

Report of Tests

Sellers Exhaust Steam Injector

Locomotive 3911

July - September 1940

Union Pacific Railroad Company  
Research & Mechanical Standards

Report Of Tests  
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Introduction

This report covers the tests conducted on Locomotive 3911 with the Sellers Exhaust Steam Injector. Locomotives 3910-14 came from the builders with this injector. Before testing the injector the Labyrinth front end, multiple stacks, and two multiple jet nozzles were applied.

In September 1940, the Sellers Exhaust Steam Injector was removed and the Elesco Type "TP" Exhaust Steam Injector applied in its place. The performance of the latter injector is covered in detail in another report.

Also another report on Locomotive 3911 with the Elesco injector covers the cylinder and boiler performance of the locomotive.

As the other reports cover the performance of Locomotive 3911 with the Elesco injector fully, this report is confined to the boiler performance and the performance of the Sellers Exhaust Steam Injector.

Summary

Fuel saved per trip by operation of the Sellers Exhaust Steam Injector is shown by Data Sheet No. 5. Fuel savings are also shown by Figure No. 3 and the following tabulation:

Firing Rate Lbs. Coal Per Hr.	Sellers Injector Compared With Live Steam Injector	
	Lbs. Coal Saved Per Hr.	Per Cent Saving
7000	370	5.02
8000	425	5.04
9000	480	5.06
10000	540	5.12
11000	600	5.17
12000	680	5.36
13000	780	5.66
14000	900	6.04
15000	1060	6.60
16000	1260	7.30
17000	1520	8.21

Locomotives 3910-14 other than Locomotive 3911 have 9000 gallon injector tubes which are ample to supply the boiler. Since the front end arrangement on Locomotive 3911 increased the boiler capacity, 11000 gallon tubes were applied to the Sellers Exhaust Steam Injector. This size was satisfactory but barely supplied the boiler at the higher demands.

As shown by the tabulation the fuel saved by the operation of the Sellers Exhaust Steam Injector runs from 5.02 to 8.21 per cent at firing rates from 7000 to 17000 pounds of coal per hour. The maximum evaporation based upon the average evaporation ratio is 88563 pounds of water per hour. See figure No. 1. With live steam injector operation the maximum evaporation is 76951 pounds of water per hour. Although the fuel savings are not very good, the increase in maximum evaporation of 11612 pounds or 15.1 per cent is substantial.

The Sellers Exhaust Steam Injector has a quite limited range. With 65 degree Fahr. tank water the maximum delivery with a full tank of water is 80552 pounds of tank water per hour. The minimum delivery is 55440 pounds of tank water per hour.

The injector is equipped with a change over controlled by exhaust pipe pressure. The operation of both the control apparatus and the injector proved to be satisfactory.

#### Territory and Trains

Tests were run in both directions between Cheyenne and Laramie, Laramie and Green River, and Green River and Ogden. All runs were made in freight service with the exception of one run from Cheyenne to Laramie. The tests represent every day performance as whatever train and tonnage was available was taken.

Tests were also run in helper service from Cheyenne to Sherman before going into regular road service in order to determine the correct exhaust nozzle area, grate openings, and secondary air openings over the fire for proper combustion.

#### Locomotive

Locomotive 3911 is equipped with multiple stacks, multiple jet exhaust nozzles, a Labyrinth front end, and secondary air admitted over the fire with 28 - 2-1/4 inch tubes.

The front end dimensions are shown by the following tabulation:

Type Nozzle	-----	Multiple Jet
Area Nozzle - Square Inches	-----	56.55
Nozzle Tip to Bottom of Front End - Inches	----	25-3/32
Nozzle Tip to Bottom of Stack Flare - Inches	---	15-3/4
Total Length Stack Including Flare - Inches	----	57-7/8
Inside Diameter of Stack at Choke - Inches	----	24-1/2
Inside Diameter of Stack at Top - Inches	-----	29-1/2

The important locomotive dimensions are shown by the following tabulation:

General Classification	-----	4-6-6-4
Union Pacific Classification	-----	CSA
Service	-----	Freight
Starting Tractive Effort - Pounds	-----	97400
Weight Locomotive - Pounds	-----	566000
Weight of Locomotive and Tender Loaded-Pounds	--	876000
Tender Water Capacity - Gallons	-----	18106
Tender Coal Capacity - Pounds	-----	44000
Expansion of Steam	-----	Single
Number of Cylinders	-----	4
Cylinder Diameter - Inches	-----	22
Cylinder Stroke - Inches	-----	32
Valve Gear	-----	Walschaert

#### Valves

Diameter - Inches	-----	12
Full Gear Travel - Inches	-----	7-1/2
Lap - Inches	-----	1-3/8
Lead - Inches	-----	1/4
Exhaust Clearance - Inches	-----	1/8

#### Boiler

Working Pressure - Lbs. per Sq. In.	-----	255
Length Between Flue Sheets - Feet-Inches	-----	22-0
Number of 2-1/4 Inch Diameter Tubes	-----	222
Number of 5-1/2 Inch Diameter Flues	-----	60

#### Firebox

Length	-----	213-1/16
Width	-----	108-1/4
Grate Area	-----	108.25
Number of Arch Tubes	-----	5
Gaines Wall in Firebox		



Heating Surface - Square Feet

Firebox and Combustion Chamber -----	548
Arch Tubes -----	77
Boiler Tubes -----	2864
Boiler Flues -----	1892
Total Evaporative Heating Surface -----	5381
Superheater -----	1650
Total Heating Surface -----	7031

Description of Sellers Exhaust Steam Injector

The Sellers Exhaust Steam Injector is a two stage injector designated as Type "RF". It is fitted with 11000 gallon tubes. When operating upon exhaust steam, the first or heating stage receives exhaust steam for its operation. When operating upon live steam, the first stage is furnished with live steam throttled down through a choke to a low pressure.

On either live or exhaust steam operation, the second or forcing stage is always furnished high pressure live steam.

The change over from live to exhaust or exhaust to live steam operation is controlled by the pressure in the exhaust steam pipe to the injector. When the exhaust pressure is high enough for the first stage to operate on exhaust steam, the exhaust control valve shuts off the live steam which operates the live steam admission valve and the latter valve automatically closes thereby opening the exhaust regulating valve which then admits exhaust steam and closes off the throttled live steam to the first stage or heating set of tubes.

When the exhaust pressure drops too low to operate the heating set of tubes, the exhaust control valve admits live steam to the live steam admission valve which opens, thereby admitting live steam which closes the exhaust regulating valve and also furnishes throttled live steam to the heating set of tubes.

On tests no trouble was experienced with any of the control apparatus.

Three levers are required in the cab to operate the injector. They are the steam starting valve lever, the water valve lever, and the exhaust steam valve lever. To start the injector, (1) open the water valve, (2) open the steam starting valve to its priming position, (3) open the exhaust lever to establish a vacuum in the heating set of

tubes (this may require moving the exhaust lever back and forth), and finally, (4) open the steam starting valve to its full open position upon which the injector delivers water to the boiler. To shut off the injector requires closing of the steam starting valve, exhaust valve, and water valve.

#### Data

All data necessary for the determination of front end, boiler, cylinder, and exhaust steam injector performance were taken.

Coal consumption was determined by measurements of the coal space at the start of a run, before and after taking coal, and at the end of a run. Tank water consumption was determined by measurements of the water in the tank at the start of a run, before and after taking water, and at the end of a run.

All blow downs were timed with a stop watch to determine the weight of water blown down. A continuous record was kept of the time the injector was operating on exhaust steam, on live steam, or shut off. A record was kept of the train movement.

A venturi meter was applied to the suction line of the Sellers Exhaust Steam Injector. Thus the rate at which tank water was being fed to the boiler was always known and furthermore, combining the rate of flow with the time gave the weight of tank water fed to the boiler on live steam operation.

The following pressures were taken: (1) Boiler, (2) Valve Chamber, (3) Exhaust Stands, (4) Exhaust in the Injector, and (5) Injector Live Steam Nozzle.

The following temperatures were taken with distant reading thermometers and mercury thermometers: (1) Tank Water, (2) Exhaust Steam entering the Injector, (3) Water leaving the Heating Set of Injector Tubes, and (4) Delivery Water to the Boiler.

The following temperatures were taken with a potentiometer: (1) Steam to Cylinders Right Side, (2) Steam to Cylinders Left Side, (3) Exhaust Steam Back Engine Right Side, (4) Exhaust Steam Back Engine Left Side, (5) Exhaust Steam Front Engine, (6) Smoke Box Gases leaving 2-1/4 inch Tube, (7) Smoke Box Gases leaving 5-1/2 inch Flue, and (8) Smoke Box Gases Entering Stack.

Superheated steam temperatures were also taken with a pyrometer.

Drafts were taken in the front end.

On the first trips smokebox gases were analyzed as a check on combustion.

#### Compiled Data and Graphical Presentation

The data taken during the tests and all calculated results are shown in condensed form on sheets in this report under the following headings:

1. General Performance
2. Average Pressures, Temperatures, and Drafts
3. Sellers Exhaust Steam Injector Performance
4. Fuel, Water, and Evaporation
5. Fuel Saved by Operation of Sellers Exhaust Steam Injector.

The following curves are presented:

Figure No. 1 - Relation Between Firing Rate and Evaporation Ratio, and Firing Rate and Evaporation with Sellers Exhaust Steam Injector.

Figure No. 2 - Relation Between Firing Rate and Boiler Heat Absorption Rate. Example shown of determination of fuel saved by exhaust steam injector.

Figure No. 3 - Relation Between Fuel Fired and Fuel Saved by Sellers Exhaust Steam Injector.

#### Criterion of Performance for Evaluating Heat and Fuel Savings by Operation of the Exhaust Steam Injector.

If it were possible to exactly duplicate runs, always pulling the same train, running at the same speed under the same weather conditions, the fuel saved by an exhaust steam injector could be determined directly by making a number of runs with the live steam injector and then comparing them with a number of runs using the exhaust steam injector. However, road conditions are variable and especially in freight service conditions are too variable for direct comparisons.

Fuel savings were determined by making use of the known fact that regardless of what device is used to feed the boiler, a definite relation exists between the firing rate and the boiler heat absorption rate. It follows that the fuel saved by feedwater heating is due to the fact that the boiler is required to supply less heat for the same evaporation. That is, the boiler is relieved of furnishing the heat supplied by the feed water heater which is recovered in the exhaust steam condensed. Figure No. 2 in this report shows an example of the method used for determining fuel savings.

In this report all exhaust steam injector performances are based upon data for the entire trip. As an example if when working the locomotive the temperature rise due to exhaust steam were 100 degrees Fahr. but due to some of the territory being down grade one half of the tank water were fed to the boiler with the injector on live steam operation, the net temperature rise due to exhaust steam for the trip would be only slightly more than 50 degrees Fahr. The territory between Cheyenne and Ogden is up and down grade and a substantial percentage of the boiler feed is on live steam operation.

#### Discussion of Sellers Exhaust Steam Injector Performance

Fuel savings obtained with the Sellers Exhaust Steam Injector ran from 5.02 to 8.21 percent at firing rates from 7000 to 17000 pounds of coal per hour. These savings are worth while but are not good.

With the Sellers Exhaust Steam Injector the maximum boiler evaporation is 88563 while with the live steam injector it is 76951 pounds of water per hour. This is a substantial increase in evaporation of 11612 pounds or 15.1 per cent.

Condensate returns ran from 3.4 to 5.9 per cent of the total water fed to the boiler. These figures are not high but may be partly accounted for by the fact that due to up and down grade territory from 13.3 to 39.7 with an average for all trips of 28.7 per cent of the tank water was fed to the boiler with the live steam injector and the exhaust steam injector on live steam operation.

The range of the Sellers Exhaust Steam Injector is quite limited. With 65 degree Fahr. tank water the maximum delivery with a full tank of water is 80552 pounds of tank water per hour. The minimum delivery is 55440 pounds of water per hour. The injector barely supplies the boiler at high loads while at light loads the injector

can not be cut fine enough to prevent greatly oversupplying the boiler.

No trouble was experienced with either the control apparatus or the injector. However, the injector is rather hard to get on and at times the vacuum is very slow to establish in the heating set of tubes.

The exhaust steam injector has two important advantages over any other type of feed water heating equipment from an operating standpoint in that (1) regardless of locomotive operation the boiler feed is always relatively hot, and (2) it is always positively known whether the injector is putting water into the boiler or not.

### Conclusions

(1) The performance of the Sellers Exhaust Steam Injector and the Exhaust Pressure Actuated Change Over is satisfactory as to reliability and stability.

(2) Fuel savings ran from 5.02 to 8.21 per cent at firing rates from 7000 to 17000 pounds of coal per hour. These savings are worth while but can not be considered good.

(3) Compared with live steam injector operation the Sellers Exhaust Steam Injector increases the maximum evaporation of the boiler from 76951 to 88563 pounds of water per hour.

(4) Condensate returns ran from 3.4 to 5.9 per cent of the total water fed to the boiler. This is a low return but may be partly accounted for by an average of 28.7 per cent of the tank water being fed to the boiler by the live steam injector and the exhaust steam injector on live steam operation.

(5) The net temperature rise due to exhaust steam condensed by the injector ran from 38.1 to 68.6 degrees Fahr. These figures show the net heating of feed water by the Sellers Exhaust Steam Injector to be low.

Office of  
Vice President  
Omaha, Nebraska  
August 27, 1941.



DATE 1940	BOILER PRES POUNDS PER SQ. IN. GAUGE	TANK WATER TEMP. - °F	TEMPERATURE RISE DUE TO EXH. ST. - °F	BLOW DOWN LBS. TOTAL	WATER ACTUALLY EVAP. BY BOILER POUNDS - TOTAL	RUNNING TIME HOURS	MILLIONS OF BTU'S ABSORBED BY EVAP. HEATING SURFACE PER HOUR IF BOILER WERE FED BY LIVE STEAM INJ.		LBS OF COAL PER HR FROM CURVE EXH. STEAM INJECTOR OPER. LIVE STEAM INJECTOR OPER.		COAL RATE DIFFERENCE LBS PER HR	COAL SAVED FOR TRIP POUNDS
							ACTUAL					
CHEYENNE TO LARAMIE												
JULY 24	253.1	69	45.67	0	98369	1.8333	59.58	62.03	10230	10866	636	1166
JULY 28	246.0	68	55.77	0	93801	1.6597	62.23	65.38	10802	11484	682	1132
JULY 29	252.4	67	56.74	0	108254	1.9583	60.93	64.07	10521	11199	678	1328
JULY 31	248.4	67	56.52	0	117198	1.9250	66.99	70.43	11840	12591	751	1446
SEPT 8	242.5	68	47.11	0	85784	1.4777	64.41	67.14	11273	11871	598	884
LARAMIE TO CHEYENNE												
JULY 24	249.0	65	42.64	566	111710	2.6777	46.68	48.46	7356	7728	372	996
JULY 28	246.8	65	51.05	0	116678	2.8250	45.79	47.90	7267	7715	448	1266
JULY 29	249.2	64	68.55	0	106150	2.0333	57.02	60.61	9682	10452	770	1566
JULY 31	247.2	63	50.83	0	107608	2.3139	51.66	54.03	8522	9039	517	1196
CHEYENNE TO SHERMAN												
JULY 25	249.8	68	56.82	0	56621	.72500	85.92	90.35	16370	17716	1346	976
JULY 27	237.9	64	52.96	0	90320	1.3861	72.15	75.61	12973	13746	773	1071
JULY 30	243.6	67	66.41	0	97287	1.1042	96.15	102.00	20345	24500	4155	4588
LARAMIE TO GREEN RIVER												
AUG. 8	246.5	65	43.69	10294	289470	5.5667	58.60	60.95	10020	10525	505	2811
AUG. 10	246.0	67	42.44	14153	275664	5.9833	52.10	54.16	8618	9067	449	2687
AUG. 12	245.7	67	38.13	31067	285710	5.6583	58.42	60.52	9982	10432	450	2546
AUG. 16	242.4	66	39.11	13519	271211	5.8167	52.91	54.82	8823	9211	388	2257
AUG. 18	251.7	64	40.64	7014	272454	5.3250	57.73	59.86	9834	10290	456	2428
GREEN RIVER TO LARAMIE												
AUG. 9	249.2	70	50.00	5458	308772	5.5000	77.68	81.24	14243	15122	879	4878
AUG. 11	252.6	71	41.65	13775	371396	6.0833	68.59	71.23	12190	12771	581	3534
AUG. 13	251.5	70	46.65	8509	439081	7.0611	69.26	72.22	12337	12988	651	4597
AUG. 15	248.1	71	45.81	10051	370224	6.4916	63.65	66.33	11108	11693	485	3148
AUG. 17	251.2	70	50.72	5032	417600	6.7917	68.12	71.35	12086	12797	711	4829
AUG. 19	252.9	70	49.18	21631	437464	6.6792	73.38	76.76	13244	14022	778	5196
GREEN RIVER TO OGDEN												
SEPT 10	240.5	64	44.18	14901	202771	4.6000	50.18	52.27	8199	8655	456	2098
SEPT 13-14	246.8	63	39.49	22572	234825	4.5500	59.46	61.69	10204	10685	481	2189
OGDEN TO GREEN RIVER												
SEPT 11	252.9	64	41.43	9115	410747	5.1708	89.48	98.84	17237	18751	1514	7829
SEPT 14	248.2	63	48.82	4011	423793	6.2417	75.76	79.11	13782	14586	804	5018



## GENERAL PERFORMANCE — LOCOMOTIVE 3911

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DATE 1940	NUMBER OF CARS		NUMBER OF STOPS	TONS	TON MILES NOT CORRECTED FOR HELPER GMTM	DURATION OF TEST						TOTAL POUNDS OF WATER ACTUALLY EVAP. BY BOILER	TOTAL POUNDS OF COAL FIRED	PER G.M.T.M.		AVERAGE SPEED MPH	HELPER USED
	LOADS	EMPTYs				TOTAL	DEAD		RUNNING		CORRECTED FOR HELPER POUNDS WATER			POUNDS COAL			
			HOURS	MINUTES	HOURS		MINUTES	HOURS	MINUTES								
CHEYENNE TO LARAMIE - WESTBOUND 56.5 MILES																	
JULY 24	51	0	3	1951	110,232	2	3	0	13	1	50	98369	21198	1107.3	238.6	30.8	2298 TO SHERMAN
JULY 28	53	0	2	2100	118,650	1	41	0	1-25	1	39-35	93801	17654	1086.5	204.5	34.0	9028 TO "
JULY 29	58	0	2	2506	141,589	2	0-30	0	3	1	57-30	108254	22530	1050.7	218.7	28.9	9026 TO "
JULY 31	46	0	1	1692	95,598	1	55-30	0	0	1	55-30	117198	24250	1225.9	253.7	29.4	NO HELPER
SEPT 8	19	0	1	—	—	1	28-40	0	0	1	28-40	85784	16669	—	—	38.2	823 TO LARAMIE
LARAMIE TO CHEYENNE - EASTBOUND 56.5 MILES																	
JULY 24	58	3	4	3230	182,495	3	10	0	29-20	2	40-40	111710	21669	641.7	118.7	21.1	NO HELPER
JULY 28	49	0	4	3080	174,020	3	2	0	12-30	2	49-30	116678	19433	670.5	111.7	20.0	" "
JULY 29	57	0	3	2800	158,200	2	11	0	9	2	2	106150	20959	671.0	132.5	27.8	" "
JULY 31	60	0	4	3300	186,450	2	30	0	11-10	2	18-50	107608	21244	577.1	113.9	24.4	" "
CHEYENNE TO SHERMAN - WESTBOUND 30.9 MILES																	
JULY 25	15	0	1	—	—	0	43-30	0	0	0	43-30	56621	10618	—	—	42.6	830 TRAIN No. 27
JULY 27	52	0	2	2052	63,407	1	28-5	0	6	1	22-5	90320	17469	2794.3	557.7	22.6	3555 TO SHERMAN
JULY 30	55	0	1	2150	66,435	1	6-15	0	0	1	6-15	97287	19422	2964.3	591.8	28.0	3555 TO "
LARAMIE TO GREEN RIVER - WESTBOUND 251.0 MILES																	
AUG. 8	59	0	4	2250	564,750	6	15	0	41	5	34	289470	53530	512.6	94.8	45.1	NO HELPER
AUG. 10	50	0	7	2140	537,140	6	37	0	38	5	59	275664	49980	513.2	93.0	42.0	" "
AUG. 12	43	7	7	2040	512,040	6	55-30	1	16	5	39-30	286710	49930	559.9	97.5	44.4	" "
AUG. 16	54	0	8	2150	539,650	6	22	0	33	5	49	271211	48077	502.6	88.1	43.2	" "
AUG. 18	53	0	4	2250	564,750	5	51-30	0	32	5	19-30	272454	50706	482.4	89.8	47.1	" "
GREEN RIVER TO LARAMIE - EASTBOUND 251.0 MILES																	
AUG. 9	61	0	4	2900	727,900	6	8	0	35	5	33	388772	78556	534.1	107.9	45.2	NO HELPER
AUG. 11	53	0	5	2850	715,350	7	22	1	17	6	5	371396	78122	519.2	109.2	41.3	" "
AUG. 13	74	1	13	3339	838,089	8	28	1	24	7	3	439081	84699	523.9	101.1	35.5	" "
AUG. 15	50	20	10	2400	602,400	7	21	0	51-30	6	29-30	370224	71516	614.6	118.7	38.7	" "
AUG. 17	68	0	11	2900	727,900	8	46	1	58-30	6	47-30	417600	82008	573.7	112.7	37.0	" "
AUG. 19	64-68	0-1	9	3280-3485	871,660	7	45	1	4-15	6	40-45	437464	94334	501.9	108.2	37.6	" "
GREEN RIVER TO OGDEN - WESTBOUND 175.6 MILES																	
SEPT 10	0	70	5	1890	331,884	5	17	0	41	4	36	202771	44525	611.0	134.2	38.2	NO HELPER
SEPT 13-14	61	0	4	2375	417,050	5	10	0	37	4	33	234825	42769	563.1	102.6	38.6	" "
OGDEN TO GREEN RIVER - EASTBOUND 175.6 MILES																	
SEPT 11	66	2	7	3330	584,748	6	17-15	1	7	5	10-15	410747	78119	831.7	158.2	34.0	5070 TO WAHSATCH
SEPT 14	70	9	8	3550	623,380	7	50	1	35-30	6	14-30	423793	88489	805.0	168.4	28.1	5014 TO "
LARAMIE TO GREEN RIVER - WESTBOUND 251.0 MILES																	
SELLERS LIVE STEAM INJECTOR																	
AUG. 14	54	0	5	1880	471,880	6	42-30	0	57-30	5	45	267078	50618	566.0	107.3	43.7	NO HELPER

SELLERS LIVE STEAM INJECTOR



DATE 1940	P R E S S U R E — POUNDS PER SQUARE INCH GAUGE					T E M P E R A T U R E S —						D E G R E E S F A H R E N H E I T						DRAFT—INCHES OF WATER	
	BOILER	VALVE CHAMBER	EXHAUST STANDS	EXHAUST TO INJECTOR	INJECTOR LIVE STEAM NOZZLE	TANK WATER	EXH. STEAM TO INJECTOR	FIRST STAGE	DELIVERY TO BOILER	STEAM TO CYLINDER RIGHT SIDE	LEFT SIDE	BACK RIGHT	ENGINE LEFT	STEAM FRONT ENGINE	SMOKE LEAVING 2-1/4 TUBES	BOX LEAVING 5-1/2 FLUES	GASES ENTERING SMOKE STACK	ENTERING STACK	FRONT FLUE SHEET
CHEYENNE TO LARAMIE																			
JULY 24	253.1	238.7	9.4	7.1	221.3	69	278	135	264	685	666	286	274	273	634	624	617	14.71	10.19
JULY 28	246.0	221.3	12.4	6.7	223.0	68	287	143	272	697	678	311	294	299	644	640	629	16.78	11.65
JULY 29	252.4	231.0	10.1	6.5	228.5	67	293	142	278	669	685	292	289	288	612	613	607	14.45	10.08
JULY 31	248.4	223.1	13.7	6.9	222.5	67	313	134	257	703	693	344	332	326	659	652	647	17.60	13.89
SEPT 8	242.5	210.0	12.2	6.1	208.3	68	286	133	256	700	680	321	296	310	648	642	636	17.50	11.91
LARAMIE TO CHEYENNE																			
JULY 24	249.0	224.7	9.3	5.9	225.6	65	294	134	269	679	662	319	305	300	621	615	612	13.14	9.49
JULY 28	246.8	204.2	8.1	5.7	221.9	65	271	139	269	660	646	291	274	265	598	598	579	11.49	8.03
JULY 29	249.2	230.1	13.6	6.3	224.8	64	309	149	280	689	699	322	322	310	641	637	638	17.40	12.44
JULY 31	247.2	227.3	11.4	6.4	223.7	63	316	130	258	697	683	338	316	316	648	641	637	17.38	12.20
CHEYENNE TO SHERMAN																			
JULY 25	249.8	228.5	11.7	5.7	227.8	68	256	133	264	690	668	295	267	264	649	647	625	16.38	11.68
JULY 27	237.9	196.5	8.7	5.4	212.0	64	286	136	260	659	650	299	284	273	602	604	587	12.67	9.17
JULY 30	243.6	221.1	11.3	6.3	220.7	67	303	147	287	675	687	315	313	305	618	626	625	16.28	11.48
LARAMIE TO GREEN RIVER																			
AUG. 8	246.5	224.3	9.8	6.4	221.6	65	266	132	258	687	670	285	270	288	623	644	610	14.54	9.98
AUG. 10	246.0	184.6	8.6	6.7	223.7	67	272	131	259	664	657	284	281	289	610	610	588	12.16	9.16
AUG. 12	245.7	163.7	7.0	5.5	222.1	67	260	125	260	658	652	284	279	288	601	601	580	10.83	8.08
AUG. 16	242.4	187.2	7.1	5.8	221.7	66	261	128	263	654	643	280	269	275	595	597	574	10.70	8.27
AUG. 18	251.7	211.9	9.0	6.0	227.5	64	257	128	265	667	656	279	271	280	620	620	596	13.41	10.25
GREEN RIVER TO LARAMIE																			
AUG. 9	249.2	221.3	12.0	6.3	225.4	70	280	135	265	688	669	313	287	303	648	635	642	14.76	11.69
AUG. 11	252.6	217.7	9.8	6.3	227.8	71	272	126	258	676	667	303	286	292	622	616	606	13.30	10.13
AUG. 13	251.5	222.5	9.9	6.1	229.0	70	275	132	267	675	663	299	282	292	624	620	609	14.25	10.07
AUG. 15	248.1	229.9	11.5	6.6	226.0	71	269	133	269	689	672	302	282	297	640	633	626	15.81	11.79
AUG. 17	251.2	219.7	10.4	6.3	228.7	70	270	132	261	675	661	299	281	301	628	622	609	13.90	10.91
AUG. 19	252.9	228.2	12.3	6.7	230.2	70	279	134	265	690	671	305	286	299	642	635	627	14.70	11.89
GREEN RIVER TO OGDEN																			
SEPT 10	240.5	210.4	7.9	5.9	207.0	64	254	132	252	674	656	290	262	275	621	609	601	12.71	8.77
SEPT 13-14	246.8	178.6	11.2	6.6	216.7	63	283	126	251	672	655	320	304	319	645	630	625	16.71	12.20
OGDEN TO GREEN RIVER																			
SEPT 11	252.9	219.0	11.1	5.8	217.2	64	303	121	248	701	676	335	303	319	650	637	636	16.79	12.07
SEPT 14	248.2	194.3	11.1	6.0	211.0	63	309	127	253	687	666	332	315	330	641	630	623	15.77	11.51
LARAMIE TO GREEN RIVER — SELLERS LIVE STEAM INJECTOR																			
AUG. 14	244.1	211.2	8.6	—	—	67	—	—	—	665	662	277	271	278	617	623	597	13.38	9.43



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DATE 1940	SELLERS EXHAUST STEAM INJECTOR				SELLERS LIVE STEAM INJECTOR				TANK WATER DELIVERED TO BOILER — POUNDS				RUNNING TIME HOURS	CONDENSATE RETURN LBS	TOTAL WATER FED TO BOILER — LBS	CONDENSATE RETURN % OF TOTAL WATER FED TO BOILER	NET TEMP RISE DUE TO EXHAUST STEAM — °F	TOTAL BTU'S RECOVERED IN EXHAUST STEAM
	TIME ON EXH. STEAM		TIME ON LIVE STEAM		TIME ON INJECTOR		BY SELLERS EXH.		BY SELLERS LIVE STEAM		T O T A L							
	MINUTES	SECONDS	MINUTES	SECONDS	MINUTES	SECONDS	ON EXH. STEAM OPER.	ON LIVE STEAM OPER.	INJECTOR									
CHEYENNE TO LARAMIE																		
JULY 24	60	20	14	0	12	20	64147	15962	14331	94440	1.8333	3929	98369	4.0	45.67	4,492,811.5		
JULY 28	56	20	13	30	7	55	65204	14844	9199	89247	1.6397	4554	93801	4.9	55.77	5,231,635.2		
JULY 29	68	20	23	5	0	0	76569	26356	0	102925	1.9583	5329	108254	4.9	56.74	6,142,205.4		
JULY 31	84	25	7	15	8	5	93173	8941	9393	111507	1.9250	5691	117198	4.9	56.52	6,624,324.0		
SEPT 8	45	10	13	10	7	35	58667	14786	8812	82265	1.4777	3519	85784	4.1	47.11	4,041,571.5		
LARAMIE TO CHEYENNE																		
JULY 24	56	0	27	50	9	30	65238	31855	11039	108132	2.6777	4144	112276	3.7	42.64	4,787,148.8		
JULY 28	44	15	29	0	3	0	75295	32694	3486	111475	2.8250	5203	116378	4.5	51.05	5,955,874.1		
JULY 29	52	30	6	55	10	40	79344	8156	12395	99895	2.0333	6255	106150	5.9	68.55	7,276,441.5		
JULY 31	62	20	14	0	8	30	76963	16085	9877	102925	2.3139	4683	107608	4.4	50.83	5,469,744.0		
CHEYENNE TO SHERMAN — HELP																		
JULY 25	40	5	5	50	0	0	46655	7130	0	53785	0.72500	2836	55621	5.0	56.82	3,217,158.4		
JULY 27	59	30	20	30	0	0	62288	23882	0	86170	1.3861	4150	90320	4.6	52.96	4,783,290.0		
JULY 30	64	20	6	45	7	30	75172	7820	8715	91707	1.1042	5530	97287	5.7	66.41	6,460,524.0		
LARAMIE TO GREEN RIVER																		
AUG. 8	152	15	57	30	32	30	183978	66550	37772	288295	5.5667	11469	299764	3.8	43.69	13,095,304.2		
AUG. 10	149	19	59	55	12	15	181427	83393	14235	279055	5.9833	10762	289817	3.7	42.44	12,299,869.8		
AUG. 12	168	10	84	10	10	5	198236	97172	11717	307125	5.6583	10652	317777	3.4	38.13	12,115,584.8		
AUG. 16	126	45	79	5	11	35	169821	91668	13462	274951	5.8167	9779	284730	3.4	39.11	11,135,347.3		
AUG. 18	147	40	67	0	20	40	167502	77975	24015	269492	5.3250	9976	279468	3.6	40.64	11,358,673.6		
GREEN RIVER TO LARAMIE																		
AUG. 9	227	25	47	25	45	0	286076	38626	52290	376992	5.5000	17238	394230	4.4	50.00	19,715,100.0		
AUG. 11	228	50	36	45	42	0	277627	44654	48804	371085	6.0833	14086	385171	3.7	41.65	16,043,954.0		
AUG. 13	322	5	55	25	39	0	318508	65469	45318	429295	7.0611	18295	447590	4.1	46.65	20,881,913.0		
AUG. 15	222	45	45	30	31	45	265629	62436	36894	364959	6.4916	15316	380275	4.0	45.81	17,418,886.8		
AUG. 17	249	5	38	30	26	35	326915	46002	30890	403807	6.7917	18825	422632	4.5	50.72	21,436,027.5		
AUG. 19	224	55	30	20	60	0	333023	36003	70320	439346	6.6792	19749	459095	4.3	49.18	22,577,056.8		
GREEN RIVER TO OGDEN																		
SEPT 10	112	0	58	0	9	15	132963	65502	10749	209214	4.6000	8458	217672	3.9	44.18	9,616,746.0		
SEPT 13-14	105	50	50	35	30	20	152526	60799	35247	248572	4.5500	8825	257397	3.4	39.49	10,165,517.5		
OGDEN TO GREEN RIVER																		
SEPT 11	177	35	57	45	36	55	290196	71782	42897	404875	5.1708	14987	419862	3.6	41.43	17,395,410.0		
SEPT 14	239	40	59	15	26	35	308400	70572	30890	409869	6.2417	17935	427804	4.2	48.82	20,885,307.5		
LARAMIE TO GREEN RIVER — SELLERS LIVE STEAM INJECTOR																		
AUG. 14	0	0	0	0	—	—	0	0	284260	284260	5.7500	0	284260	.0	.00	.0		



DATE 1940	TOTAL TANK WATER - LBS	CONDENSATE FROM EXHAUST STEAM INJECTOR - LBS.	BLOWDOWN POUNDS	TOTAL POUNDS OF WATER EVAPORATED BY BOILER		TOTAL POUNDS OF COAL FIRED	POUNDS OF WATER EVAP PER LB OF COAL FIRED		RUNNING TIME HOURS	POUNDS OF COAL FIRED PER HOUR OF RUNNING TIME ACTUAL	MILLIONS OF BTU'S ACTUALLY ABSORBED BY EVAP. HEATING SURFACE PER HOUR OF RUNNING TIME
				ACTUAL	ADJ. FOR BLOWDOWN		ACTUAL	ADJ. FOR BLOWDOWN			
CHEYENNE TO LARAMIE											
JULY 24	94440	3929	0	98369	98369	21198	4.64	4.64	1.8333	11563	59.58
JULY 28	89247	4554	0	93801	93801	17654	5.31	5.31	1.6597	10637	62.23
JULY 29	102925	5329	0	108254	108254	22530	4.80	4.80	1.9583	11505	60.93
JULY 31	111507	5691	0	117198	117198	24250	4.83	4.83	1.9250	12597	66.99
SEPT 8	82265	3519	0	85784	85784	16669	5.15	5.15	1.4777	11280	64.41
LARAMIE TO CHEYENNE											
JULY 24	108132	4144	566	111710	111865	21669	5.16	5.16	2.6777	8092	46.68
JULY 28	111475	5203	0	116678	116678	19433	6.00	6.00	2.8250	6879	45.79
JULY 29	99895	6255	0	106150	106150	20959	5.06	5.06	2.0333	10308	57.02
JULY 31	102925	4683	0	107608	107608	21244	5.07	5.07	2.3139	9181	51.66
CHEYENNE TO SHERMAN — HELD											
JULY 25	53785	2836	0	56621	56621	10618	5.33	5.33	.72500	14646	85.92
JULY 27	86170	4150	0	90320	90320	17469	5.17	5.17	1.3861	12603	72.15
JULY 30	91707	5580	0	97287	97287	19422	5.01	5.01	1.1042	17589	96.15
LARAMIE TO GREEN RIVER											
AUG. 8	288295	11469	10294	289470	292265	53530	5.41	5.46	5.5667	9616	58.60
AUG. 10	279055	10762	14153	275664	279497	49980	5.52	5.59	5.9833	8353	52.10
AUG. 12	307125	10652	31067	286710	295207	49930	5.74	5.91	5.6583	8824	58.42
AUG. 16	274951	9779	13519	271211	274894	48077	5.64	5.72	5.8167	8265	52.91
AUG. 18	269492	9976	7014	272454	274388	50706	5.37	5.41	5.3250	9522	57.73
GREEN RIVER TO LARAMIE											
AUG. 9	376992	17238	5458	388772	390217	78556	4.95	4.97	5.5000	14154	77.68
AUG. 11	371085	14086	13775	371396	375125	78122	4.75	4.80	6.0833	12842	68.59
AUG. 13	429295	18295	8509	439081	441283	84699	5.18	5.21	7.0611	11995	69.26
AUG. 15	364959	15316	10051	370224	372904	71516	5.18	5.21	6.4916	11017	63.65
AUG. 17	403807	18825	5032	417600	418933	82008	5.09	5.11	6.7917	12075	68.12
AUG. 19	439346	19749	21631	437464	443229	94334	4.64	4.70	6.6792	14124	73.3P
GREEN RIVER TO OGDEN											
SEPT 10	209214	8458	14901	202771	206790	44525	4.55	4.64	4.6000	9679	50.18
SEPT 13-14	248572	8825	22572	234825	241044	42769	5.49	5.64	4.5500	9400	59.46
OGDEN TO GREEN RIVER											
SEPT. 11	404875	14987	9115	410747	413258	78119	5.26	5.29	5.1708	15108	89.48
SEPT. 14	409869	17935	4011	423793	424876	88489	4.79	4.80	6.2417	14177	75.76
LARAMIE TO GREEN RIVER											
AUG. 14	284260	0	17182	267078	272179	50618	5.28	5.38	5.7500	8803	54.80



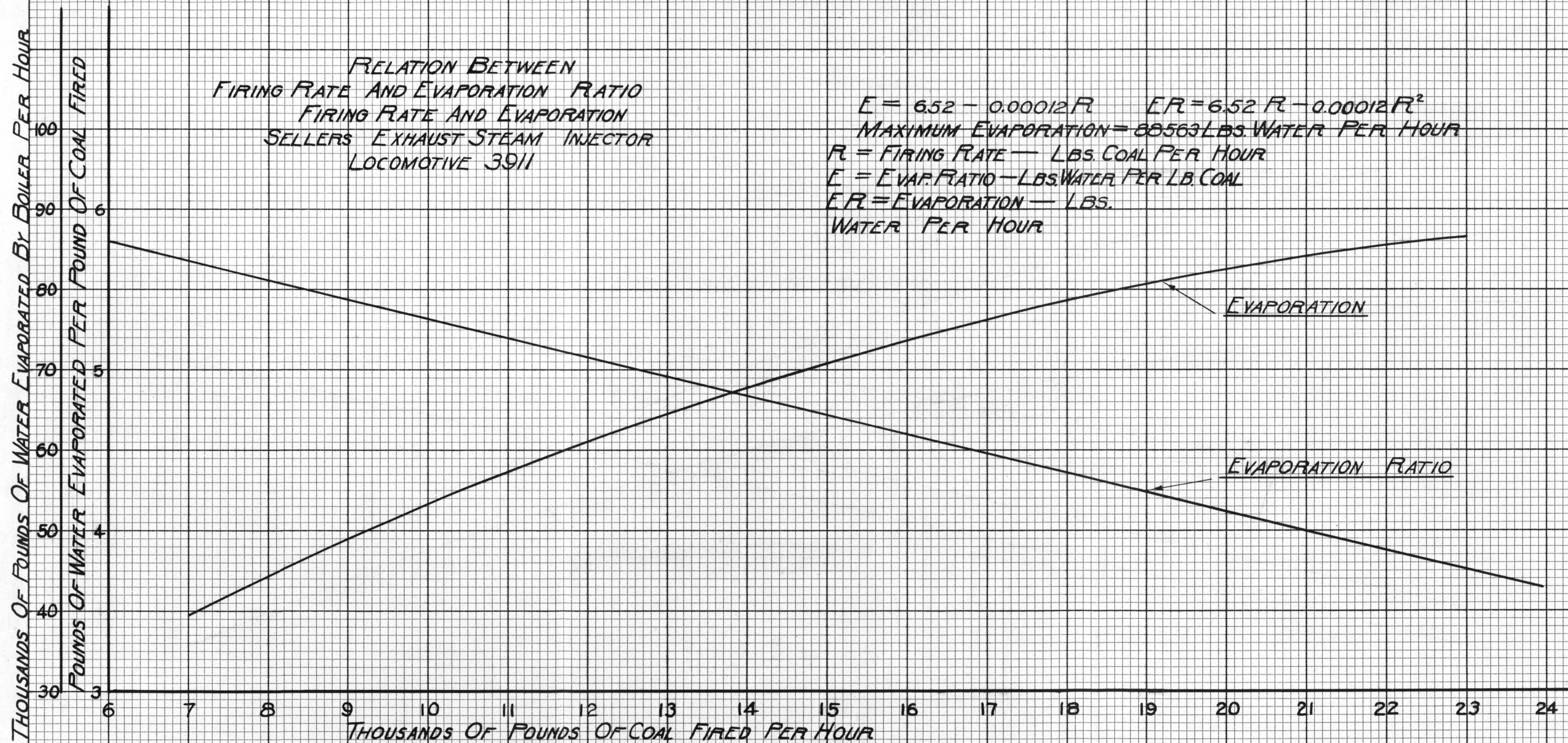


FIGURE NO. 1



MILLIONS OF B.T.U.'s ABSORBED BY EVAPORATIVE HEATING SURFACE PER HOUR

RELATION BETWEEN FIRING RATE AND BOILER HEAT ABSORPTION RATE  
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THOUSANDS OF POUNDS OF COAL FIRED PER HOUR

EXAMPLE OF FUEL SAVED DETERMINATION  
JULY 25, CHEYENNE TO SHERMAN  
WITH SELLERS EXHAUST STEAM INJECTOR  
ACTUAL BOILER HEAT ABSORPTION EQUALS  
 $85.92 \times 10^6$  B.T.U.'s PER HOUR WITH A FIRING RATE  
OF 16370 LBS. OF COAL PER HOUR. TEMPERATURE  
RISE DUE TO EXHAUST STEAM EQUALS  $56.8^\circ\text{F}$ .  
IF LIVE STEAM INJECTOR HAD BEEN USED BOILER  
HEAT ABSORPTION REQUIRED IS  $90.35 \times 10^6$  B.T.U.'s  
PER HOUR WITH A FIRING RATE OF 17716 LBS.  
OF COAL PER HOUR.  
FUEL SAVING =  $(17716 - 16370) = 1346$  LBS. OF  
COAL PER HOUR.

FUEL  
PER HOUR  
SAVED IN  
EXAMPLE

FIGURE NO. 2



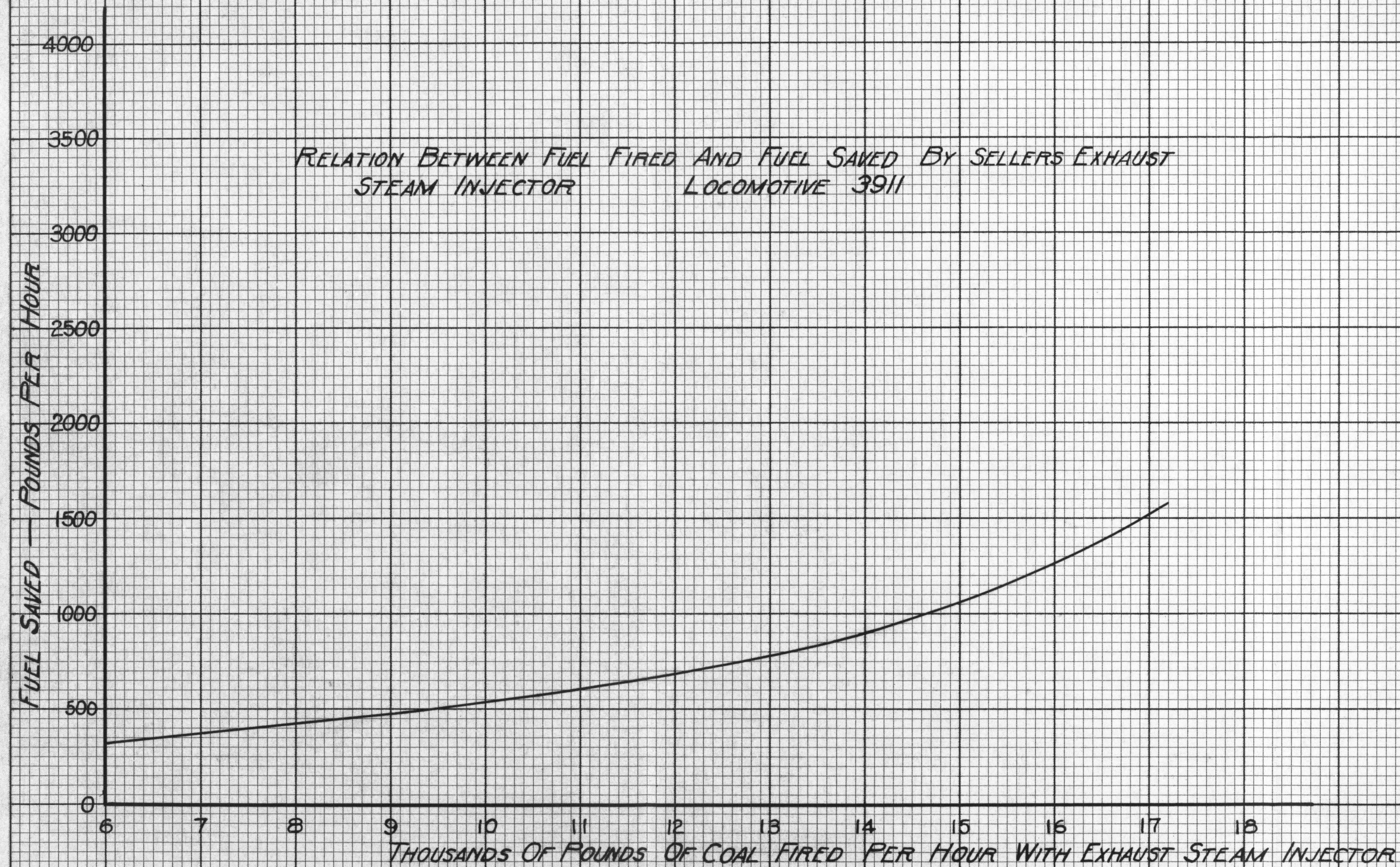


FIGURE NO. 3