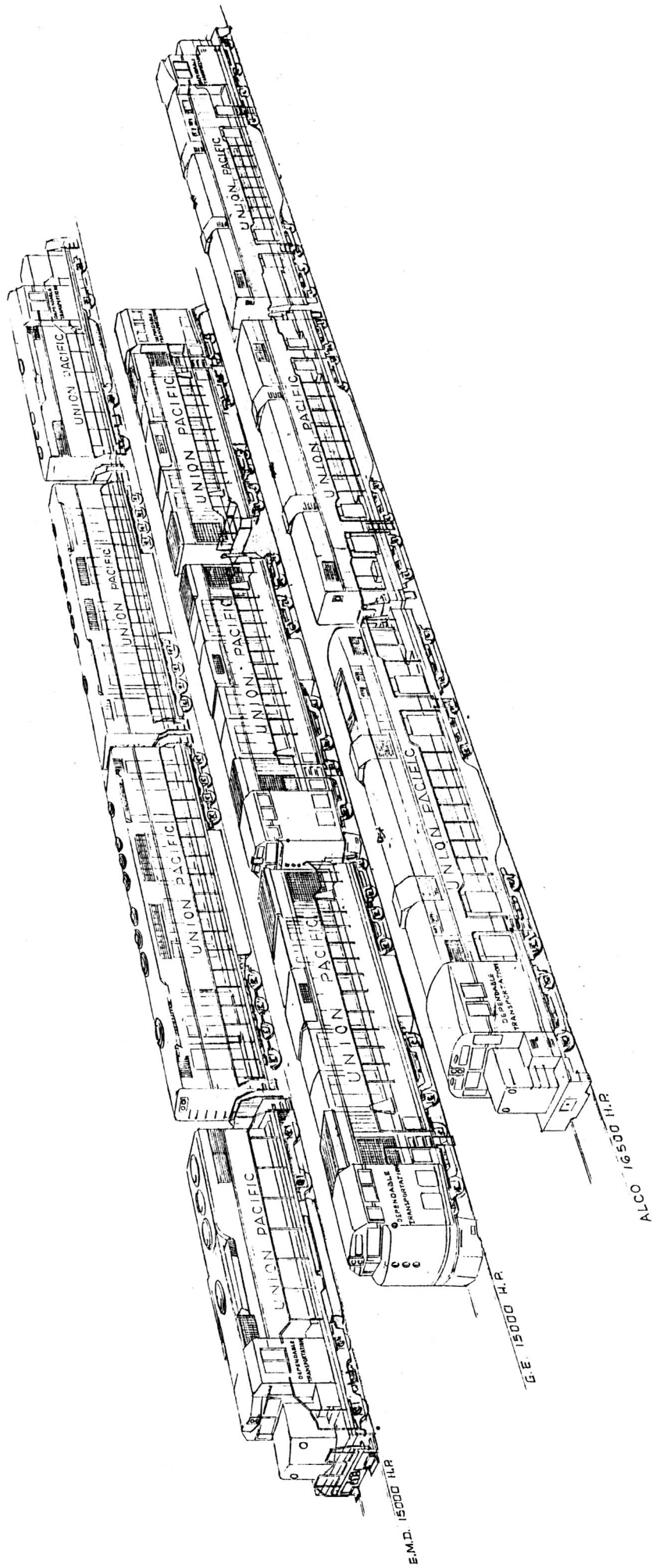


HIGHER HORSEPOWER DIESEL UNITS

Union Pacific Railroad

Presented at Meeting of
Coordinated Mechanical Research
Group, San Francisco, June 4, 1963



E.M.D. 15000 H.P.

E. E. 15000 H.P.

ALCO 16500 H.P.

HIGHER HORSEPOWER DIESEL UNITS

Early in 1962 studies and tests were started to determine the best size locomotive consist for handling high speed freight trains on the Union Pacific.

During the steam locomotive era it was customary to size motive power so that one locomotive unit was usually able to handle an ordinary train over most districts without a helper. As steam locomotives increased in power, so did the tonnage of trains. With the changeover to the more efficient diesel electric unit and its relatively small horsepower it was necessary to operate units in multiple in order to obtain a large horsepower package. As freight schedules became tighter, more and more diesel units were added. The locomotive builders called this "flexibility", but to some of the Western Railroads it became expensive. It was not unusual to see a freight train with six or eight diesel units. Sometimes there were more.

The locomotive consist studies indicated that regardless of horsepower rating, the routine maintenance of a diesel unit cost approximately \$7,000 per year. These items included inspection, servicing and handling, together with the maintenance of car body, couplers, draft gear, jumper cables, air compressors, air brake equipment and electrical parts. The studies also indicated that slightly over three horsepower of locomotive was needed for every trailing ton of freight.

Road tests indicated that a locomotive consist of 15,000 HP is required to handle today's fast trains on the U.P. Fuel capacity must be sufficient for 1,000 miles. One 8500 HP gas

turbine electric locomotive operating with three trailing 2400 HP diesel electric units, making a total of 15,700 HP (shaft horsepower output for traction) was required to move a westbound forwarder train on schedule from North Platte, Nebraska to Los Angeles, California, a distance of 1530 miles. Average total elapsed time for this trip was 42 hours, 34 minutes, average running time 36 hours, 1 minute. Schedule for this trip was 41 hours, 5 minutes. Over this run elevation varies from sea level to 8,000 ft., grades from level to 2.2% and temperatures, on occasion from -40° to 125° F.

Based on these studies and tests the U.P. informed the locomotive builders that all main line freight locomotives purchased in the future should be 15,000 HP, in not more than three units.

Only one of the locomotive builders, Electro-Motive was willing to build a prototype locomotive along these lines without an order. The other two builders, Alco and G.E. were unwilling to build prototype locomotives without an order. To expedite the evaluation of this concept orders were placed with Alco and General Electric Co. for prototype 3 unit locomotives. The 3 unit Alco locomotive is rated at 16,500 HP and the G.E. at 15,000 HP. Both utilize the same running gear arrangement as was used on the UP's 4500 HP gas turbine electric locomotives constructed in 1952-54. This running gear has proven very successful. It consists of two span bolsters, each supported by two 4-wheel motorized trucks.

Both the Alco and G.E. units will mount two 16 cylinder engines in each car body. The two engine per car body concept has a successful history in the EMD "E" series passenger units and the KM diesel hydraulic units. Despite this, the necessity to use two diesel engines per car body is a sad reflection on the inability or unwillingness of engine manufacturers to produce a single locomotive type diesel engine in the 5,000 HP range. All of the existing engines in the 2500 HP range have been upgraded from lower HP engines. This upgrading is fast approaching its economical limit. Only the Swiss design Sulzer engine seems to offer much hope for large horsepower in a single engine.

EMD's answer to this problem was announced in the May 20 issue of Railway Age. A 5,000 HP unit, Model DD-35, will consist of two 16 cylinder engines driving eight motors mounted in two 4-axle trucks. The truck is of Flexicoil design, quite similar to the successful three axle truck used with SD-24 units. Four axle trucks pose many design and maintenance problems, hence the performance of the 4-unit 15,000 HP prototype EMD demonstrator locomotive, consisting of two 2500 HP GP-35 units and two 5,000 HP DD-35 units will be watched with great interest.

Pertinent items on the prototype Alco and G.E. locomotives now under construction for the U.P. are listed on the following pages.

<u>Item</u>	<u>Alco 16,500 HP Locomotive</u>	<u>GE 15,000 HP Locomotive</u>
Manufacturer's Model	DL-855, A unit DL 856, B unit	U-50
Car Body	Hood Type	Hood Type
Consist	A-B-A	A-A-A
Unit wheel arrgt.	B-B-B-B	B-B-B-B
Unit--length over pulling faces	86'0"	83'6-1/2"
Consist--length over pulling faces	258'0"	250'7-1/2"
Unit wheel base	70'7-1/2"	68'1"
Consist wheel base	242'7-1/2"	235'2"
Maximum curvature	21 degrees	21 degrees
Axle load at rail	69,000 lb.	69,700 lb.
Unit weight, fully loaded	552,000 lb.	557,600 lb.
Consist weight, fully loaded	1,656,000 lb.	1,672,800 lb.
Starting Tractive Effort at 25%	414,000 lb.	418,200 lb.
Continuous Tractive Effort	308,400 lbs. at 16.9 MPH	304,800 lbs. at 15.5 MPH
Fuel Capacity	6,000 gals.	5850 gals.
Wheel Diameter	40" AR	40" AR
Gearing	74/18	74/18
Maximum speed	70 MPH	70 MPH
Traction Motors per unit	Eight GE 752E4	Eight GE 752E4
Motor Nose Suspension	Rubber "doughnut" type with lateral stabilizing rod and flangeless motor support bearing	Lord Rubber Cushion.
Draft Gear	M-380	MF-400
Coupler	Type H tightlock with alignment control feature, bottom operated.	Type F without alignment control feature.

<u>Item</u>	<u>Alco 16,500 HP Locomotive</u>	<u>GE 15,000 HP Locomotive</u>
Running gear	Two span bolsters each mounted on two 4-wheel trucks.	
Axle journal bearings	Timken heavy duty type AP journal bearings, Class GG for 7" diameter journals.	
Wheel Slip device	GE wheel slip axle alternator, Type 17MM24, all axles.	
Speed Recorder	Chicago Pneumatic	
Wheel Slip Supression	New York Air Brake Co.	
Main Generators per unit	Two GE 5-GT-598	Two GE 5-GT598 Note: Generators are the same except for gear box and ventilating arrangement.
Diesel Engines per unit	Two Alco 251-16 cyl.	Two GE 7F DL-16
HP/Engine	2750	2500
Air Brake Equipment	26L, Pkg. style	24RL, Pkg. style
Main Reservoir Cap. per unit	100,000 cu. in.	112,000 cu. in.
Sanders	Jet type with Salem sand traps, control valves, cab control valves. Forward sand pipes ahead of each wheel and backup sand pipes behind each truck. Automatic sanding with any emergency application. Pneumatic and electric trainlining of sanding signal.	
Sand Box Capacity	8 cu. ft. per wheel	
Main Reservoir Drains	Salem automatic drain valves and timers, with two way check valves in sanding and air brake systems.	
Fuel Fittings	Buckeye automatic shutoff	
Traction Motor Disconnects	Williamsrip	
Flush Toilet	Mink-Dayton	
Engine Water Freezing Protection	Automatic draining of engine water cooling system if water temperature approaches freezing.	

<u>Item</u>	<u>Also 16,500 HP Locomotive</u>	<u>GE 15,000 HP Locomotive</u>
Piping	All welded wherever possible--screwed fittings avoided all possible.	
Auxiliary Generator	25 KW DC on each engine	18 KW DC (GY-27) on each engine
Exciters Power Reduction	Two GY-48B On lead power plant of each A unit.	Two GY-50 On lead power plant of each A unit.
Horn	Leslie 5-chime located over radiators to avoid freezing.	
Engine Room Air Filtration	Farr Inertial	Farr Inertial
Secondary Engine air filtration	Farr Rotonamic	Aerotec
Inter-car connections	Duplex jumper cables, sander, main reservoir and air control pipes both ends.	
Cab Signal Equipment	To be installed by Railroad.	
Fuel oil heater	Kelty water to oil heat exchanger. By-pass lube oil coil in fuel tank.	
Loadmeters	Loadmeter in cab for each generator.	
Windshield	Solex--safety glass.	
Receptacles	21 point and 12 point, no field loop.	
MU Equipment	To operate in multiple with other diesel units and gas turbine electric locomotives.	
Cooling System	Twin System, full flooded, pressurized designed for 125° F ambient. Inlet and outlet shutters. Engine driven radiator fan with Eddy current clutch.	Twin System, self draining pressurized designed for 125°F ambient. Engine driven radiator fan.
Delivery	4th Quarter 63	4th Quarter 63

Comparison Of Number Of Maintenance Items
5000 HP Unit Vs. Two 2500 HP "A" Units

<u>Item</u>	<u>5000 HP "A" Unit</u>	<u>Two 2500 HP "A" Units</u>
Trucks	Four 4-Wheel	Four 4-Wheel
Traction Motors	8	8
Diesel Engines	2	2
Main Generator	2	2
Car Body	1	2
Pilot	2	4
Draft Gears	2	4
Couplers	2	4
Uncoupling Rigging	2	4
Head Lights	2	4
Train Control	1 set	2 sets
Track Pickup Bars MG Set		
Decoder Units		
Horn	1 set	2 sets
Bell	1	2
Windshield Wipers	6	12
Brake Equipment	1 set	2 sets
Electrical Control Stand	1	2
Speed Recorder	1	2
Windshields & Side Windows	1 set	2 sets
Cab Doors	2	4
Cab Seats	3	6
Sander Control Valve	1	2
Drinking Water Coolers	1	2
Rear View Mirrors	2	4
Clear Vision Wings	2	4
Cab Awnings	2	4

<u>Item</u>	<u>5000 HP "A" Unit</u>	<u>Two 2500 HP "A" Units</u>
Flare & Fusee Equipment	1 set	2 sets
Fuel Tank	1	2
Fuel Fill Fittings	2	4
Fuel Tank Gauges	1 set	2 sets
Fuel Tank Heat Exchanger	1	2
Air Brake Control Valves	1	2
M.U. Receptacles (Duplexed)	2 sets	4 sets
M.U. Cables (2 each end)	1 set	2 sets
Air Hoses & Cutout Cocks	2 sets	4 sets
No. Boxes & Class Lights	1 set	2 sets
Cab Heaters	2	4
Hand Brake	1	2
Flush Type Hopper	1	2
Fuel Heat Exchanger	1	2
Air Gages	1 set	2 sets
Electric Meters in Cab	1 set	2 sets
Batteries	1 set	2 sets
Fire Extinguishers	4	8
Emergency Tools & Supplies	1 set	2 sets
Compressor Control Magnet	1	2
Compressor Control Switch	1	2
Main Reservoir Safety Valve	1	2
Dynamic Brake Control	1	2
Platform Safety Appliances, Hand Rails, Steps, Ladders, Etc.	1 set	2 sets

Cost of 2-Unit vs. Single Unit Operation of Equal Horsepower

Rate	Daily		Trip		Periodical		Monthly		Quarterly		Semi-Annual		Annual	
	Mins.	Cost	Mins.	Cost	Mins.	Cost	Mins.	Cost	Mins.	Cost	Mins.	Cost	Mins.	Cost
Machinist	10"	\$.55	50"	\$ 2.77	234"	\$ 12.97	507"	\$ 28.10	671"	\$ 37.19	1399"	\$ 77.55	2008"	\$111.30
Electrician	3-326		60"	3.33	112"	6.21	601"	33.31	601"	33.31	663"	36.75	1097"	60.81
Pipefitter	3-326		20"	1.11	30"	1.66	121"	6.71	154"	8.54	534"	29.60	854"	47.34
Boilermaker	3-326												218"	12.08
Carman	3-272												94"	5.13
Laborer	2-889												324"	15.60
Supplyman	3-310												44"	2.43
Hostler	3-492												20"	1.16
Hostler Helper	3-253												20"	1.08
Clerk (Cab Card)	3-370												30"	1.68
Total	10"	\$.55	3'34"	\$ 11.88	7'40"	\$ 25.51	26'10"	\$ 85.40	29'27"	\$ 96.32	50'46"	\$167.03	78'29"	\$258.61
Inspections Per Year	169		169		12		8		2		1		1	362
Cost Per Year -														
Inspn. & Servicing		\$92.95		\$2007.72		\$306.12		\$683.20		\$192.64		\$167.03		\$258.61
														\$3300.00
														\$7008.27

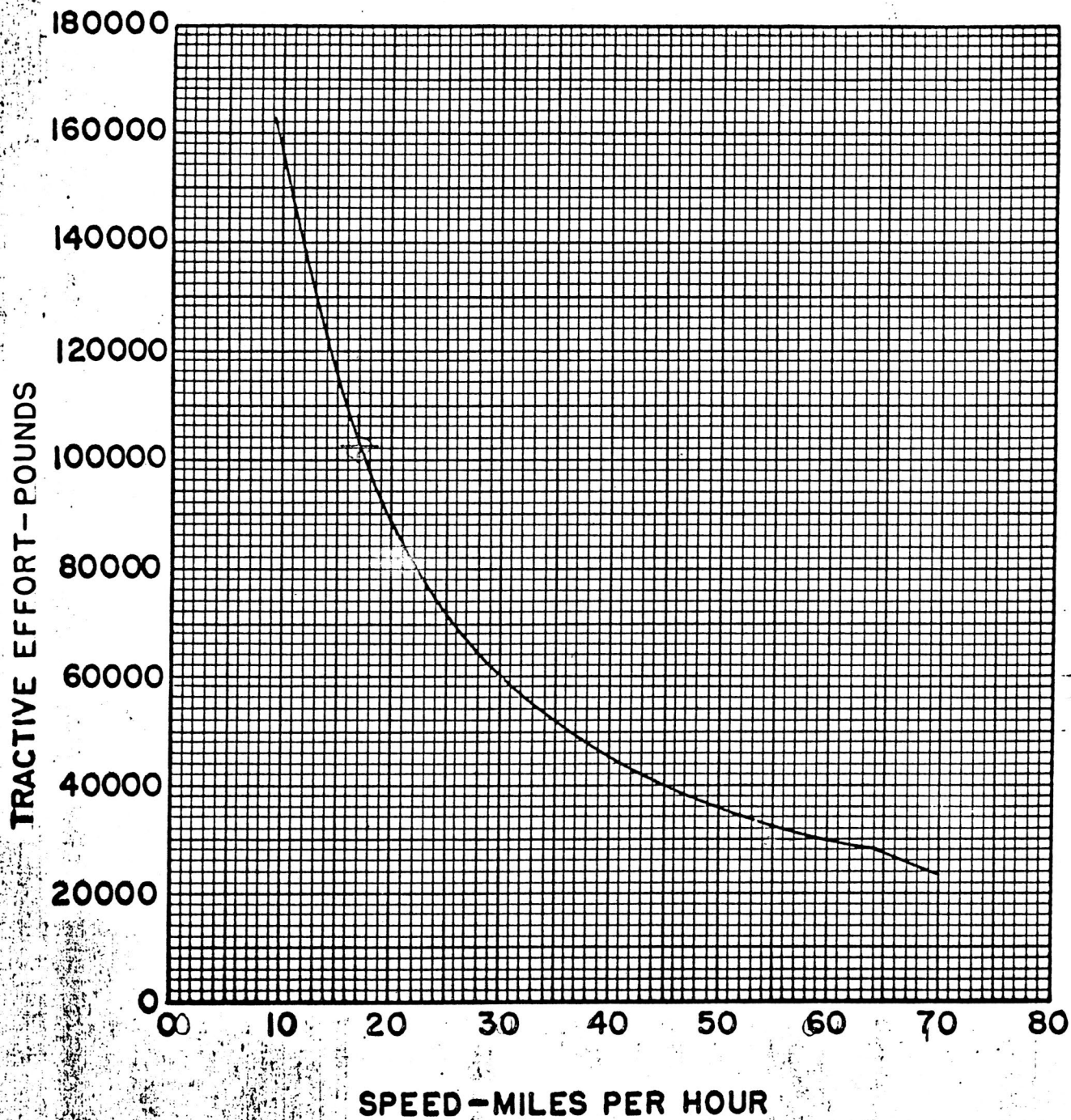
Maintenance

Estimated cost of maintaining car body, couplers, jumper cables, air compressors, air brake equipment, electrical parts and miscellaneous components 20% of 16.5¢ total maintenance cost per mile X 100,000 miles

Total cost per year, excluding fuel costs

Office of
General Supt. MP&M
Omaha - July 9, 1962

ALCO 5500 H.P. LOCOMOTIVE



GE 5000 HP LOCOMOTIVE

100X140 7/100 Tech Division

GENERAL ELECTRIC COMPANY CHENECTADY, N. Y., U.S.A.

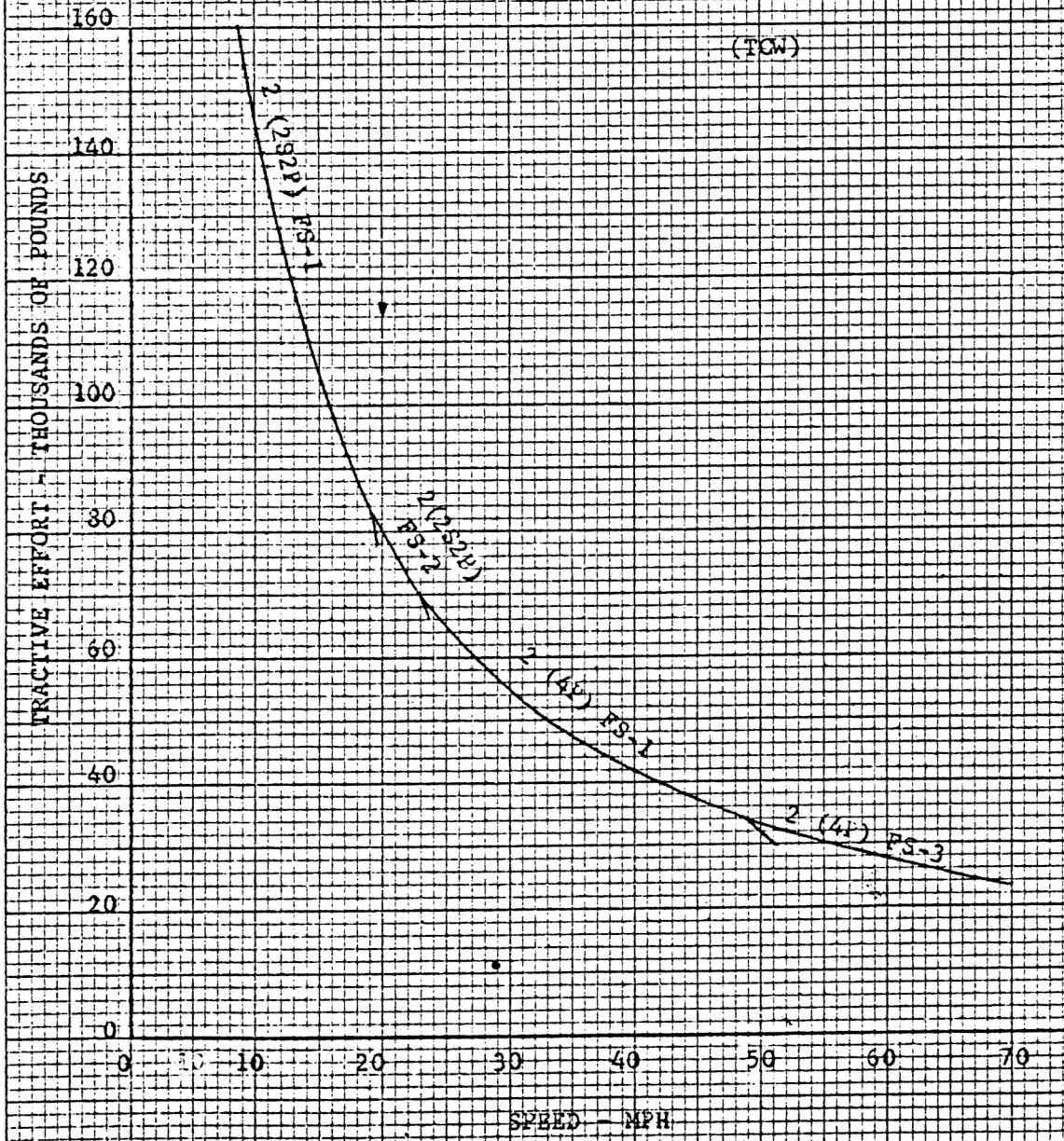
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SPEED TRACTIVE EFFORT CURVE DIESEL ELECTRIC LOCOMOTIVE

EQUIPMENT
 2 - 1000 RPM DIESEL ENGINES
 2 - GT-593 GENERATORS
 8 - GE-752 MOTORS
 GEARING 74/13
 WHEEL DIAMETER 40"

BASED ON 2500 HP INPUT TO
 EACH GENERATOR FOR TRACTION
 @ 1000 RPM

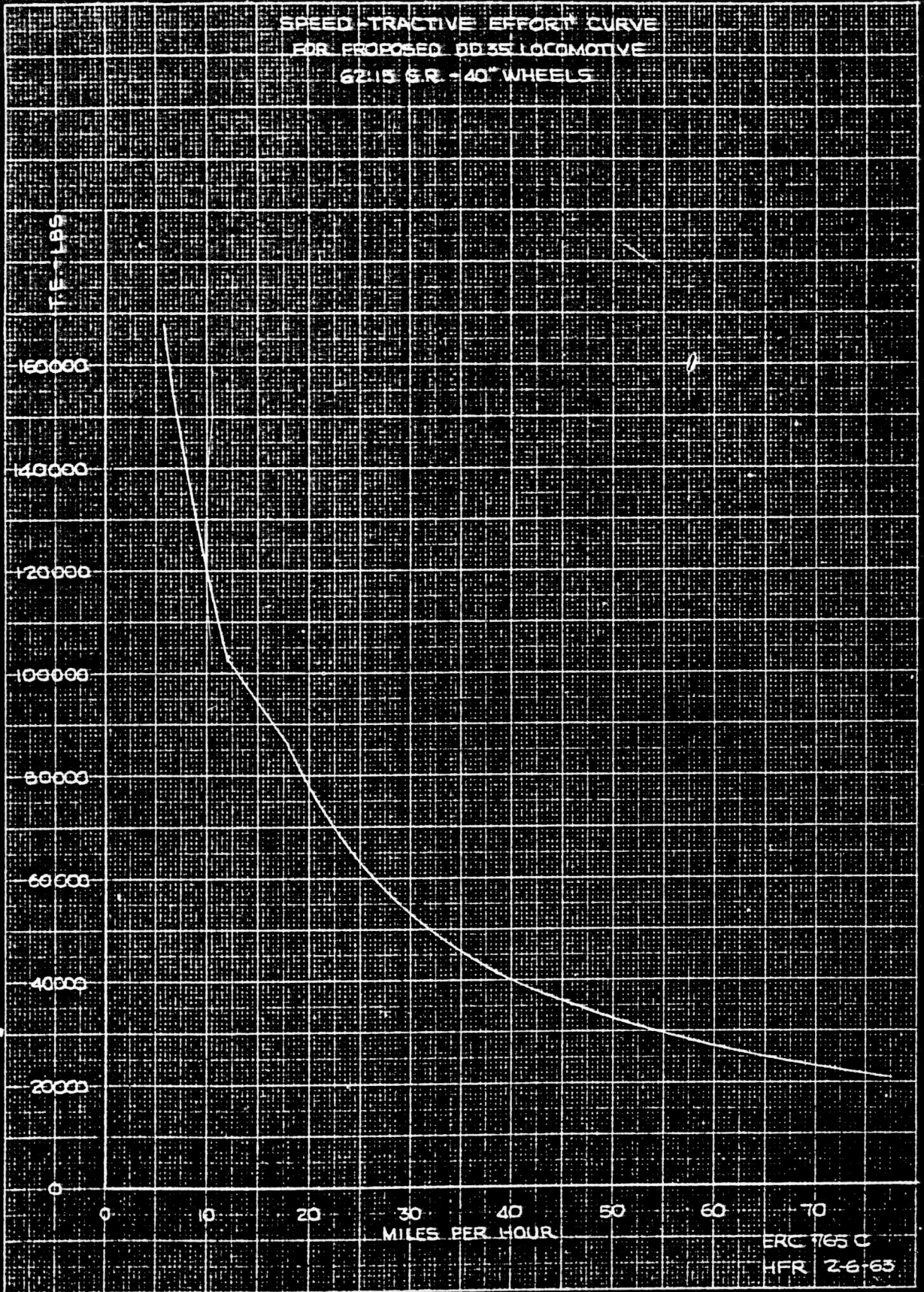
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DD35 5000 HP

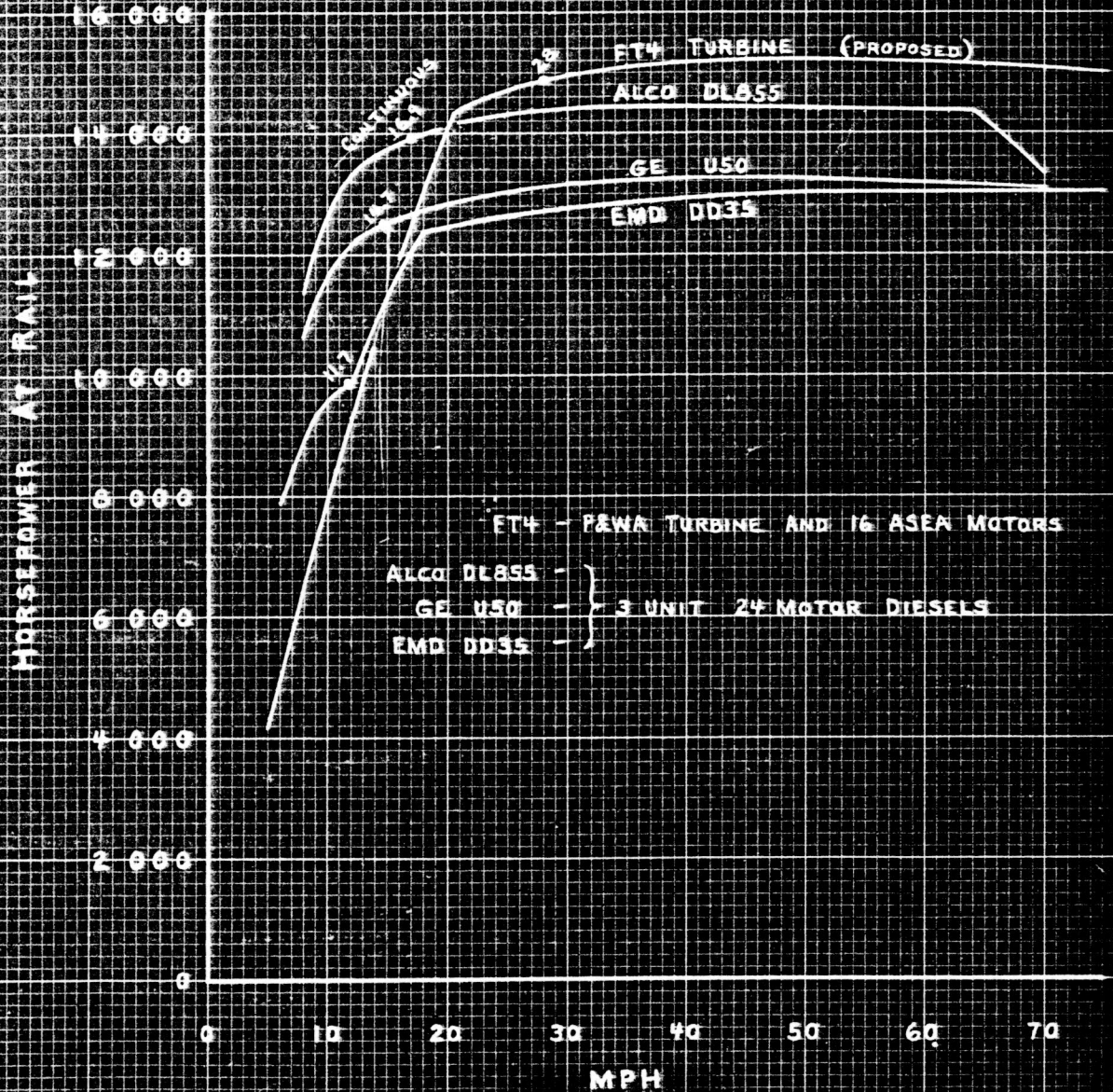
SPEED-TRACTIVE EFFORT CURVE
FOR PROPOSED DD35 LOCOMOTIVE
62.15 G.R. - 40" WHEELS



ME 10 X 10 TO THE CM 359-14
ALUFEL & BASS CO. PATTENTED

ERC 765 C
HFR 2-6-63

HORSEPOWER AT RAIL -- NEW LOCOMOTIVES



ET4 - P&W TURBINE AND 16 ASEA MOTORS

ALCO DL855 -

GE U50 -

EMD DD35 -

} 3 UNIT 24 MOTOR DIESELS

HORSEPOWER AT RAIL

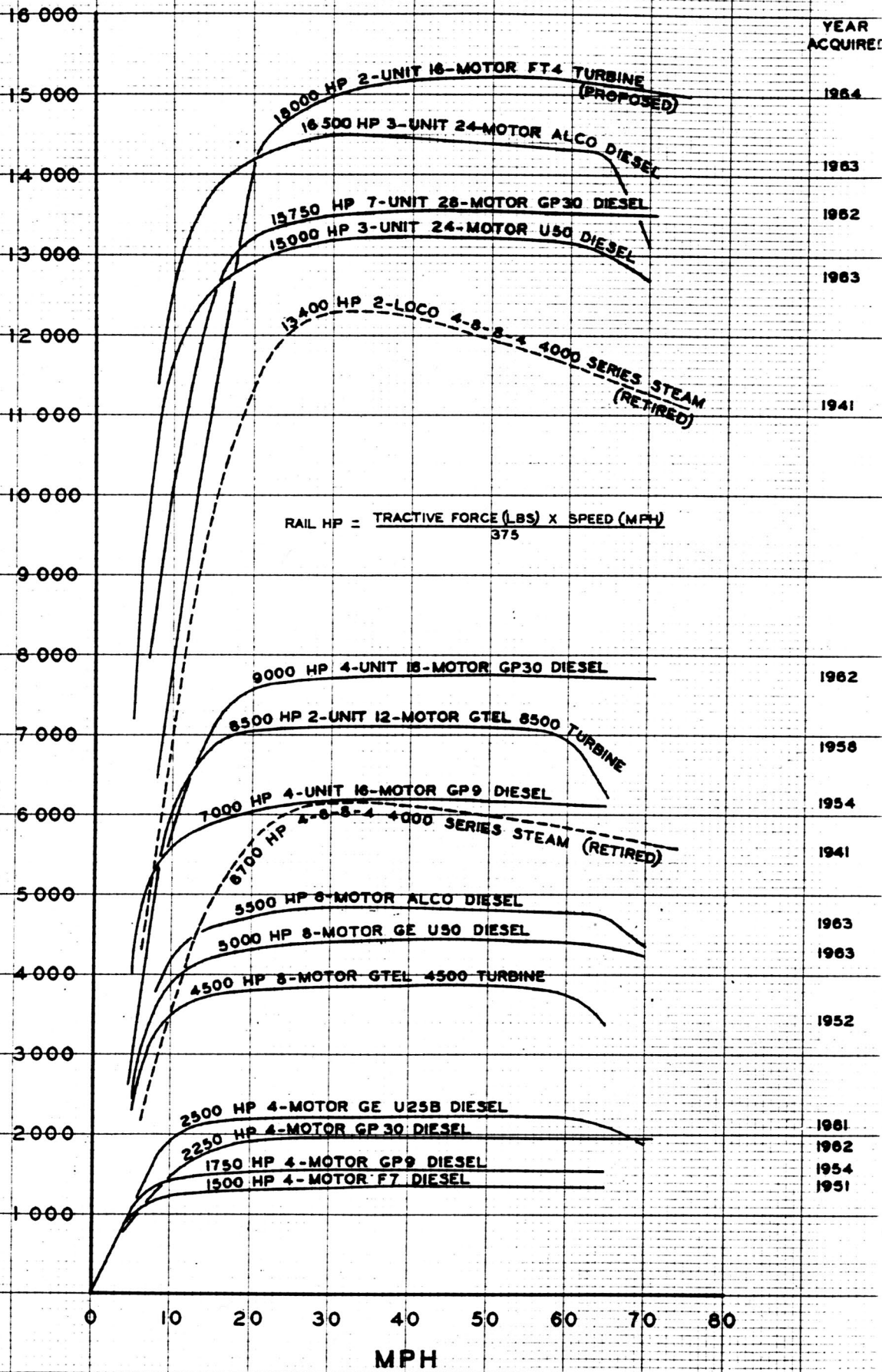


FIG. 8 RAIL HORSEPOWER VS SPEED, UNION PACIFIC LOCOMOTIVES