

SOUTHERN PACIFIC COMPANY
(PACIFIC LINES)

DYNAMOMETER TEST NO. 9
OF
ARTICULATED CONSOLIDATION TYPE
(4-8-8-2)

LOCOMOTIVE 4185
CLASS AC-8

Dated: April 16, 1941

SOUTHERN PACIFIC COMPANY
(Pacific Lines)

DYNAMOMETER TEST NO. 9

Southern Pacific locomotive No. 4185, class AC-8, was put in test service intermittently during November and December 1940 for the purpose of obtaining the operating characteristics of this class of power under various loads with particular reference to the effect of load on the speed, the fuel and water rates and the driving tire wear.

PHYSICAL DATA

The locomotive is one of 28 articulated, cab-ahead, 4-8-8-2 type locomotives purchased from Baldwin Locomotive Works in 1939. They are designed for a maximum speed of 75 miles per hour and can operate on curves up to a maximum of 18 degrees. They have four simple cylinders and operate with a boiler pressure of 250 pounds per square inch. Piston valves are operated by Walschaert direct link motion valve gear controlled by an ALCO power reverse gear. The valves are set for a maximum cut off of 81% of stroke.

The locomotives are equipped with a type "E" superheater with multiple type front end throttle, tangential steam dryer and a pyrometer. They are also equipped with a Signal Foam Meter and a Valve Pilot. The feedwater heater is a Worthington No. 6-SA; the injector a Nathan No. 17, non-lifting type. Each has a capacity of 12,000 gallons an hour.

Superheated steam is supplied to the feedwater pumps, air compressors, blower, and is used to atomize the oil at the burner. The injector, turbo-generator, tank heater and oil heaters use saturated steam.

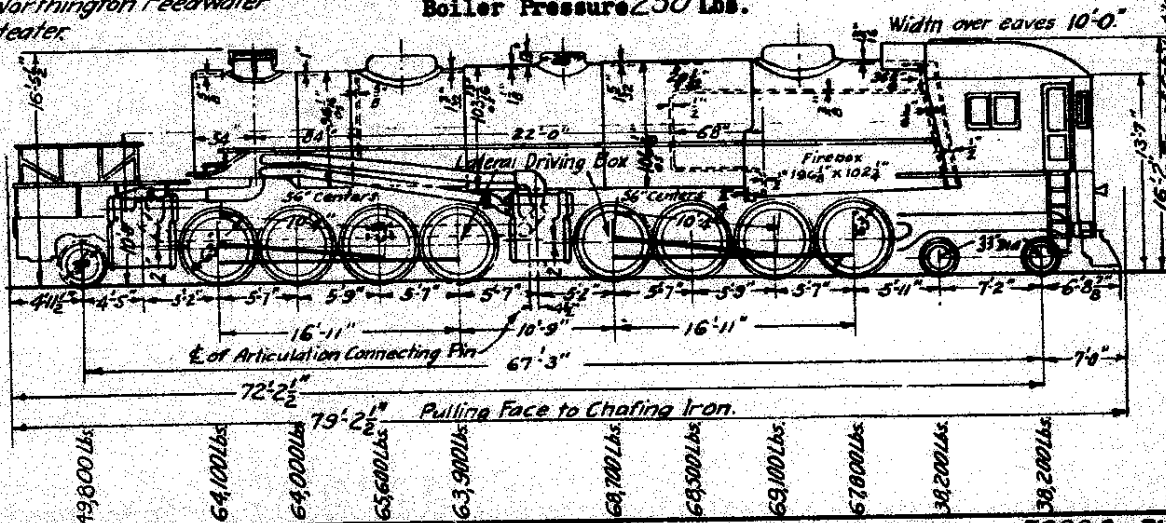
The present standard exhaust nozzle is 6-3/4" in diameter with a 1/2" cross-split. The air opening of the side dampers in the firepan is equal to 38% of the gas area of the tubes and the center damper opening is equal to 5%.

On these locomotives all journal bearings on the engine and tender are oil lubricated, with mechanical lubricators supplementing the spring pad lubricators on the driving journal bearings only.

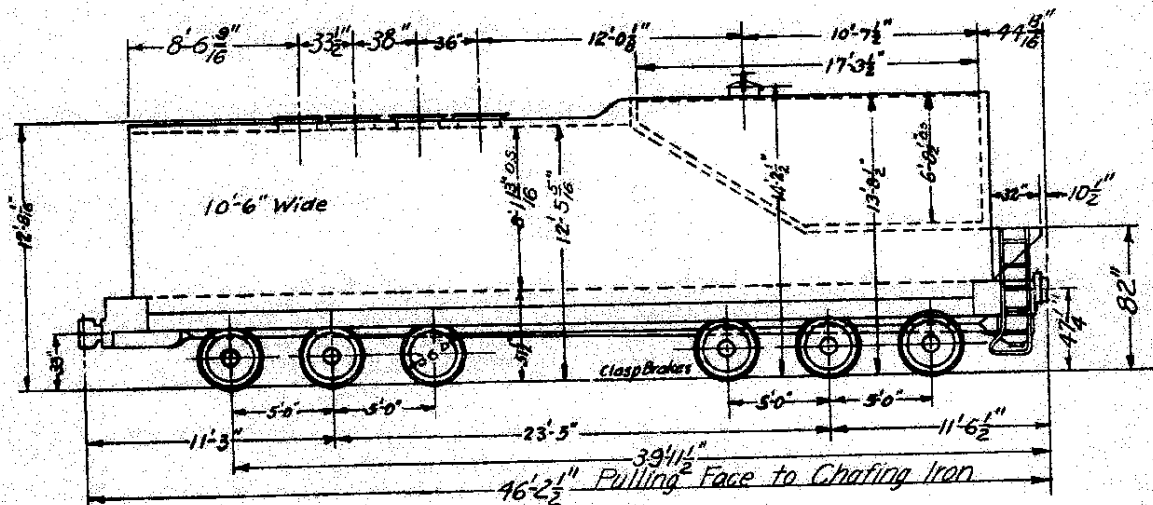
The general dimensions and design of the locomotive are as shown on the page following.

Equipped with No. 65A
Worthington Feedwater
Heater

Class AC-8 AC-63²⁴⁻²⁴ 532-SF
Boiler Pressure 250 Lbs.



Cylinders	24" Dia. X 32" Stroke	Heating Surface of Boiler Tubes	5992 Sq. Ft
Weight on Drivers	531,700 Lbs	Heating Surface of Firebox	513 Sq. Ft
Weight on Front Truck (Cab End)	76,400 Lbs	Heating Surface-Evaporating	6505 Sq. Ft
Weight on Trailing Truck	49,800 Lbs	Heating Surface of Superheater	2988 Sq. Ft
Weight on Engine-Loaded	657,900 Lbs	Heating Surface-Combined	9493 Sq. Ft
Driving Axle Journals-Main	12" x 15"	Boiler Capacity	818
Driving Axle Journals-Front	11" x 15"	Tractive Effort to Adhesive Wt.	234
Driving Axle Journals-Others	11" x 15"	Tractive Effort-(M.E.P. 85 %)	124,300 Lbs
Engine Truck Journals	7" x 14"	Valves, piston type, size	11"
Trailing Truck Journals	8" x 14"	Maximum travel	6 1/2"
Boiler Tubes-Length of	22'-0"	Steam Lap	15/16"
Boiler Tubes-No. of	91-2 1/2" & 240-3 1/2"	Lead	3/16"



TENDER CLASS 220-R-3

DIMENSIONS AND WEIGHTS FOR LOADED TENDER.		SIZE OF TRUCK JOURNAL	
CAPACITY OF OIL TANK	6,400 GALS.	WEIGHT OF TRUCK	27,500 LBS.
GALLONS OF OIL TO MARKER BAR	6,100 GALS.	WIDTH OVER FRONT STEPS	10'-1-1/8"
CAPACITY OF WATER TANK	21,900 GALS.	WIDTH OVER BACK STEPS	10'-0"
WEIGHT OF TENDER, EMPTY	160,000 LBS.	EXTREME WIDTH (Top tank beading)	10'-6-7/8"
WEIGHT OF 21,900 GALLONS OF WATER	182,500 LBS.	Width over end sills	10'-0"
WEIGHT OF 6,100 GALLONS OF FUEL OIL	50,800 LBS.		
WEIGHT OF TENDER, LOADED	393,300 LBS.		
JOURNAL PRESSURE IN POUNDS PER SQUARE INCH OF PROJECTED AREA, Max. (Front Truck)			
325 Lbs.			

CONDITION OF THE LOCOMOTIVE

Locomotive 4185 was first placed in service in September 1939 and made 63,000 miles prior to a Class 4 repairs in September 1940. At the time the locomotive was fitted for test it had made an additional 6300 miles, had had a new set of driving tires applied at the time of shopping and the locomotive was in good condition.

TEST DATA

In the Dynamometer Car the continuous chart recorded the drawbar pull, speed, driving wheel revolutions, fuel and water used and other data. Data readings were taken on the locomotive at intervals of five minutes while the locomotive was operating at full throttle. At the time of starting and stopping the oil and water meters were read and check measurements made by means of a gage stick in the oil and water sections of the tender which had been calibrated.

Water lost through blowoff and that delivered to the boiler by the injector were approximated by timing the length of operation. Temperature measurements were made by mercury and flexible extension tube dial thermometers, the temperature of the steam to the front engine only, being measured with the electrical pyrometer with which this class of locomotive is equipped.

TERRITORY

All tests were run on the Sacramento Division between Roseville California and Sparks, Nevada. The line is all double track although both tracks do not follow the same location through. The general characteristics of the line are shown on the page following.

PEAK
6884.7

ROSEVILLE	162.3
Rocklin	249.0
Penryn	593.2
Newcastle	956.3
Auburn	1266.0
Bowman	1625.2
East Applegate	1965.0
N.E. Mills	2212.7
COLFAX	2417.6
Cape Horn	2663.5
Gold Run	3226.9
Alta	3607.4
Midas	4145.2
Blue Cañon	4692.7
Emigrant Gap	5218.9
Cisco	5932.8
Spruce	6543.6
NORDEN	6675.8
Andover	6398.8
TRUCKEE	5818.8
Boca	5532.5
Floriston	5320.0
Verdi	4892.7
DIVISION POINT	
RENO	4498.9
SPARKS	4475.5

					DIVISION POINT		
2.24	-	-	224	193°	-	RENO	4498.9
						SPARKS	4475.5

(5)

Location	Elevation (ft)
SPARKS	4425.5
RENO	4498.9
DIVISION POINT	4894.0
Floristown	5326.9
Boca	5532.4
TRUCKEE	5818.8
Andover	6398.8
Summit	6965.8
NORDEN	6875.8
Spruce	6543.8
Cisco	5992.8
Emigrant Gap	5218.9
Blue Cañon	4692.7
Midas	4145.2
Gold Run	3226.9
Cape Horn	2663.5
COLFAX	2417.6
N.E. Mills	2280.5
West Applegate	2015.0
Clipper Gap	1759.4
Auburn	1360.5
Newcastle	960.2
Penryn	627.6
Loomis	402.2
Recklin	249.0
ROSEVILLE	162.3

Loomis	402.2
Recklin	249.0
ROSEVILLE	162.3

BETWEEN

OFFICE GEN'L SUPT. MOTIVE POWER
SAN FRANCISCO, CALIF. FEB. 26, 1941.

TRAINS

The engine was tested in freight service only, running single during daylight hours.

Eastbound trains, out of Roseville, consisted of empties of all types, with loads of Company oil when available; Westbound trains, out of Sparks, were ordinarily made up of empty refrigerator and tank cars and such loads as could be made available.

The tonnage of the trains was figured by the Yard Offices in accordance with the present timetable method of allowances for light and under loaded cars. For stock cars an allowance, usually 7 M's, is made when the floor is covered with sand.

For test purposes this method is not sufficiently accurate and from the actual weight of the train and the number of cars an equivalent tonnage was calculated which, if composed of 80 M cars, would result in identical resistance. This provides tonnages which are comparable regardless of whether empties or loads or both made up the train.

Eastbound out of Roseville, tonnages of from 2600 to 3000 M's, including allowances, were hauled through to Sparks. Westbound out of Sparks, conditions ordinarily would not permit a suitably heavy train because of the necessity then, of setting out at Truckee to reduce for the heavier grade starting there. Usually the Sparks tonnage was a compromise which would permit full throttle operation Sparks to Truckee, without exceeding the speed limit and yet not be too great for the heavier grade from Truckee to Norden.

FUEL

The fuel was the present standard cracked oil of the Dubbs type, and had a heat value of 18,250 to 18,280 BTU's per pound, moisture free. Because of its heavy body at normal temperatures, this fuel must be heated to at least 150°F in order to reduce the viscosity sufficiently for the oil to atomize properly at the burner. This is accomplished by a closed heater in the tender for maintaining a temperature there which will provide a free flow of oil from the tender. Because of the distance from the tender to the burner and to facilitate control of the temperature, two steam heated sections of pipe called "oil heaters" are spaced along the fuel oil line between the tender and the burner. A temperature gage placed in the cab, indicates to the fireman the temperature of the oil at the burner so that it may be maintained at the desired temperature by use of one or both of the oil heaters.

CHANGES MADE DURING THE TEST

During the latter part of the test, the exhaust nozzles were increased from 6-3/4" diameter to 7" diameter. No changes were made to the front end arrangement or the draft openings in the firepan when the nozzles were enlarged, as time did not permit.

DATA AND RESULTS

On the pages immediately following are the tabulations and graphs of the data and results.

AVERAGED DATA AND RESULTS
Loco. 4185 Class AC-8 - Dynamometer Test No.9

District Tonnage Handled Including Timetable Allowance - Ms.	Roseville to Colfax			Colfax to Norden		
	2808	2893	2995	2808	2893	2995
Test Run Numbers	3,13,19	5,11,17	7,23	3,13,19	5,11,17	7,23
Date of Test, Year 1940	11/12	11/14	11/17	11/12	11/14	11/17
	12/3	11/25	12/15	12/3	11/25	12/15
	12/11	12/8		12/11	12/8	
<u>Distance, Time & Speed</u>						
Length of Run - Miles	35.5	35.6	35.5	50.5	50.5	49.7
Running Time - Hrs. Mins.	1:22	1:25½	1:29	2:47	3:04.7	3:08.5
Time Standing During Test- Hrs.Mins.	0:0	0:0	0:08	0:32	0:44.3	0:44.5
Total Time - Hrs. Mins.	1:22	1:25½	1:37	3:19	3:49	3:53
Number of Stops During Run	0	0	1.0	1.3	2.0	2.0
Average Speed-Based on Running Time	26.0	25.0	23.9	18.1	16.5	15.8
Speed on Ruling Grade	26.1	24.6	23.5	14.5	12.7	11.2
<u>General Operating Conditions</u>						
No.Times Front Unit Slipped	0	2	2	0	9	1
No.Times Back Unit Slipped	0	2	1	0	4	0
Weather Conditions, General	Good	Good	Good	Good	Good	Good
Weather Temperatures-Max.& Min. °F	44-53	40-50	50-57	53-59	54-64	51-54
Weather Temperatures-Average °F	48°	47°	52°	56°	59°	53°
Rail Conditions	Good	Fair	Good	Good	Fair	Good
<u>Train Data</u>						
Number loaded Cars, inc. Test Car	9	6	3	9	6	3
Number empty Cars, inc. Caboose	29	42	53	29	42	53
Total Number Cars	38	48	56	38	48	56
Actual Weight of Train, Excl.of Loco., Ms.	2767	2874	2940	2767	2874	2940
Weight of Train, *Adj. Ms	2798	2972	3100	2785	2931	3032
Weight of Train, *Adj.-Tons	1399	1486	1550	1392	1465	1516
*Weight of train, adjusted to 80 M cars.						

AVERAGED DATA AND RESULTS
Loco. 4185 Class AC-8 - Dynamometer Test No.9

District Tonnage Handled Including Timetable Allowance - Ms	Roseville to Colfax			Colfax to Norden		
	2808	2893	2995	2803	2893	2995
<u>Train Data (Cont'd)</u>						
Ton Mileage - Excl. of Loco.	49,664	52,902	55,025	70,321	74,077	75,345
<u>Average Pressures-Lbs. Per Sq. In. Gage</u>						
Boiler Pressure	245	245	247	247	246	247
Steam Chest Pressure-Front Unit	218	212	214	220	218	220
Steam Chest Pressure-Back Unit	206	203	200	209	210	209
Back Pressure-Front Unit	14.5	15.1	15.1	15.4	14.9	14.4
Back Pressure-Back Unit	13.9	13.5	13.4	14.0	13.5	12.9
Exh. Steam to Feedwater Heater	12.8	12.5	12.4	13.0	12.5	11.9
Pressure Drop Through Superheater	22.6	20.8	18.9	19.6	18.9	16.9
<u>Average Temperatures °F</u>						
Temp. Steam to Front Unit	703	705	709	700	691	690
Temp. Steam to Back Unit	666	668	661	655	660	662
Temp. Exhaust Steam (Back Unit)	333	326	318	344	340	348
Temp. Feedwater from F.W. Hot Pump	235	231	230	230	228	230
Temp. Water to Feedwater Heater (Tender Temp.)	50	49	43	44	45	44
Temp. Flue Gas in Smokebox	580	578	575	574	572	570
Draft at Smokebox Tube Sheet, - In. Water	15.4	16.6	16.9	17.1	16.6	16.4
Draft at Smokebox Front, -In. Water	15.9	17.1	17.4	17.6	17.1	16.9
Carbon Dioxide (CO ₂) in Flue Gas, %	11.6	12.6	13.1	11.1	11.0	11.6
<u>Oil Data</u>						
Heat Value of Fuel Oil, BTUs per lb. (As fired)	18,200	18,200	18,200	18,200	18,200	18,200
Weight of Oil Per Gallon, lbs.	8.328	8.328	8.328	8.328	8.328	8.328
Oil Fired, Total, Gals.	1,051	1,097	1,155	2,082	2,241	2,337

10

AVERAGED DATA AND RESULTS
Loco. 4185 Class AC-8 - Dynamometer Test No.9

District Tonnage Handled Including Timetable Allowance - Ms	Roseville to Colfax			Colfax to Norden		
	2808	2893	2995	2808	2893	2995
<u>Oil Data (Cont'd)</u>						
Oil Fired While Standing, Gals.	0	0	0	26	29	22
Oil Fired While Running, Gals.	1,051	1,097	1,155	2,056	2,212	2,315
Oil Fired While Running, Lbs.	8,753	9,136	9,619	17,122	18,421	19,279
Oil Fired Per Hour While Running, Lbs.	6,403	6,416	6,486	6,150	5,993	6,136
Oil Fired Per Hour Per Cu.Ft. Firebox Volume, Lbs.	7.53	7.55	7.63	7.23	7.05	7.22
Oil Fired Per 1000 Ton Miles-Gallons	21.2	20.7	21.0	29.2	29.9	30.7
<u>Water Data</u>						
Gallons Water From Tank to F.W.H.	10,797	11,160	11,545	21,848	22,860	24,555
Gallons Water From Tank to Injector	200	0	0	140	280	0
Gallons Water, Correction for Boiler Level *	87(L)	103(L)	314(L)	587(L)	301(L)	388(L)
Total Water used, Gals.	11,084	11,263	11,859	22,575	23,441	24,943
Total Water used, Lbs.	92,330	93,862	98,784	188,050	195,263	207,775
Exhaust Steam Condensed by F.W.H., Gals.	#1,995	2,026	2,157	#3,993	4,113	4,501
Exhaust Steam Condensed by F.W.H., Lbs.	#16,622	16,876	17,968	#33,261	34,261	37,493
Total Water Delivered to Boiler, Gals.	13,079	13,289	14,016	26,568	27,554	29,444
Total Water Delivered to Boiler, Lbs.	108,948	110,697	116,753	221,311	229,525	245,268
Water to Boiler Per Hour, Gals.	9,568	9,332	9,451	9,543	8,963	9,371
Water to Boiler Per Hour, Lbs.	79,701	77,736	78,727	79,493	74,662	78,060
Gallons Water from Tender Per 1000 Ton Miles	221	210	209	313	312	326

* L indicates less water in boiler at end of run.

Runs 3 - 19 only.

AVERAGED DATA AND RESULTS
Loco. 4185 Class AC-8 - Dynamometer Test No.9

District Tonnage Handled Including Timetable Allowance - Ms	Roseville to Colfax			Colfax to Norden		
	2808	2893	2995	2808	2893	2995
<u>Boiler Data</u>						
Equivalent Evaporation Per Hour, Lbs.	#94,307	93,301	94,330	#91,921	89,463	92,736
Equiv. Evap. Per Hr. Per Sq. Ft. Firebox Heating Surface, Lbs.	#183.8	181.9	183.9	#179.2	174.4	180.8
Equiv. Evap. Per Hr. Per Sq. Ft. Total Heating Surface, Lbs.	#9.9	9.8	9.9	#9.7	9.4	9.8
Equiv. Evap. Per Lb. Oil Fired, Lbs.	#14.7	14.5	14.5	#15.3	14.9	15.1
Water Evap. Per Lb. Oil Fired, Lbs.	#12.3	12.1	12.1	#12.8	12.5	12.6
Boiler Efficiencies, Excl. F.W.H. - %	#78.5	77.7	77.5	#81.5	79.3	80.5
Boiler Efficiencies, Incl. F.W.H. - %	#91.2	89.8	90.3	#94.7	92.1	93.6
<u>Drawbar Data</u>						
Drawbar Horsepower Hrs. as Measured	3,629	4,068	4,159	6,925	7,574	7,811
D.B.H.P. Hr. Equivalent to Loco. Grade and Curve Resistance	1,141 •	1,141	1,141	2,329	2,329	2,329
Equiv. D.B.H.P. Hr. on Level Tangent Track	4,770	5,209	5,300	9,254	9,903	10,140
Equiv. Average D.B. Pull on Level-Lbs.	50,387	54,870	55,986	68,717	73,537	76,509
Equiv. Average D.B.H.P. on Level	3,489	3,658	3,574	3,324	3,274	3,227
Steam Per Equiv. D.B.H.P. Hr., Lbs. (inc. - aux.)	#22.64	21.25	22.02	#23.62	23.18	24.03
Water Supply Req. Per Equiv. D.B.H.P. Hr. - Gals.	2.32	2.16	2.24	2.44	2.37	2.46
Lbs. Oil Per D.B.H.P. Hr.	1.835	1.754	1.815	1.846	1.860	1.901
Thermal Efficiency - Percent	7.62	7.97	7.70	7.56	7.52	7.36

Runs 3 - 19 only.

AVERAGED DATA AND RESULTS
Loco. 4185 Class AC-8 - Dynamometer Test No.9

District	Sparks to Truckee	Truckee to Norden
Test Run Numbers	6, 16	6,10,20
Date of Test, Year 1940	11/15 12/7	11/15 11/20 12/12
<u>Distance, Time & Speed</u>		
Length of Run - Miles	37.5	15.6
Running Time - Hrs. Mins.	2:5	1:7
Time Standing During Test - Hrs. Mins.	0:1	0:0
Total Time - Hrs. Mins.	2:6	1:7
Number of Stops During Run	1	0
Average Speed-Based on Running Time	18.0	14.0
Speed on Ruling Grade	15.5	12.0
<u>General Operating Conditions</u>		
No. Times Front Unit Slipped	1	1
No. Times Back Unit Slipped	8	4
Weather Conditions, General	Good	Good
Weather Temperatures-Max. & Min. °F	33-51	22-58
Weather Temperatures-Average °F	43	40
Rail Conditions	Good	Good
<u>Train Data</u>		
Number Loaded Cars, inc. Test Car	18	21
Number Empty Cars, inc. Caboose	81	31
Total Number Cars	99	52
Weight of Train, incl. Timetable Allowance - Ms	6,250	3,750
Weight of Train, Tons	3,125	1,875

AVERAGED DATA AND RESULTS
Loco. 4185 Class AC-8 - Dynamometer Test No.9

District	Sparks to Truckee	Truckee to Norden
<u>Train Data (Cont'd)</u>		
Ton Mileage - Excl. of Loco.	117,200	29,250
<u>Average Pressures-Lbs.Per Sq.In.Gage</u>		
Boiler Pressure	245	247
Steam Chest Pressure - Front Unit	218	221
Steam Chest Pressure - Back Unit	204	211
Back Pressure - Front Unit	15.7	14.7
Back Pressure - Back Unit	14.2	14.0
Exh.Steam to Feedwater Heater	13.2	13.0
Pressure Drop Through Superheater	18.9	15.6
<u>Average Temperatures °F</u>		
Temp.Steam to Front Unit	704	697
Temp.Steam to Back Unit	658	649
Temp.Exhaust Steam (Back Unit)	348	349
Temp.Feedwater from F.W. Hot Pump	228	229
Temp.Water to Feedwater Heater (Tender Temp)	49	39
Temp.Flue Gas in Smokebox	573	570
Draft at Smokebox Tube Sheet, - In.Water	17.5	16.5
Draft at Smokebox Front, - In.Water	18.0	17.0
Percent Carbon Dioxide (CO ₂) in Flue Gas	10.9	10.5
<u>Oil Data</u>		
Heat Value of Fuel Oil, B.T.U.'s Per Lb. (As fired)	18,200	18,200
Weight of Oil Per Gallon, Lbs.	8.328	8.328
Oil Fired, Total, Gals.	1,610	784

AVERAGED DATA AND RESULTS
Loco. 4185 Class AC-8 - Dynamometer Test No.9

District	Sparks to Truckee	Truckee to Norden
<u>Oil Data (Cont'd)</u>		
Oil Fired While Standing, Gals.	0	0
Oil Fired While Running, Gals.	1610	784
Oil Fired While Running, Lbs.	13,408	6,529
Oil Fired Per Hour While Running, Lbs.	6,436	5,845
Oil Fired Per Hour Per Cu.Ft. Firebox Volume, Lbs.	7.59	6.90
Oil Fired Per 1000 Ton Miles - Gallons	13.7	26.8
<u>Water Data</u>		
Gallons Water From Tank to F.W.H.	16,705	7,966
Gallons Water From Tank to Injector	0	0
Gallons Water, Correction for Boiler Level*	140(L)	453(L)
Total Water Used, Gals.	16,845	8,419
Total Water Used, Lbs.	140,320	70,130
Exhaust Steam Condensed by F.W.H., Gals.	2,932	1,444
Exhaust Steam Condensed by F.W.H., Lbs.	24,423	12,028
Total Water Delivered to Boiler, Gals.	19,777	9,863
Total Water Delivered to Boiler, Lbs.	164,742	82,159
Water to Boiler per Hour, Lbs.	79,085	73,554
Gallons Water from Tender per 1000 Ton Miles	142.5	272.3
<u>Boiler Data</u>		
Equivalent Evaporation Per Hour, Lbs.	94,860	87,571
Equiv.Evap.Per Hr.Per Sq.Ft.Firebox Heating Surface, Lbs.	184.9	170.7
Equiv.Evap.Per Hr.Per Sq.Ft.Total Heating Surface, Lbs.	10.0	9.22

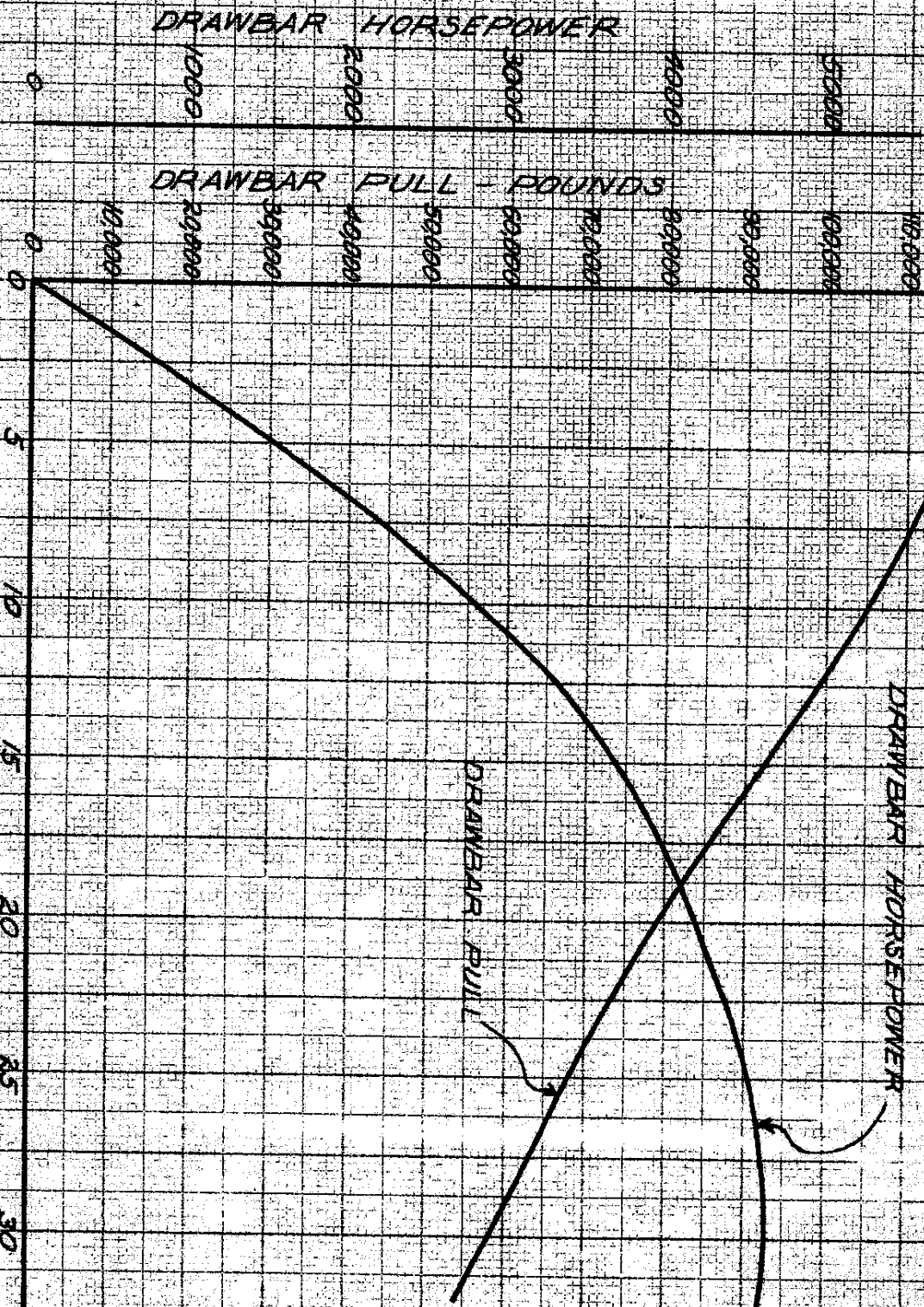
* L indicates less water in boiler at end of run.

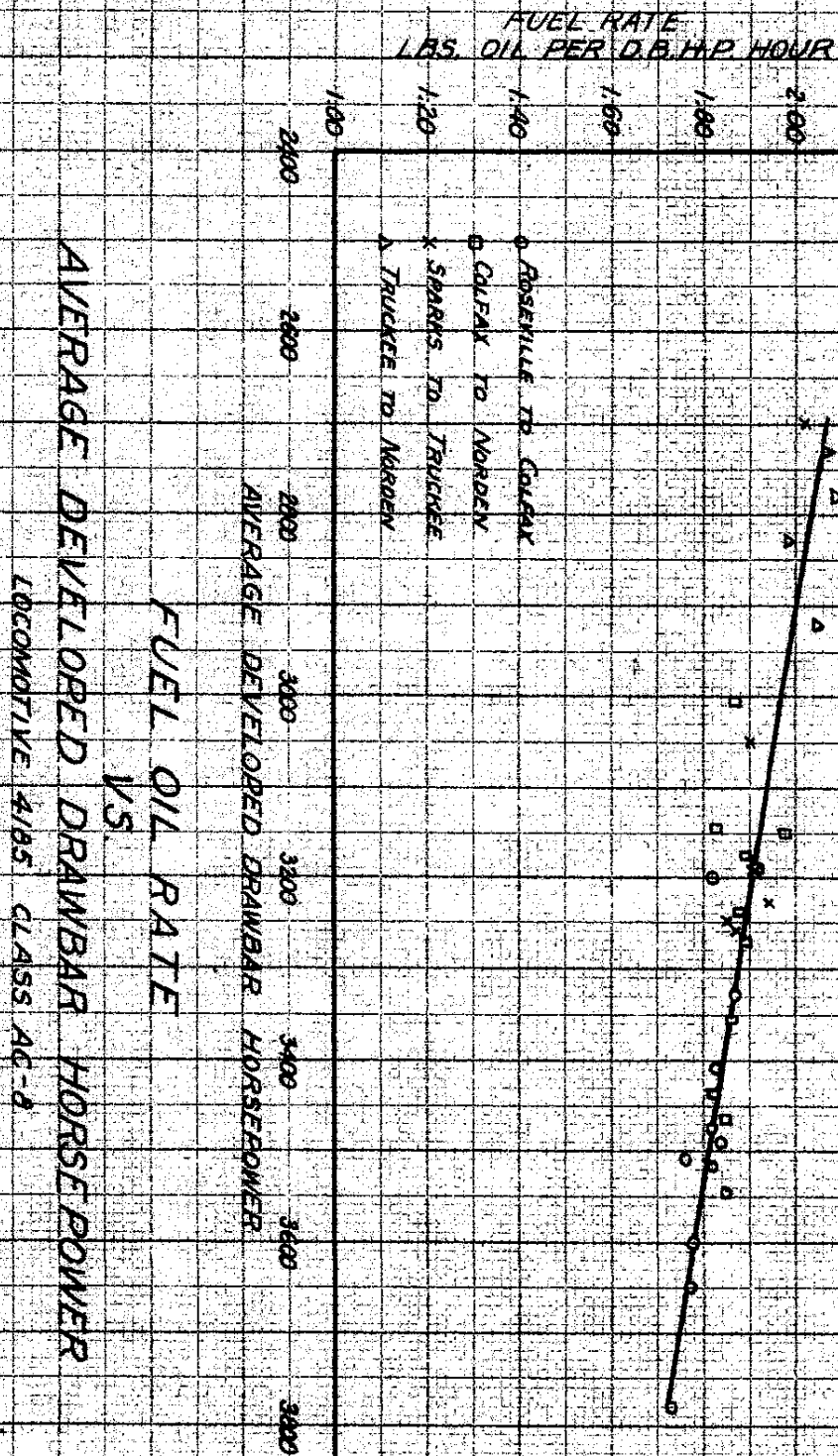
AVERAGED DATA AND RESULTS
Loco. 4185 Class AC-8 - Dynamometer Test No.9

District	Sparks to Truckee	Truckee to Norden
<u>Boiler Data (Cont'd)</u>		
Equiv.Evap.Per Lb.Oil Fired, Lbs.	14.7	15.0
Water Evap.Per Lb.Oil Fired, Lbs.	12.3	12.6
Boiler Efficiencies, Excl. F.W.H. - %	78.7	80.2
Boiler Efficiencies, Incl. F.W.H. - %	90.4	93.5
<u>Drawbar Data</u>		
Drawbar Horsepower Hrs., as measured	6,230	2,578
D.B.H.P. Hr.Equivalent to Loco. Grade and Curve Resistance	729	652
Equiv. D.B.H.P. Hr. on Level Tangent Track	6,959	3,230
Equiv.Average D.B.Pull on Level - Lbs.	69,590	77,640
Equiv.Average D.B.H.P. on Level	3,340	2,890
Steam Per Equiv. D.B.H.P. Hr., Lbs. (inc. aux.)	23.7	25.4
Water Supply Req. Per Equiv. D.B.H.P. Hr. - Gals.	2.42	2.61
Lbs. Oil Per D.B.H.P. Hr.	1.927	2.021
Thermal Efficiency - Percent	7.26	6.92

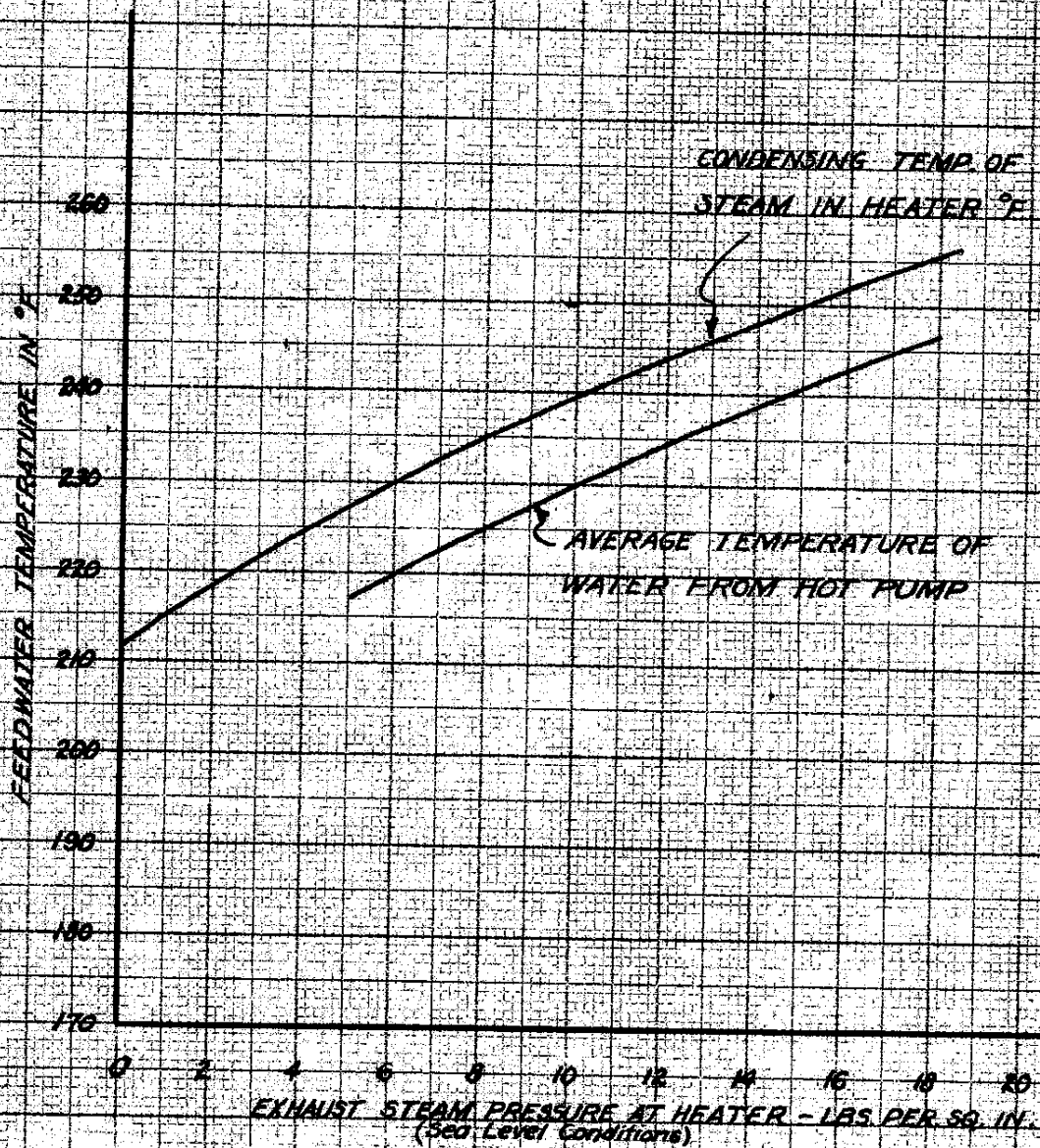
Southern Pacific Lines
Office of Genl. Supt. Motive Power
San Francisco Calif April 7, 1941

DRAWBAR PULL AND HORSEPOWER (LEVEL TRACK)
LOCOMOTIVE #185 CLASS AC-8





Southern Pacific Lines
Office of Gen'l Supt. Marine Power
San Francisco, Calif. April 7, 1941



FEEDWATER TEMPERATURES

WORTHINGTON 6 SA F.W. HEATER

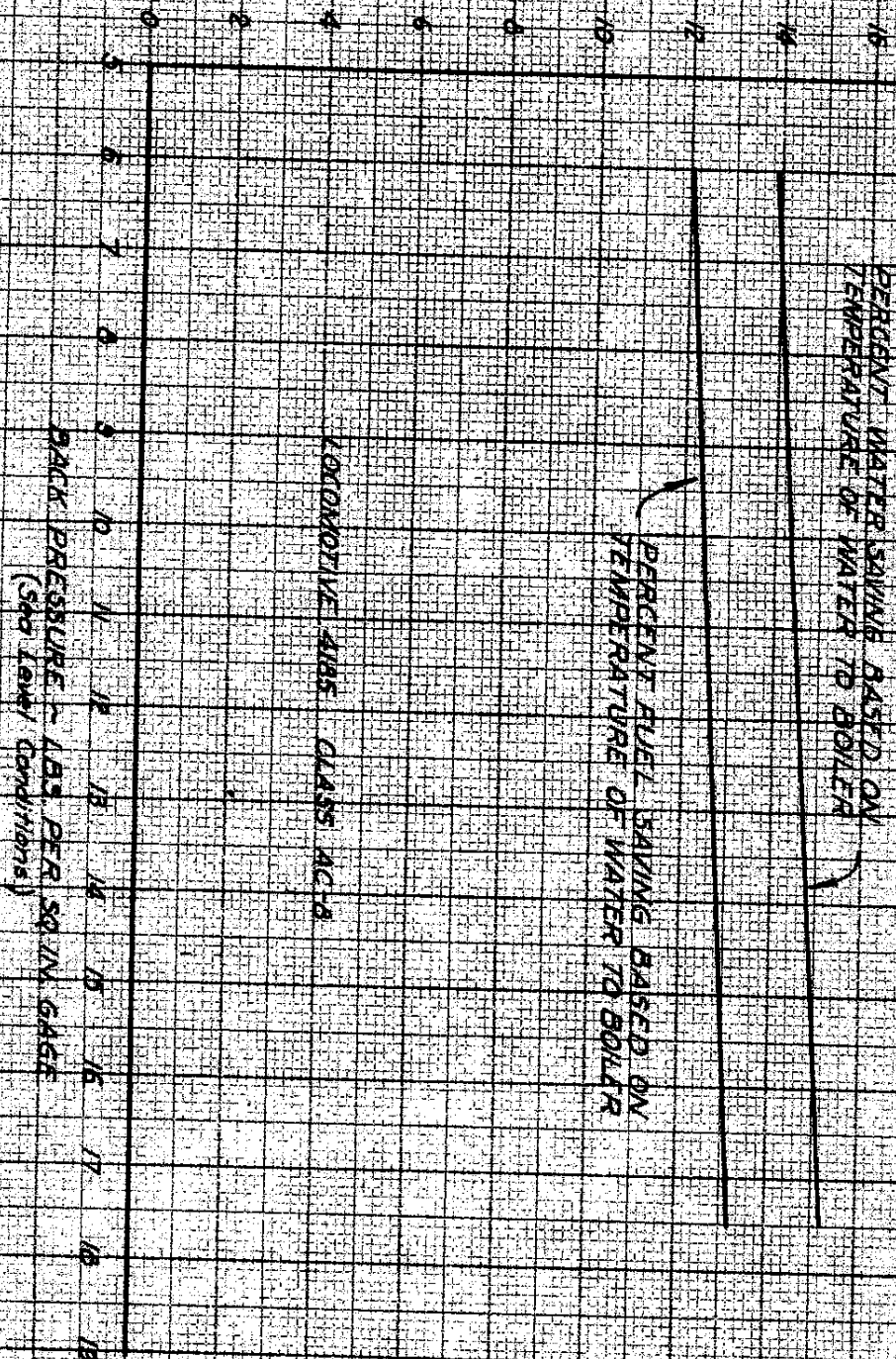
LOCOMOTIVE 4185 CLASS AC-8

Southern Pacific Lines

Office of Gen'l Supt. Motive Power

San Francisco, Calif. Feb. 4, 1941

FUEL AND WATER SAVING - PERCENT



FUEL AND WATER SAVING WITH FEEDWATER HEATER (BASED ON ASSUMED LIVE STEAM INJECTOR OPERATION)

Note:

Fuel saving shown is based on heat recovery only and does not include fuel saving that would accrue due to improvement in boiler efficiency and reduction in back pressure, especially at high power outputs.

Southern Pacific Lines
Office of Genl. Supt. Marine Power
San Francisco Calif. April 7, 1941

SPEED IN MILES PER HOUR

0 4 8 12 16 20 24 28

2750 2800 2850 2900 2950 3000 3050 3100

ROSEVILLE TO COLFAX

AVERAGE SPEED

SPEED ON RULING GRADE

COLFAX TO NORDEN

AVERAGE SPEED

SPEED ON RULING GRADE

LOCOMOTIVE 4185 CLASS AC-B

• AVERAGE SPEED

○ SPEED ON RULING GRADE

WEIGHT OF TRAIN, M.T. ADJUSTED TO 80 M CARS

TRAIN SPEED VS LOAD

NOTE: Average Speed based on Running Time, not Time Over District

Southern Pacific Lines
Office of Genl Supt Motive Power
San Francisco, Calif April 7, 1921

WORK AT DRAWBAR - DRAWBAR HP. HOURS

ROSEVILLE TO COLFAX

COLFAX TO NORDEN

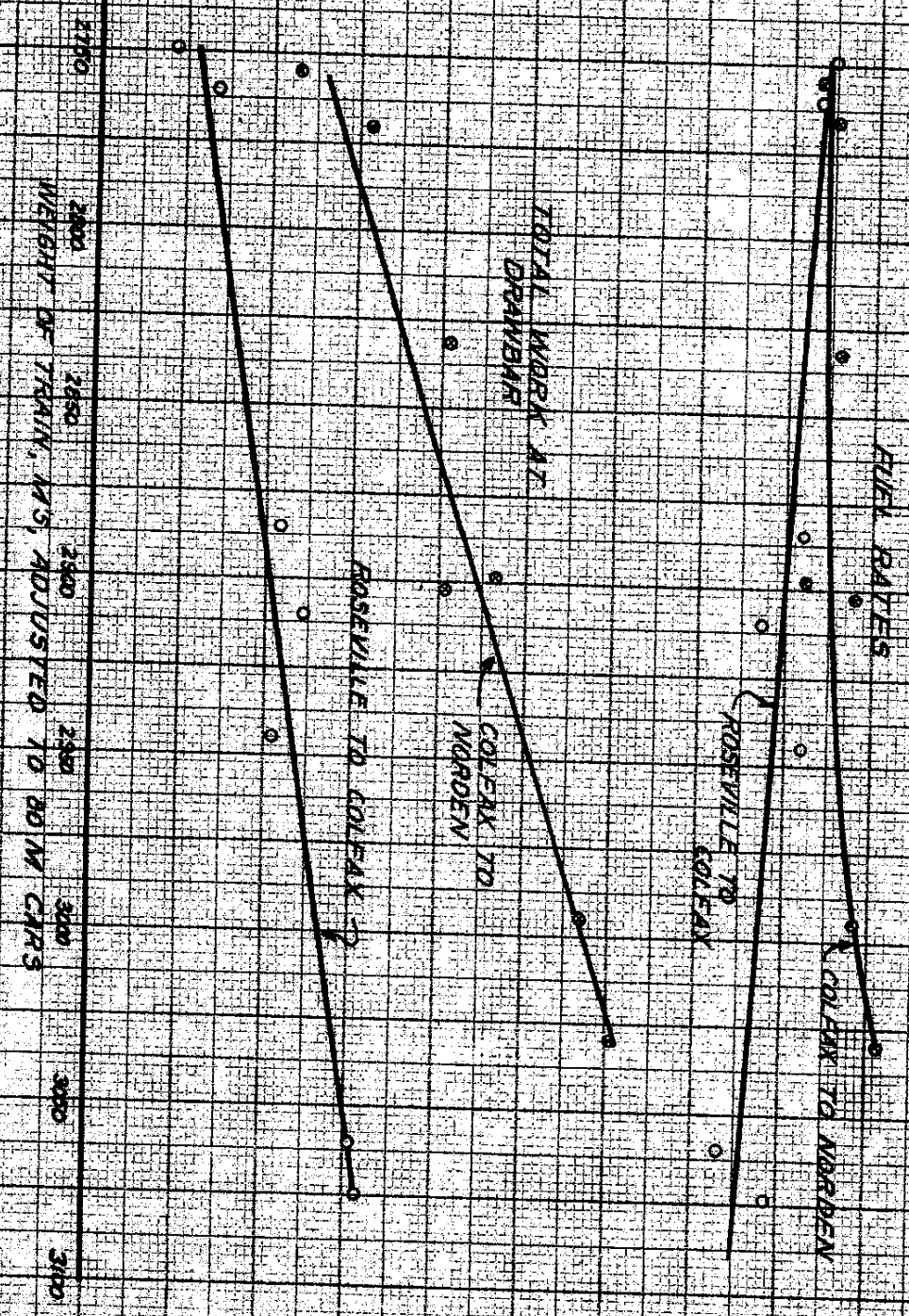
FUEL RATE - LBS. OIL PER DRAWBAR HORSEPOWER

FUEL RATE AND WORK VS. LOAD

LOCOMOTIVE 4105 CLASS 5 AC-8

Southern Pacific Lines

Office at 6401 S. 1st St. Marine Power
San Francisco Calif April 7 1941



TOTAL OIL USED WHILE RUNNING - GALLONS

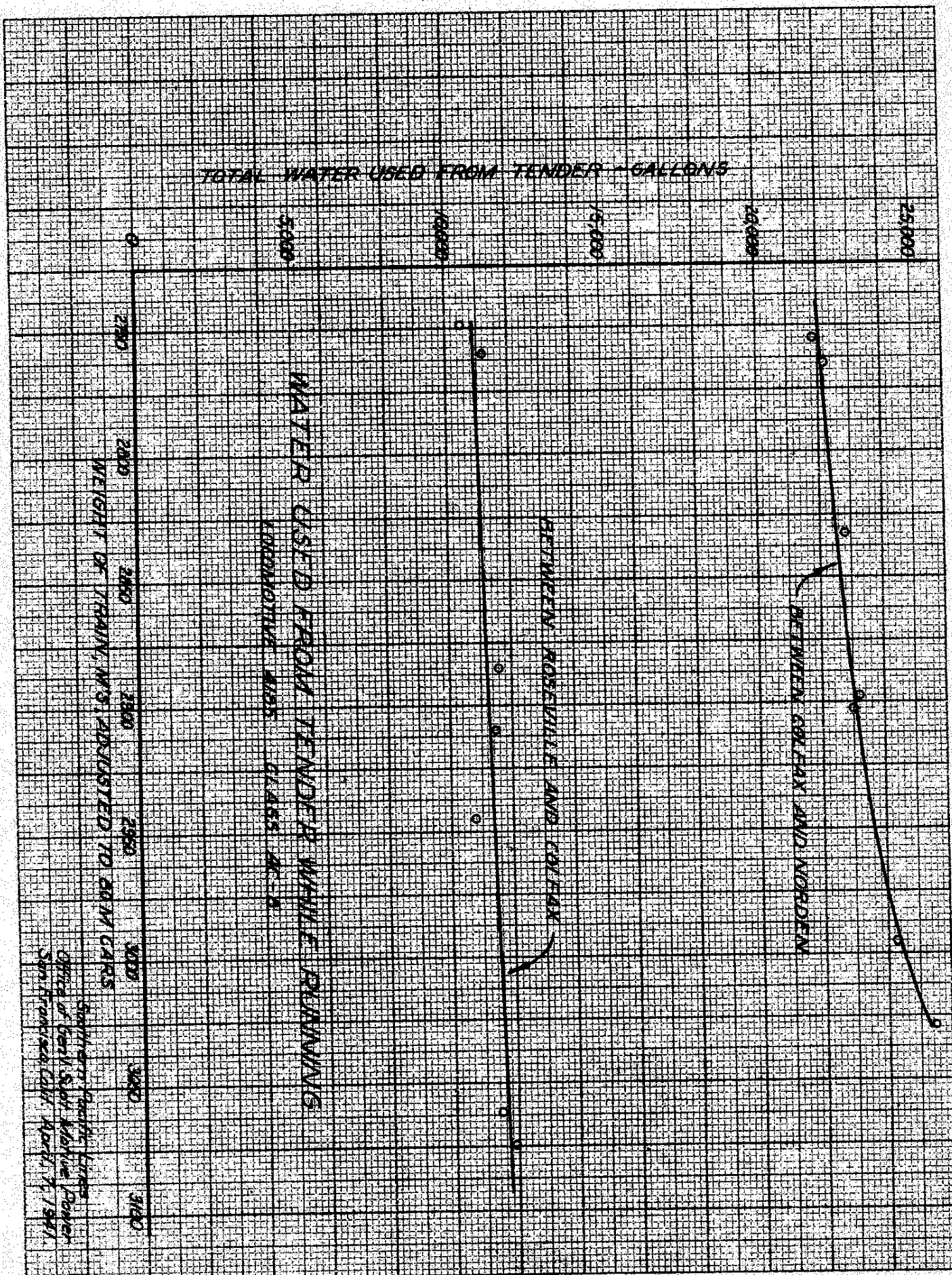
OIL USED FROM TENDER WHILE RUNNING
LOCOMOTIVE AIRS CLASS A-C-B

BETWEEN AOSVILLE AND COLLECK

BETWEEN COLLECK AND NORDEN

WEIGHT OF TRAIN IN S. ADJUSTED TO 40 M. CARS

Southern Pacific Lines
OFFICE CHIEF, SOUTHERN PACIFIC
SAN FRANCISCO, CALIF. April 2, 1941.



Length of 100 ft. train
 Office of Civil Supply, Air Force, Power
 San Francisco, Cal. April 7, 1941

GALLONS OF OIL PER 1000 TON MILES

0 1 2 3 4 5 6 7 8 9

2750

2800

2850

2900

2950

3000

3050

3100

WEIGHT OF TRAIN, M.T.S. ADJUSTED TO 40 M. T.A.B.S.

GALLONS OF OIL PER 1000 TON MILES

BY DISTRICTS

LOCOMOTIVE A1B5

CLASS A1-B

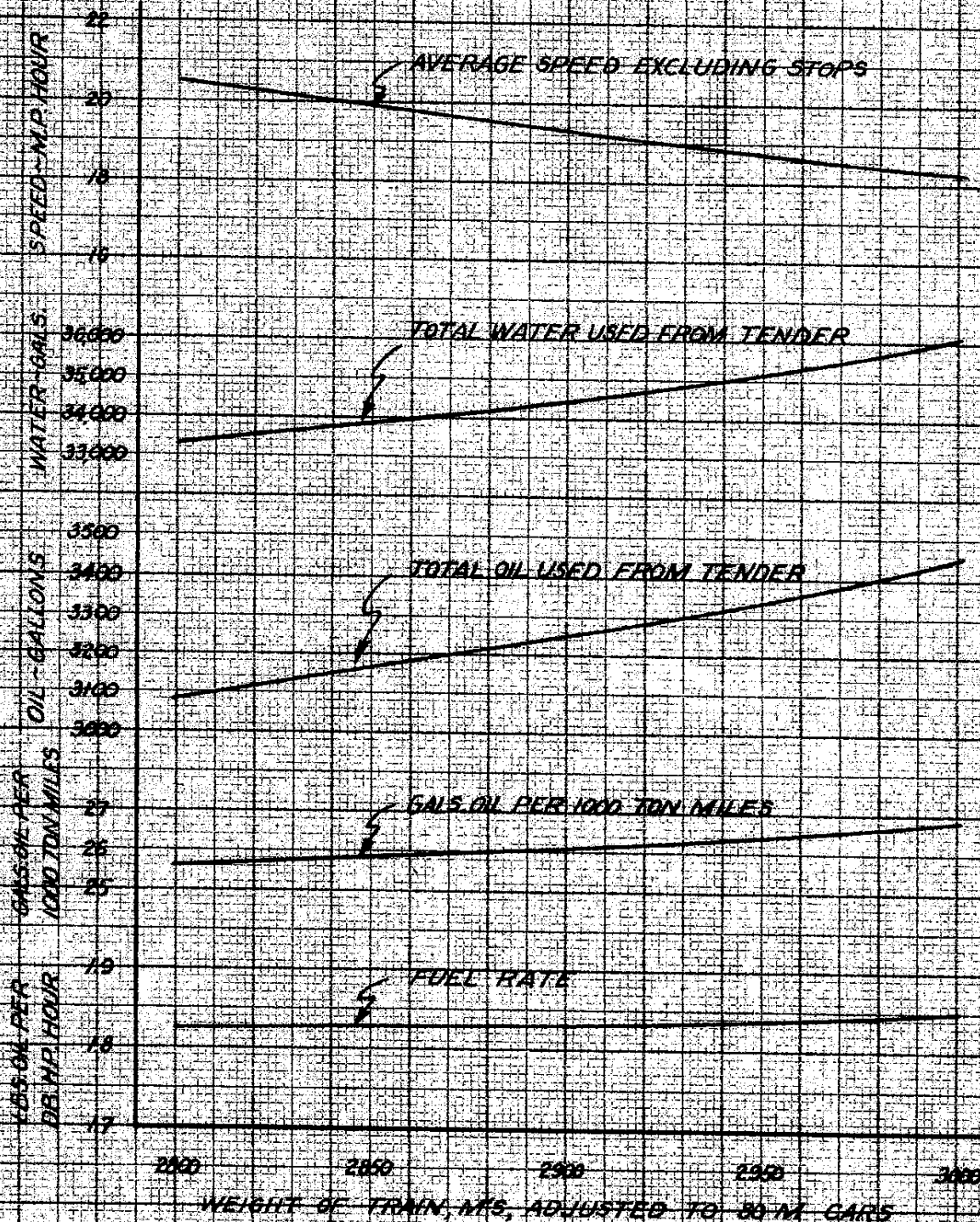
Southern Pacific Lines

Office of Civil Service, National Council

San Francisco, Calif. April 2, 1961

ROSEVILLE TO COLFAX

COLFAX TO NORDEN



AVERAGE DATA FOR THROUGH TRAIN
ROSEVILLE TO NORDEN
LOCOMOTIVE 4185 - CLASS AC-B.

Southern Pacific Lines
Office of Gen'l Supt. Motive Power
San Francisco, Calif. April 7, 1941

RESULTS, CONCLUSIONS & RECOMMENDATIONS

DRAWBAR PULL AND HORSEPOWER

The drawbar pull and drawbar horsepower obtained, adjusted to level track, are shown on page 16. Due to the test being conducted in freight service in mountain territory, the locomotive was not operated much at speeds higher than 30 miles per hour. Because of this limitation, the maximum performance was not obtained for speeds over 25 miles an hour. The fuel rate curve on page 17, shows that the fuel rate continually decreased as the average horsepower developed increased, which also indicates that the locomotive was not forced to maximum output.

EFFICIENCY OF THE LOCOMOTIVE.

The curves on pages 17 and 21 show the fuel used per horsepower at the drawbar, as compared to average horsepower output and as compared to train-load, Eastbound. These curves show a very efficient fuel performance, the fuel rate varying from 2.06 lbs. to 1.74 lbs. per drawbar horsepower hour. The lower values of fuel rate were obtained at the upper speeds and outputs.

The efficiency of the boiler was extremely good, varying from 77.5% to 81.5% exclusive of the feedwater heater and from 89.8% to 94.7% with the heater included, which represents an excellent performance, especially at the higher outputs. There is no evidence of boiler efficiency falling off as the firing rate is increased within the limits of the test.

The feedwater heater performance curves are shown on pages 18 and 19. The curve on page 18 shows the average feedwater temperatures obtained at the hot pump, compared with the

condensing temperature of the exhaust steam, for various pressures. The differential is about 10° for the entire range of back pressures observed during the test. This represents as high a temperature as can be obtained and still maintain reliable operation of the hot pump. The curve on page 19 shows the percent fuel and water saved by the heater on heat transfer basis as compared to back pressure. The fuel saving is from 12% to 13% and the average being $12\frac{1}{2}\%$. The corresponding average saving in water is $14\frac{1}{2}\%$.

TONNAGE RATING

In conducting these tests the tonnage of the trains was varied on the Eastbound runs to investigate the effect of tonnage rating on the performance of the locomotive. A similar investigation, although not as extensive, was made on the Westbound runs from Truckee to Norden. Due to the necessity of not using helpers on test trains, and to operating conditions, no check was made of ratings from Roseville to Colfax and from Sparks to Truckee.

Present ratings as shown on timetable are 3250 M's from Colfax to Sparks and 4150 M's from Truckee to Summit. These ratings were set several years ago on a basis of 10 miles per hour on ruling grade. Because of winter conditions, tests were run Eastbound with trains of approximately 2800 M's, 2900 M's and 3000 M's, or 86%, 89% and 92% of present full timetable rating; it not being considered advisable to attempt operation with full rating of 3250M's. With operation of trains of from 2598 to 3008 M's, excessive slipping was encountered on 5 out of 15 trips, although rail conditions were comparatively good for the time of the year except on a few runs.

The curves on pages 20 to 25 inclusive, show the comparative performance with various weights of train Eastbound. On all these curves the train-loads have been adjusted to the equivalent weights of trains of 80 M cars, to eliminate all changes in resistance caused by varying proportions of empty and loaded cars. On page 20 are shown the average speeds and speeds on ruling grade, for trains of from 2750 M's to 3050 M's. From Colfax to Norden, the average speed varies from over 18 miles an hour with 2750 M's to 15 miles per hour with 3050 M's; the speed on ruling grade varies from over 15 miles per hour down to $10\frac{1}{2}$ for these same loads. The heaviest pulls, as indicated on the dynamometer record, are just West of Gold Run, at Alta, and roughly, from Midas to Knap. The speed curves as shown, were prepared from runs where rails conditions were good and temperatures were normal for the time of year. As shown on the curve of speed on ruling grade, Colfax to Norden, on page 20, the speed on ruling grade is $10\frac{1}{2}$ miles per hour with 3050 M's, and it is apparent that present timetable rating of 3250M's could only be handled under unusually favorable circumstances.

On pages 21, 24 and 25 are shown the variations of fuel per drawbar horsepower hour, average speed excluding stops, and fuel per 1000 ton miles, both for districts Roseville to Colfax and Colfax to Norden, as well as for through runs from Roseville to Norden. On the higher speed district from Roseville to Colfax, the fuel rate on a horsepower basis, decreases slightly as load increases and fuel per 1000 ton miles is appreciably constant. However, on the heavy grade from Colfax to Norden, the fuel rate,

both on a horsepower hour and a ton mile basis, becomes higher as the train-load is increased; both curves show that the fuel rates increase more rapidly as the load increases beyond 2900 M's, a result of the lower superheat and engine efficiency at low speeds.

In view of this effect on fuel rate and the data developed as to speed on ruling grade as shown on the curves, page 20, it is recommended that rating for these locomotives be set at 2900 M's Colfax to Sparks which would give an average speed from Colfax to Norden, exclusive of stops, of about 16 miles per hour, and a speed on ruling grade of over 12 miles per hour. This would provide efficient operation of the locomotive and maintain sufficient speed on ruling grade to avoid excessive slipping.

From Truckee to Summit, trains were loaded with from 3395 M's to 3754 M's apart from two runs where very light trains were hauled when tonnage was not available. Of the 13 runs with loads of from 3395 to 3754 M's, excessive slipping was experienced on four. On the runs where the train-load was from 3700 to 3754 M's, the speed on ruling grade was from $11\frac{1}{2}$ to 13 miles per hour with good rail conditions. Present timetable rating of 4150 M's at 10 miles per hour represents an extremely heavy load for this class of locomotive, particularly in view of the fact that the upper part of this run is through a succession of snowsheds and tunnels where rail conditions are bad during most of the year. A rating that involves operation at 10 miles per hour under best conditions is excessive for normal operation. In view of test experience over this district it is recommended that the rating be set at 3700 M's

from Truckee to Summit.

Ratings on the above two districts should be subject to reductions of 10% for winter ratings when rail conditions are poor and slipping is liable to be excessive, with a further reduction for extremely adverse conditions.

Excessive slipping of drivers causes rapid tire and rail wear, and results in increased cost of maintenance and in machinery failures.

TESTS ON "CREEPING" OF DRIVING TIRES

During the course of the test, the locomotive was equipped with revolution counters on the front and back sets of drivers, both to record slipping and to study the "creep" of the drivers under heavy load. "Creep" of drivers is defined as not slipping freely or quarter slipping but as a slight continuous motion of the drivers on the line of rail contact caused by the heavy turning effort transmitted.

It was believed that if such action were appreciable it would shed some light on the question of rapid tire wear on the AC class locomotives operating on the Sacramento Division. The number of revolutions of the drivers on heavy upgrade pulls when there was no apparent slipping, was compared with profile distance and with the number of revolutions of drivers on down-grade parallel track operation. It was found that wheel "creep" on up-grade is very small, being in the neighborhood of from 0.5% to 0.9% excess revolutions. The "creep" on the several runs was irregular, but showed a tendency to increase somewhat with the heavier loads.

However the results are not entirely consistent in this regard. It appears therefore, that the slight creep is not a material factor in the rapid driving tire wear.

It was noted that there was little evidence of quarter slip in the revolution counter records; the drivers either held the rail or lost traction completely.

ENLARGED NOZZLE TESTS

Poor operating conditions on the few runs made with the exhaust nozzles enlarged to 7" did not permit a comparison to be made but observations during the runs indicated the steaming qualities were adversely affected. Winter storms and other conditions prevented further investigation.

Office Genl. Supt. Motive Power,
Southern Pacific Company,
San Francisco, California,
April 16th, 1941.