Experimental Investigation of the Air and Fuel Heating Devices Used on The Case 15-27 Kerosene Tractor.

A Report Submitted to

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By

Richard Boonstra W. Arthur Tobey

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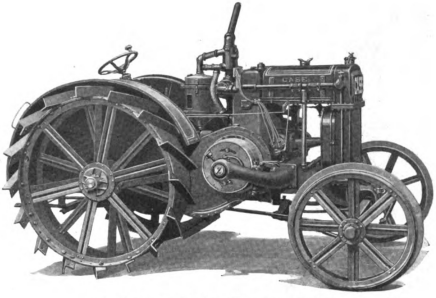
THESIS



CASE 15-27 KEROSENE TRACTOR

EXPERIMENTAL INVESTIGATION OF THE AIR AND FUEL HEATING DEVICES USED ON THE CASE 15-27 KEROSENE TRACTOR

PURPOSE

The purpose of this investigation was to study, experimentally, the air and fuel heating devices necessary to the efficient us of kerosene in tractor motors, especially, the devices used on the Case 15-27 Kerosene Tractor.

APPARATUS AND EQUIPMENT

The apparatus used in the investigation consisted of the following:

CASE 15-27 Kerosene Tractor, No. 42526.

Prony Brake, with its equipment.

Fuel Weighing Apparatus.

Thermometers.

Speed Counter.

Incidental equipment.

Fig. 1. VIEW OF APPARATUS.

THE CASE 15-27 KEROSENE TRACTOR NO. 42526

For our experimental work we secured, thru the M. A. C. Farm Mechanics department, the use of a stock 15-27 J. I. Case Kerosene tractor from the Branch office of the Company in Lansing. Mr. Miller, General Manager of the office, generously gave us the use of the tractor and the permission to make any tests we desired on the tractor.

The Case Tractor as shown in Fig. uses a special designed intake and exhaust manifold. The details of this manifold are shown by the blue print in the envelope in the back of this report. By the use of the manifold, the temperatures of the vaporized mixture as it comes from the carburetor can be raised until it will completely burn in the cylinders of the motor. In addition to the heating within the manifold, the air is heated by an exhaust air heater before it enters the carburetor. The air-heater, -washer, and -passageways are shown in Fig. 2 and also on the blue-print in the envelope on the back cover.

PRONY BRAKE EQUIPMENT

The prony brake equipment consisted of a water-cooled brake pulley mounted on a two-bearing shaft, a belt pulley, brake and arm, and platform scales. This equipment was mounted on a heavy iron bed. A 5-inch rubber belt was used to connect the engine with the brake. This equipment is shown in the photograph Fig. 1.

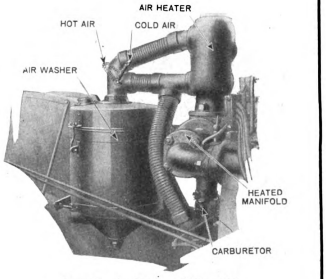


Fig. 2. Air Intake and Manifold

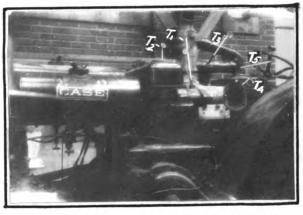


Fig. 3. THERMOMETERS IN PLACE.

T_1- Temperature of left manifold intake.
T_2- Temperature of right manifold intake.
T_3- Temperature of preheated air.
T_4- Temperature of vaporized mixture.
T_5- Temperature of incoming air.

FUEL WEIGHING EQUIPMENT

This equipment consisted of platform balances, fuel reservoir with stop-cock connections, and weights. This equipment can also be seen in the photograph Fig. 1.

THERMOMETERS

The thermometers used in this investigation were of Fahreheit scale. Two were high reading mercury thermometers, reading to 400°, and the other three reading to 220°F. The two 400° thermometers were placed in thermometer wells in the manifold intake close up to the cylinder blocks. One 220 thermometer was placed in a well at a point in the passageway for the heated air. The third was placed in a well just above the air washer.

In our preliminary tests we used oil-thermometer wells. These wells were made of a piece of 1/4 inch copper tubing, 5 or 6 inches long, one end hammered shut and soldered oil tight. We found that in the manifold temperature wells the high temperature melted the solder and oil leaked out. To remedy this, instead of using oil we plugged the space around the thermometer tightly with asbestos paper. This type of well proved to be satisfactory as fluctuations in manifold temperatures were easily detected.

For the manifold thermometer wells, a short piece of copper tube closed at one end was pressed into a 2-inch pieceof 1/4 inch threaded iron pipe. A hole was drilled and tapped for this pipe in the manifold intkae in place of the priming cup.

The other thermometer wells were soldered in place.

INCIDENTAL EQUIPMENT

Incidental equipment such as speed counters, wrenchs, etc., need no explanation.

THE TESTS

After our preliminary tests had been made to determine the behavior of the tractor and other apparatus, we started the experimental tests. These tests were really divided into two main parts. The first part consisted of the tests made on the tractor without any change in its standard equipment. The second part consisted of the tests made after the standard equipmenthad been changed. The tests themselves were practically the same in both cases.

The change in the equipment for the second group of tests was this: the manifold was taken apart and the exhaust manifolds for the two outside cylinders were truned so as to exhaustthe gases out into the air instead of out the exhaust pipe. Asbestos board was bolted to the ends of the main part of the exhaust manifold to cover the opening made by the removal of outside cylinder manifolds. Fig. 4 shows the tractor with the change made.

Both of the groups of tests were divided into three parts. The first division of tests under this classification were the tests made using the air preheater. The second division were the tests made with the air preheater off. The third division were the tests made using air taken in at the carburetor directly from the room. This classification might be more clearly

understood if put in this way: the air taken in at the carburetor was heated to a high temperature under the first division of tests, was heated slightly under the second division, and under the third division the air was taken into the carburetor at room temperature.

DESCRIPTION OF TEST

Before any of the tests were begun, the engine was started on gasoline and allowed to run a few minutes under load. As soon as the motor became hot enought to vaporize the kerosene, the gasoline was turned off and the kerosene turned on. The engine was always started with heated air. The tests were never started until the engine had run long enough to adjust itself to the load and its speed had become fairly constant. At the beginning of each test, the fuel in the fuel reservoir on the balances was weighed, just at the second the time was taken, the thermometers having been placed in their proper places before the starting of the test. Every five minutes the temperatures were read and recorded and every ten minutes the spped of the brake was taken. The brake load was kept constant during the test, one man doing nothing but watch and adjust the brake. At the end of each test, the unused fuel in the fuel reservoir was weighed just as the time was taken as in the beginning of the test. The barometer readings were recorded with the other data taken. All measurements, weights, time, etc., were taken with great care, so that the results of the tests might be as accurate as possible.

From the data obtained for each test, the brake horse

power, the thermal efficiency, and the fuel consumption was calculated. Every test was made in the manner described so that we are reasonably sure that the averages which are the results of all the tests in each group are data that show the true performance of the tractor. The averages were made showing the results of each test in each group and from them the curves were made. The curves show graphically all the average results of our tests.

DESCRIPTION OF FUEL ANALYSIS

A distilling apparatus of 100 cc. capacity was used to determine the different vaporization points of a composite sample of the kerosene used in the tractor motor.

The vaporization points so obtained in the chemical laboratory were duplicated and the results plotted on a graph, using volume in cubic centimeters as abscissa and temperature in degrees centigrade as ordinate. The results so plotted show a wide range of temperatures. Within this range of temperature there are two hydrocarbon compounds, $C_{11}H_{24}$ and $C_{12}H_{26}$. The carbon content in these two compounds is 84.7% and 84.6% respectively. The hydrogen content is 15.3% and 15.4%. The average theoretical B. T. U. value of these compounds is 20,376.

Assuming complete combustion the following method was used to calculate the B. T. U. value per lb. of fuel.

$$C_{11}H_{24} + 34O = 11\ CO_2 + 12\ H_2O$$

$$\text{Carbon Content} = \frac{132}{156} = 84.7\%$$

$$\text{Hydrogen Content} = \frac{24}{156} = 15.3\%$$

Heating value $= 14{,}600C + 52{,}230(H - \frac{O}{8})$

Heating value $= (14{,}600 \times 84.7 + 52{,}230 \times 15.3)$

The same method was used with C H and average B. T. U. used in our calculations was 20,376, the average B. T. U. value of the two compounds.

The specific gravity was determined by weighing a portion of the composite sample in a specific gravity bottle on an analytical balance. The specific gravity was found to be 0.8038. The weight per gallon was 6.70 lbs. at room temperature of 74 F.

CALCULATIONS

The calculations necessary to complete the report were quite simple. The calculations that were used are:

Brake Horse Power

Brake Constant = .0004

Brake Horse Power = .0004 x R.P.M. x Load

Thermal Efficiency

By fuel analysis, Kerosene = 20,376 B.t.u.

Per lb. 1 H. P. per hour = 2,546 B.t.u.

$$\therefore \text{Thermal Efficiency in \%} = \frac{2{,}546 \times \text{Horse Power per hour}}{20{,}376 \times \text{Fuel Consumption (lbs. per hour)}}$$

FUEL CONSUMPTION

1 gallon = 6.70 lbs. Kerosene (By Sp. Gr.)

$$\therefore \frac{\text{lbs Kerosene used 1 hr.}}{6.70} = \text{gallons used 1 hr.}$$

$$\frac{\text{Horse Power 1 hr.}}{\text{Gallons per hr.}} = \text{H. P. hrs. per gal.}$$

CONCLUSIONS

Air Conditions:

(1) The air conditions under which these tests were run closely approximate the average conditions of air temperature, pressure, and humidity under which tractors in this part of the country are likely to operate.

Air Heater:

(1) In starting the engine the air heater is advantageous because it aids carburization until the engine is thoroughly warmed.

(2) Our tests show that the air is heated to quite an extent with the air damper in the cold air position.

(3) Heated air has a higher saturation point than cold air, consequently, when passed thru the carburetor it absorbs more fuel than is used in the engine cylinder. This excess fuel is vaporized in the exhaust manifold. Its latent heat of vaproization is probably responsible for the lower manifold temperatures which we obtained when using heated air compared to the higher temperatures which we obtained when taking cold air at room temperature in at the carburetor.

(4) Thus, the use of heated air tends to lower the thermal efficiency and to increase the fuel consumption.

Air Washer:

(1) The temperature conditions within the engine are not effected by the use of the air washer.

The Use of Cold Air at the Carburetor:

(1) Our tests show that the use of air at room temperature in the carburetor after the engine has been thoroughly heated increases the temperature in the manifold, decreases the fuel consumption, and increases the thermal efficiency.

(2) That in order to use the air washer and at the same time take in air at room (atmospheric) temperature, it would be necessary to pass the air from the air washer to the carburetor without its being heated.

The Effect of Lower Manifold Temperatures:

(1) Our tests show that the lowering of the temperature within the manifold (by by-passing some of the exhaust gases) and at the same time using air at the carburetor at room temperature increases the thermal efficiency and decreases the fuel consumption.

1.

Air Preheated before entering Carburetor by Preheater.

742 80 30

3a.											
	304	332	166	130							
	320	342	168	129					880		
	322	345	168	129							
	326	348	166	128					874		
	328	348	168	128							
	330	350	170	128					360		
Ave.	322	344	169	129	72	29.25	4.36	6.35	871	27.8	11.9

Same as (3a) but with better adjustment of carburetor.

742 80 30

$3a_1$	324	338	164	126							
	327	340	166	128					900		
	335	346	167	126							
	335	348	169	128					892		
	334	346	168	129							
	334	344	168	129					880		
Ave.	333	345	167	128	62	29.25	4.36	6.55	891	28.6	12.2

The kerosene for these tests weighed 6.70 lbs. per gallon. Fuel consumption given per hour. Temperature in degrees F.

With Preheater as before.

		742			80					30	
5a											
	331	364	184	144							
	333	366	185	145					880		
	335	367	186	146							
	338	368	186	145					900		
	338	370	186	146							
	338	369	186	146					880		
Ave.	335	367	186	145	84	31.25	4.66	6.52	890	28.5	11.8

With Preheater and Air Washer.

		742			80					30	
6a.	352	300	180	144							
	360	302	186	146					860		
	364	302	185	147							
	364	305	185	147					870		
	367	304	186	146							
	367	306	186	148					884		
Ave.	365	305	184	145	74	31.13	4.65	6.03	871	28.0	11.7

The kerosene for these tests weighed 6.70 lbs. per gallon. Fuel consumption given per hour. Temperature in degrees F.

The exhaust from the two outside cylinders was directed into the air instead of into manifold heater.

With Preheater.

745 80 30

10a											
	246	242	160	134					928		
	252	257	161	136					908		
	256	260	163	137							
	258	264	164	138					904		
	257	263	163	138							
	258	264	163	138					910		
Ave.	255	258	162	137	91	30.63	4.68	6.11	912	29.2	11.8

Made without the air Preheater. Air preheated to some extent in the air-passage ways.

742 80 30

2b	308	296	138	99							
	306	296	141	100					906		
	309	301	144	101							
	307	300	144	102					920		
	306	302	140	102							
	308	304	141	102					910		
Ave.	307	298	140	101	70	25.5	3.81	7.66	913	29.2	14.8

The kerosene for these tests weighed 6.70 lbs. per gallon. Fuel consumption given per hour. Temperature in degrees F.

4.

Without Air Preheater.

743 80 30

4b											
	322	340	136	97							
	319	338	139	97					920		
	318	338	140	98							
	322	340	142	99					920		
	318	337	142	100							
	317	336	141	99					910		
Ave.	319	338	141	98	62	25.13	3.75	7.80	912	29.2	14.80

Without Air Preheater.

742 80 30

5b.	325	360	152	117							
	326	364	160	118					920		
	326	364	160	120							
	326	364	160	120					900		
	328	365	162	121							
	329	360	161	121					910		
Ave.	327	364	159	120	85	27.25	4.07	7.18	910	29.2	13.3

The kerosene for these tests weighed 6.70 lbs. per gallon. Fuel consumption given per hour. Temperature in degrees F.

Without Air Preheater.

					745			80		30	
8b.											
	325	304	138	112							
	330	306	139	114					920		
	330	310	140	115							
	332	314	141	113					910		
	333	314	141	114							
	336	312	140	113					910		
Ave.	331	309	140	113	76	25.75	3.84	7.60	913	29.2	14.2

Two outside cylinders exhausting into the air.

					745			80		30	
10b	256	258	180	120							
	259	250	153	122					920		
	258	260	156	124							
	258	260	158	124					900		
	258	260	157	123							
	258	259	156	123					912		
Ave.	257	259	156	123	92	27.13	4.05	7.21	912	29.2	13.4

The kerosene for these tests weighed 6.70 lbs. per gallon. Fuel consumption given per hour. Temperature in degrees F.

Cold Air at room Temperature taken at the Carburetor.

	742			80				30		
2c										
	334	322	89							
	342	328	90					934		
	842	331	90							
	342	331	90					918		
	340	330	90							
	338	330	90					916		
Ave.	339	328	90	70	20.00	3.01	9.77	920	29.4	18.3

Same as above.

	742			80				30		
4c	344	360	86							
	346	364	86					904		
	348	368	87							
	350	370	87					910		
	352	372	89							
	352	372	88					905		
Ave.	347	368	87	60	19.88	2.96	9.77	906	29.0	18.25

The kerosene for these tests weighed 6.70 lbs. per gallon. Fuel consumption given per hour. Temperature in degrees F.

Air taken in a Room Temperature thru the carburetor.

742 80 30

5c

	338	376	104							
	332	372	105					895		
	333	372	105							
	328	369	104					910		
	325	364	104							
	325	366	104					914		
Ave.	330	370	104	85	21.75	3.25	8.91	906	29.0	16.75

Same as above.

737 80 30

7c.	339	350	105							
	342	356	110					930		
	344	360	110							
	343	362	113					920		
	339	360	114							
	339	360	115					914		
Ave.	341	358	113	86	21.88	3.26	9.02	920	29.4	16.9

The kerosene for these tests weighed 6.70 lbs. per gallon. Fuel consumption given per hour. Temperature in degrees F.

Air taken in at Room Temperature in the Carburetor.

737 80 30

8c

	341	328	108							
	341	333	107					912		
	340	336	108							
	338	337	110					900		
	335	333	108							
	334	332	107					920		
Ave.	338	333	108	80	21.00	3.13	9.3	910	29.1	17.30

Air taken in thru Caruretor as before.

742 75 30

9c

	346	345	116							
	344	339	116					904		
	349	347	120							
	347	344	120					904		
	344	344	120							
	344	345	121					914		
Ave.	346	341	120	95	20.5	3.06	8.91	907	27.2	16.35

The kerosene for these tests weighed 6.70 lbs. per gallon. Fuel consumption given per hour. Temperature in degrees F.

9.

Two outside cylinders exhausting in the air.

			745			80			30	
10c										
	262	262	108							
	274	275	110					920		
	280	281	112							
	283	283	114					920		
	283	283	114							
	282	283	114					910		
Ave.	275	276	112	95	19.88	2.96	9.8	916	20.3	18.4

Same as above.

			746			80			30	
	277	256	110							
11c	277	252	110							
	278	256	110							
	278	258								
	278	260								
	279	276*								
	280	277^								
	280	278								
	279	276								
	278	278								
	279	278								
	278	277								
Ave.	278	277	110	95	20.19	3.00	9.8	9.17	20.4	18.05

* Thermometer not in tight.

^ Changed.

The kerosene used for this test weighed 6.70 lbs.

Fuel onsumption given per hour. Temperature in degrees F.

AVERAGE OF TESTS.

Using Preheater:

3a	322	344	169	129	72	4.36	6.35	28.8	11.9
3a	333	345	167	128	62	4.36	6.55	28.6	12.2
5a	335	367	186	145	84	4.66	6.52	28.5	11.8
6a	365	305	184	145	74	4.65	6.03	28.0	11.7
Ave.	339		174	138	73	4.51	6.36	28.2	11.9

Without Preheater but thru passageway.

2b	307	298	140	101	70	3.81	7.66	29.2	14.8
4b	319	338	141	98	62	3.75	7.80	29.2	14.5
5b	327	364	159	120	85	4.07	7.18	29.2	13.3
8b	331	309	140	113	76	3.84	7.60	29.2	14.2
Ave.	324		145	108	73	3.87	7.56	29.2	14.2

AVERAGES OF TESTS.

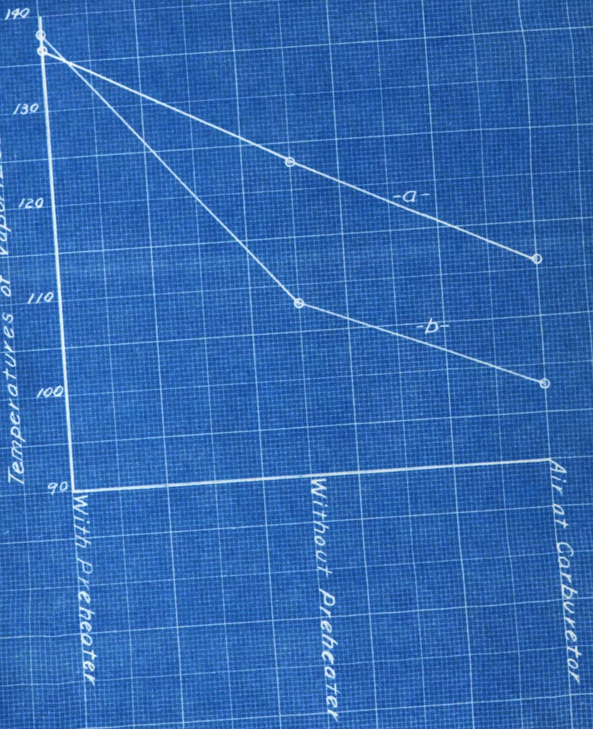
Air thru Carburetor:

2c	339	328	90	70	3.01	9.77	29.4	18.30
4c	347	368	87	60	2.96	9.77	29.0	18.25
5c	330	370	104	85	3.25	8.91	29.0	16.75
7c	341	358	113	86	3.26	9.02	29.4	16.90
8c	338	333	108	80	3.13	9.30	29.1	17.30
Ave.	345		98	76	3.12	9.36	29.2	17.50

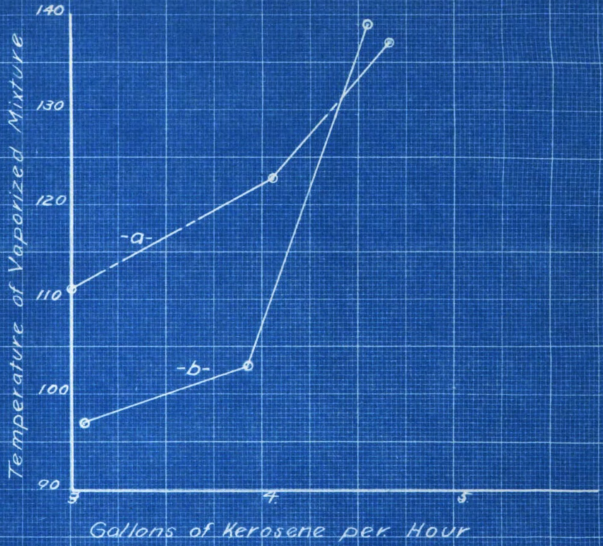
Averages when exhausting into air from two outside cylinders.

10a	255 208 257	162	137	91	4.68	6.11	29.2	11.8
10b	257 259 258	258	123	92	4.05	7.21	29.2	13.4
10c	275 276 275		112	95	2.96	9.8	29.3	18.40
11c	278 277 277		110	95	3.00	9.8	29.4	18.00
Ave.	276		111	95	2.98	9.8	29.3	18.20

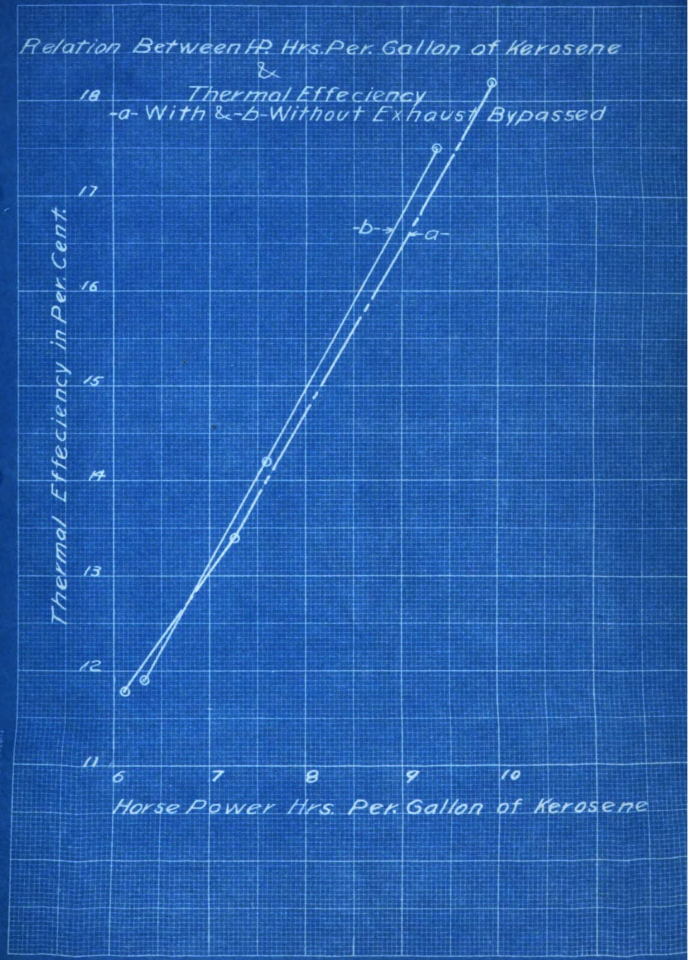
Vaporized Mixture Temperatures
-a- With & -b- Without Exhaust Bypassed

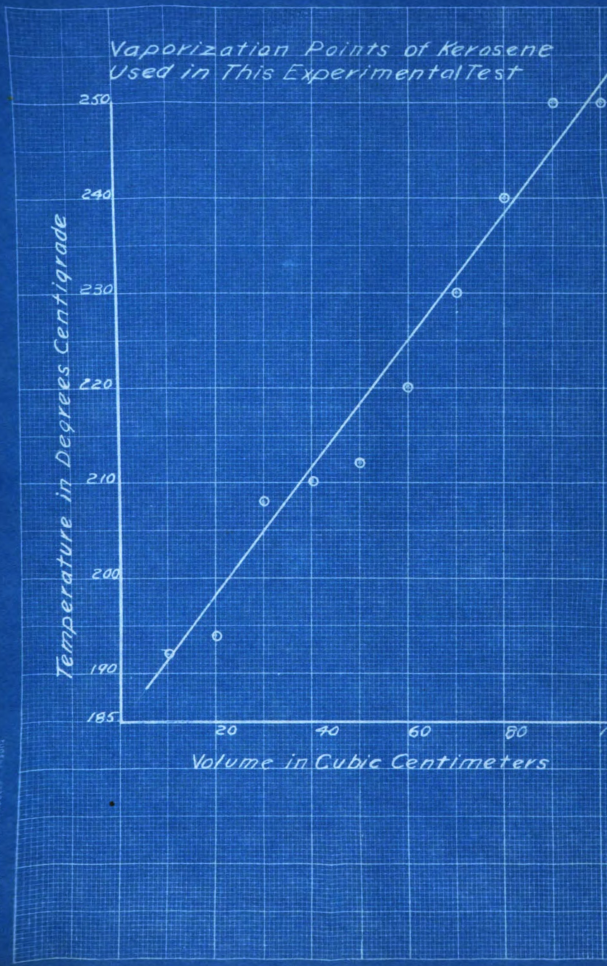


Relation Between Temperature of Mixture and Fuel Consumption -a- With & -b- Without Exhaust Bypassed



Temperatures in Manifold
a- With -& -b- Without Exhaust Bypassed
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
-b-
-a-
With Preheater
Without Preheater
Air at Carburetor


Relation Between H.P. Hrs. Per. Gallon of Kerosene
&
Thermal Effeciency
-a- With &-b- Without Exhaust Bypassed
Thermal Effeciency in Per. Cent.
18
17
16
15
14
13
12
11
-b-
-a-
6
7
8
9
10
Horse Power Hrs. Per. Gallon of Kerosene


Vaporization Points of Kerosene
Used in This Experimental Test
Temperature in Degrees Centigrade
250
240
230
220
210
200
190
185
20
40
60
80
Volume in Cubic Centimeters

Fuel Consumption & Comparison Between Thermal Effeciencies -a- With & -b- Without Exhaust Bypassed