THESIS

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TITLE.

An Investigation conducted on a three-port two-cycle Mietz and Weiss kerosene engine and the designing of an automatic valve for the intake of the air required to determine by its use the possibility of improving its economy.

FOREWORD.

We are deeply indebted to Professor Riley for his invaluable aid and helpful suggestions in conducting these investigations.

We also wish to thank Professor Gill and Messrs. Eames, O'Neill and Davies for their kind assistance.

EXPLANATION AND PURPOSE.

In three-port two-cycle engines of the Mietz and Weiss type, there is a certain amount of useless work performed by the piston in a suction and compression of the air in the crank-case before it is admitted to the cylinder. It was thought that a properly designed check valve would eliminate the suction part of this loss and thereby lessen the fuel consumption of the engine.

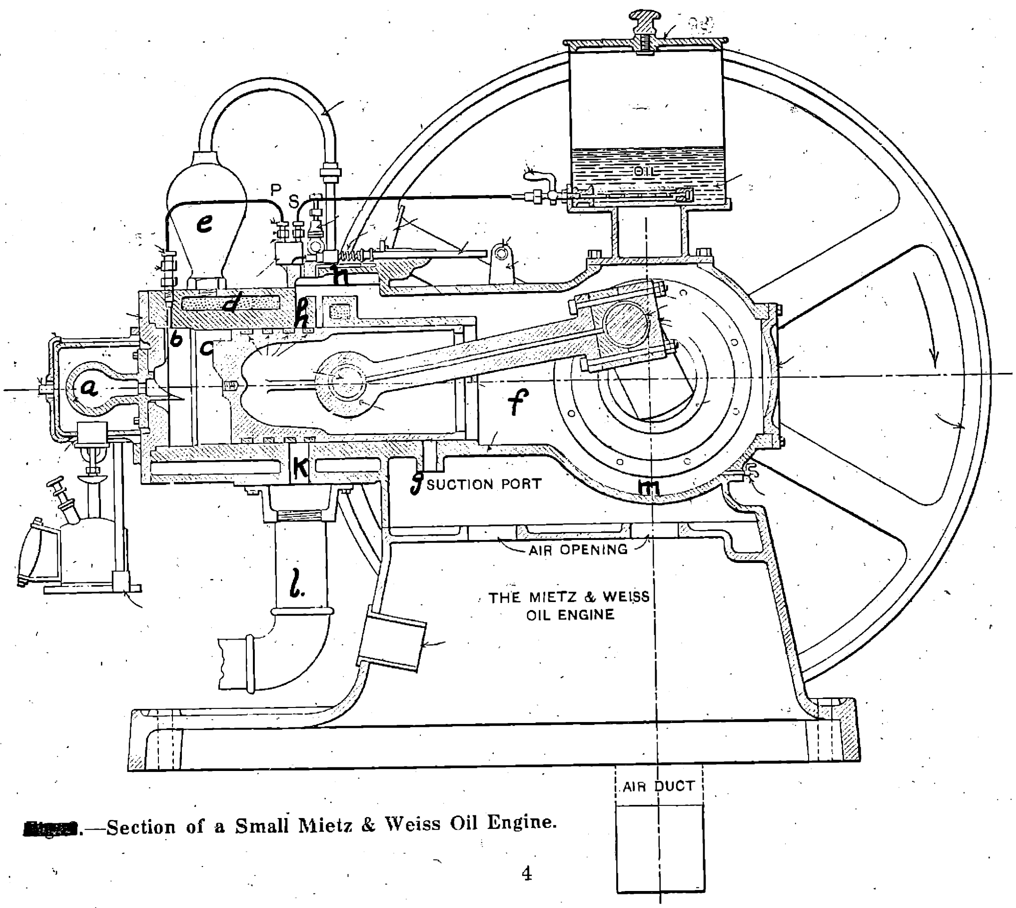
DESCRIPTION OF ENGINE.

The engine tested was a Mietz and Weiss Oil Engine with 7-inch piston diameter and 8-inch stroke.

An illustration of the engine is given in figure #1. It works on the two cycle principle, -- that is, an explosion is obtained in the cylinder at each revolution of the crank shaft. The liquid fuel is injected into the combustion chamber of the cylinder at about the time that the compression stroke is completed. The nozzle "b", figure #1, from which the oil is ejected points so that the jet of oil projected into the cylinder strikes a deflector plate "c", extending out from the inner end of the piston, and part of it is deflected into the hot bulb, "a", placed at the back of the cylinder.

The ignition is obtained by vaporizing the oil with air which is under compression in the hot chamber "a". This bulb is heated on starting by an independent torch and afterwards the heat created by constant combustion maintains the ignition automatically at the proper temperature.

FIGURE #1.



[redacted].—Section of a Small Mietz & Weiss Oil Engine.

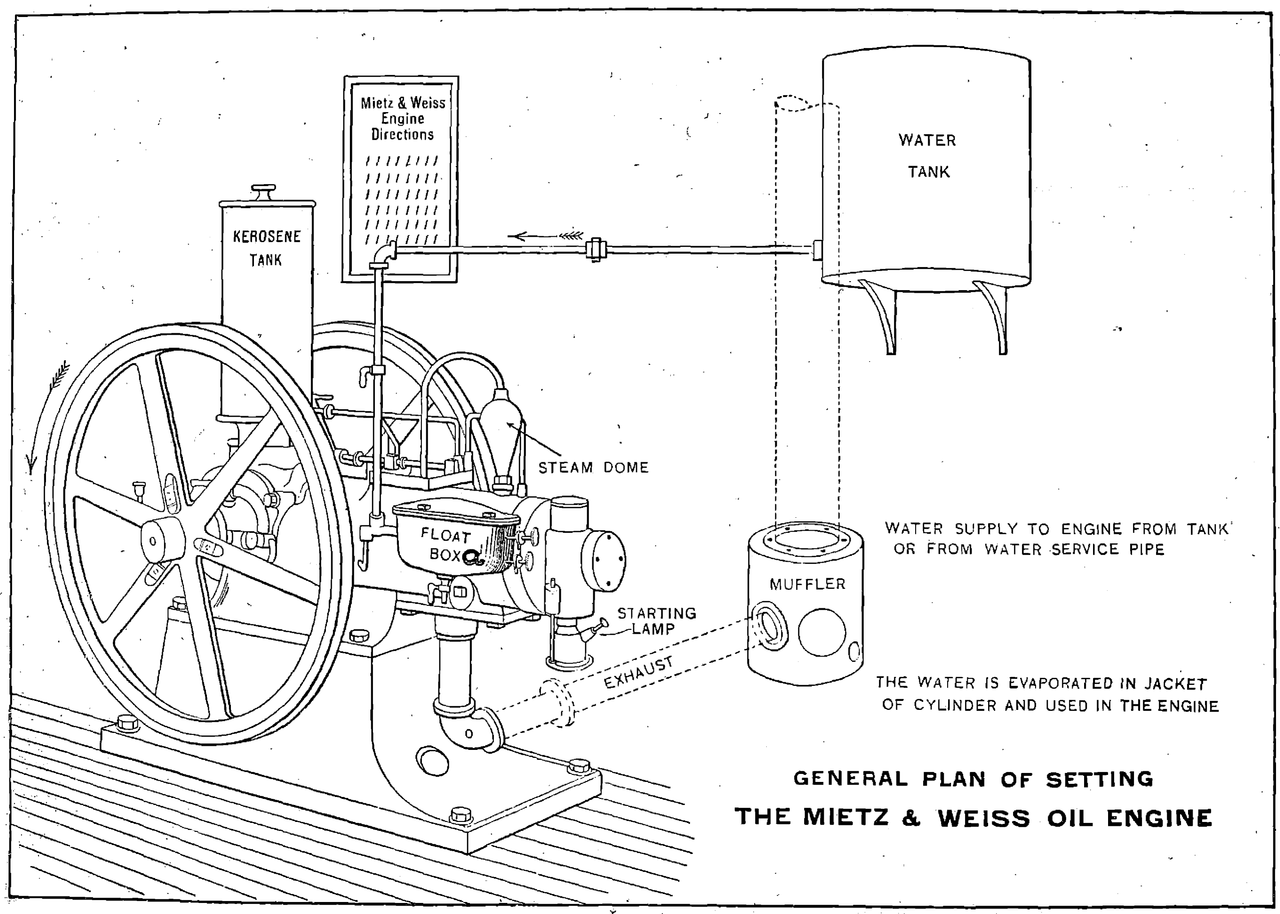
The engine is arranged to allow steam formed in the water jacket "d" surrounding the cylinder to enter through the dome "e" into the combustion chamber with the fuel. The advantages of this are:

(1) The engine works more quietly with it than without. The heavy blow of the explosion and the metallic sound heard at full load is reduced.

(2) A somewhat higher compression can be used with the water injection without fear of pre-ignition.

(3) The lubrication of the cylinder is assisted and the piston is maintained in a cleaner condition because of the softening effect of the vapor upon the deposition of carbon.

FIGURE #2.



GENERAL PLAN OF SETTING
THE MIETZ & WEISS OIL ENGINE

The regulation of the water supply is maintained by means of the constant level tank "a" shown in figure #2, sectional in figure #3. This tank is connected to the side of the motor

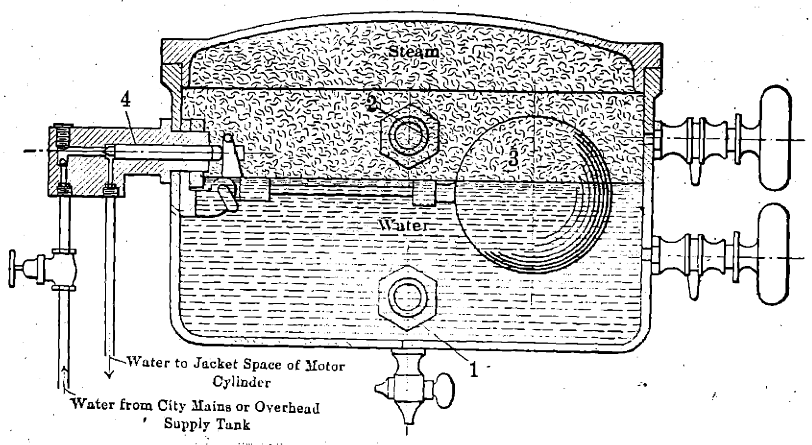


Fig. #3.

cylinder, and communicates to the water jacket space. The level of the water in the jacket space is the same as in the tank.

Air is admitted to the crank chamber "f" through the port "g" when the piston is near the head end dead point. This air is compressed by the explosion stroke of the piston, and is drawn into the cylinder through the port "h" at a slight pressure during each outward stroke of the piston.

The exhaust opening "k" is automatically uncovered as the piston travels toward the end of the stroke and the products of combustion are free to pass to the exhaust pipe "l", while the piston travels to the end of the stroke and the first part of the return stroke, until the port is again covered. The compression period then commences for the next explosion.

Lubrication is accomplished by the following method:

The deficiency of pressure in the crank chamber is used to raise the oil from a well placed below the sight feed oilers which supply oil to the cylinder and crank chamber. The crank shaft bearing is lubricated in addition by the splash of the crank in the oil pocket "m", figure #1.

Fuel is supplied to the engine partly by gravitation. The quantity injected, however, into the cylinder, is regulated by a small oil supply pump "n", figure #1.

The governor is of the centrifugal type and acts through a variable stroke on the kerosene pump, graduating the charge for varying loads. The governor weight is arranged near the shaft at the hub of the fly-wheel to which it is pivoted at one end, the other end being secured to an adjustable spring, the tension of which determines the speed. The eccentric is free to slide at right angles to the shaft, and, being pivoted to the extreme end of the governor weight, receives a slight turning movement ahead, from no load to full load. The regulation of this governor is extremely close.

DESIGN OF VALVE.

The ideal valve for an engine of this kind is one which will admit the air with the least possible resistance, starting as soon as possible after the beginning of the suction stroke. At the same time, particular care must be taken to guard against any leakage of air through the valve when the piston starts to return on its compression stroke.

The following types of valves were considered:

1. Spiral spring valve (made by Mesta Machine Shops, Pittsburgh, Pa.)

This consists of a flat steel plate, cut in the form of a spiral, held stationary at the center and seating at the edges on a leather washer. The spring and the seat are housed in an iron casting.

2. A metal poppet valve similar to those used in the intake and exhaust of gasolene engines of the ordinary automobile type.

3. The third type of valve which was finally adopted as being the simplest in operation and construction was an automatic leather-disc check valve.

Figure #4 shows an assembly of a valve of this type as it was finally used in the tests.

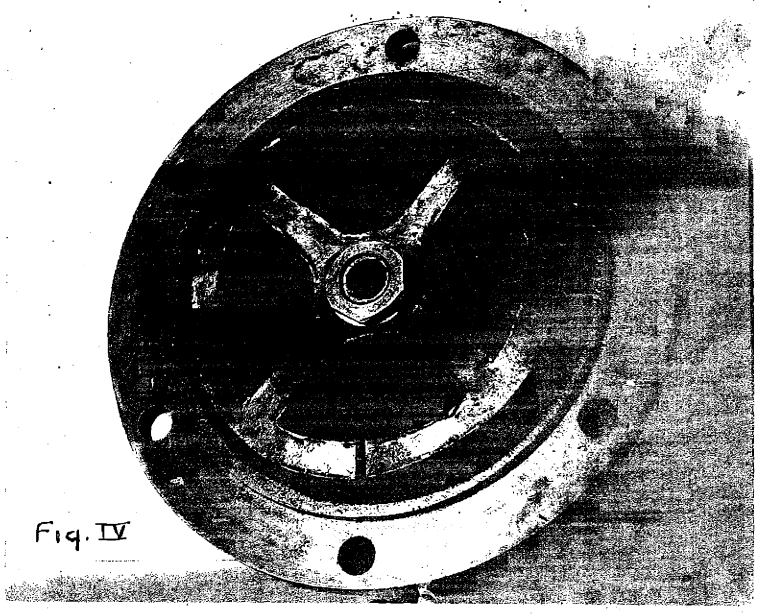
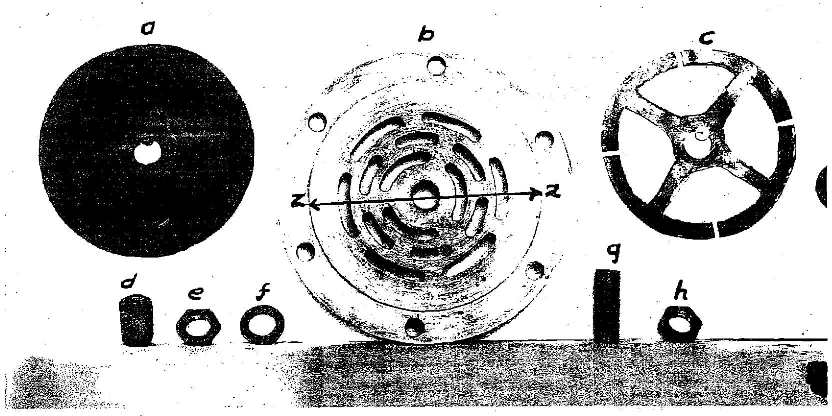


Fig. IV

In figure #5 the separate parts are shown.

Fig. V



"a" is a leather disc 6 1/2 inches in diameter, 1/8 inch thick at the centre, tapering radially to a thickness of 3/32 inch at the perimeter.

"b - a gray iron casting of the following dimensions:

Over all diameter............... 9 inches

Thickness........................ 1/2 inch

Diameter crank case opening

(zz fig. #5 - "b").. 7 1/8 inch

"c" is a spring 6 inches in diameter cut from sheet steel No. 24, U.S. Standard gage.

"g" is a nipple which is screwed through casting "b". "a", "c", and washer "f" are then slipped over "g" and held in place by nut "e". On the other side, nut "h" is threaded securely against casting "b". A coupling "d" is threaded onto "g". The indicator pet-cock screws into this coupling.

The action of the valve is as follows: On the suction stroke the pressure of the outside air forces back the leather flap from the seat, allowing the air to flow through the ports into the crank case. On the return stroke of the piston the leather disc returns to its seat, causing a pressure to build up in the crank case until the port into the cylinder is uncovered. It was thought in the original design of the valve that the pressure in the crank case would hold the leather disc against its seat securely enough to prevent any backward leakage through the ports. However, it was found, after actually testing the valve, that the return of the disc to its seat was not prompt and positive enough to obtain the desired result, and the engine, due to this leakage, failed to receive sufficient air for a proper mixture. To remedy this, spring "c" described above was placed behind the leather disc and gave satisfactory results.

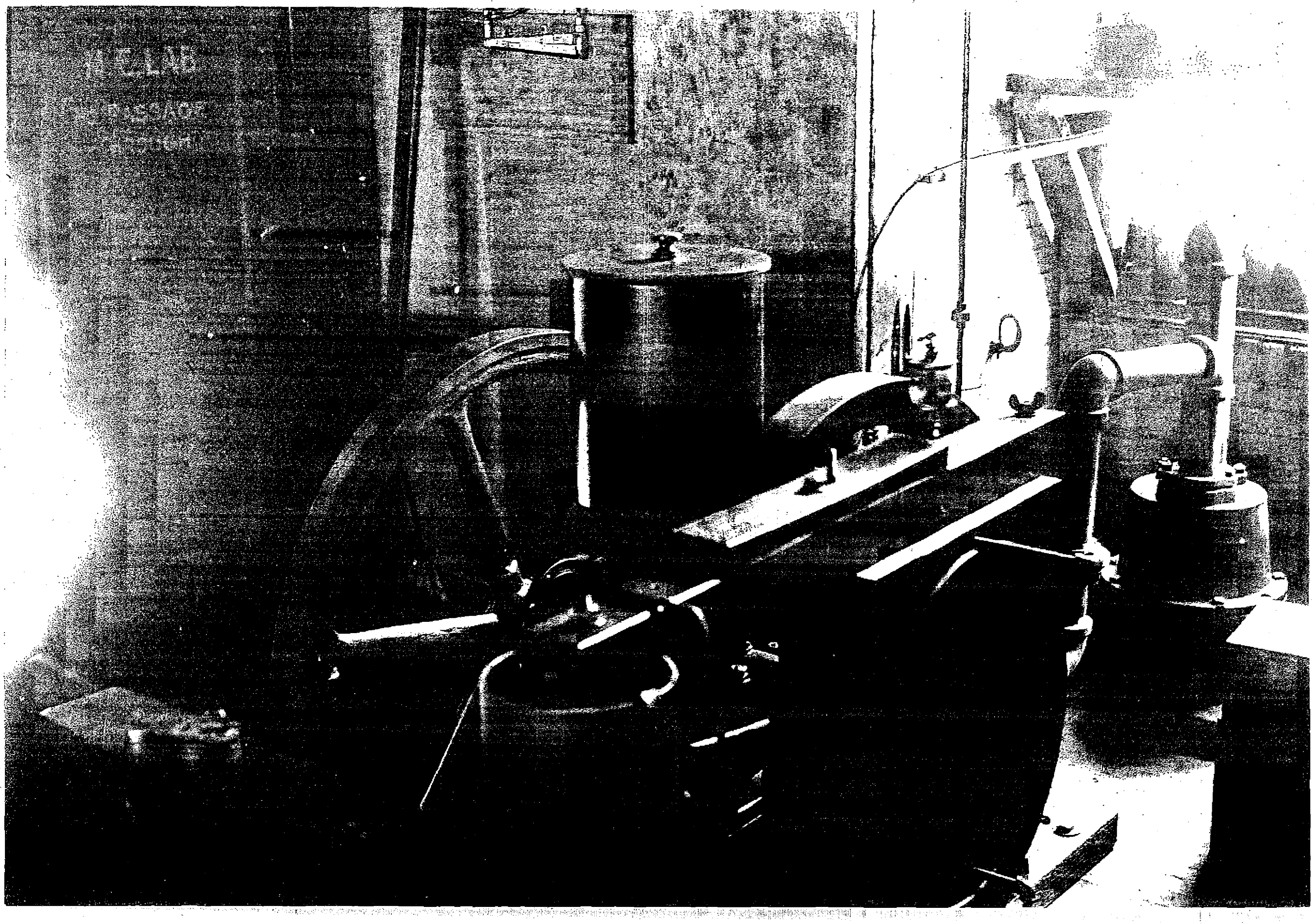


Figure #6.

A picture of the engine and apparatus set up for testing.

APPARATUS AND METHOD OF TESTING.

The following is a description of the method of testing and the apparatus used.

Two series of tests were run with and without the valve with loads varying from no-load to maximum, above which the engine would not run without excessive pounding.

The following readings were taken:

(1) Duration of test.

(2) Load on the brake.

(3) Revolutions per minute.

(4) Fuel consumption.

(5) Indicator cards of the crank chamber and combustion chamber.

(1) The length of each test was thirty minutes.

(2) The load on the engine was measured by means of a ~~prong~~ Prony brake. The drum was attached to the fly-wheel "b" shown in the photograph, figure #6. Before each test the tare load on the brake was checked and the average of these was used in the computation of Horse-power.

(3) The revolutions were taken by means of a stop watch and revolution counter, every five minutes for a

period of two minutes.

(4) Fuel consumption by weight for the exact duration of each test was measured by the method of differences. In order that the engine might be kept running between each test, the pipe from a fuel tank located on a scale was connected to the pipe from the full reservoir on the engine by means of a two-way cock. In this way it was possible to obtain the exact amount of fuel consumed during the test.

(5) Indicator cards of crank chamber and cylinder were taken simultaneously for each test. For each load four sets of cards were taken and their areas used in the computation of the mean effective pressure.

Before taking cards, the indicator motion was adjusted so that the motion of the piston was accurately reduced.

This was accomplished in the following manner. The quarter, half and three-quarter points of the piston were made to correspond with successive quarter points on the indicator drum. By so doing, true pressures in the cylinder were shown at their proper positions on the cards.

GENERAL DESCRIPTION OF TESTS.

In conducting the tests, the principal difficulty encountered was due to the fact that the engine ran with considerable irregularity. After running the engine for a period of an hour or more and allowing it to stop, it was impossible to re-start it again until it had thoroughly cooled, on account of a binding or partial seizure of the piston. Upon removal of the cylinder head, it was found that considerable carbon had been dragged back onto the cylinder wall.

This carbon deposit had accumulated and formed a sticky tar-like substance. It was thought that this was the accumulation over a long period of inexperienced operation and improper care. However, after thoroughly cleaning out the cylinder and running an entirely new series of tests, with what was considered the proper amount of lubrication, it was only a short while before the same difficulty was again encountered. This led us to believe that either the lubricant or the kerosene was of a grade unsuited for engines of the hot-bulb ignition type.

Upon testing, the lubricant was found to contain a much too great percentage of tar residue. The kerosene, while not of the highest quality, was deemed to be satisfactory for the purpose. Acting upon the result of this investigation, it was considered desirable to use a high-grade engine oil of a paraffin base rather than an oil of an asphalt base. With the introduction of the new oil the seizure of the piston was eliminated and the engine could be readily re-started immediately after allowing it to stop. After a few preliminary tests, it was found that the engine ran with enough regularity to permit our conducting a series of tests which we believed to show valid results.

TABULATION OF DATA.

Following tests run without valve.

Test.	Load.	Duration.	Weight kerosene.	R.P.M. (average)
I	172 lbs.	30 min.	3.66 lbs.	352.2
II	165 "	30 "	3.34 "	358.2
III	158 "	30 "	2.97 "	358.6
IV	150 "	30 "	2.59 "	355.1
V	142 "	30 "	2.41 "	355.0
VI	135 "	30 "	2.00 "	360.
VII	0 "	30 "	1.82 "	362.2

Tare load on the brake = 121.5 lbs.

In this series of tests 172 lbs. was the maximum load obtainable.

TABULATION OF DATA.

Following tests run with valve.

Test.	Load.	Duration.	Weight kerosene.	R.P.M. (average)
I	178 lbs.	30 min.	4.03 lbs.	347.6
II	172 "	30 "	3.98 "	346.4
III	165 "	30 "	3.47 "	349.8
IV	158 "	30 "	3.44 "	354.2
V	150 "	30 "	3.00 "	355.0
VI	142 "	30 "	2.69 "	355.6
VII	135 "	30 "	2.13 "	356.6
VIII	0 "	30 "	1.85 "	360.0

M.E.P. = 41.90

H.P. = 11.50

Spring = 160 lbs.

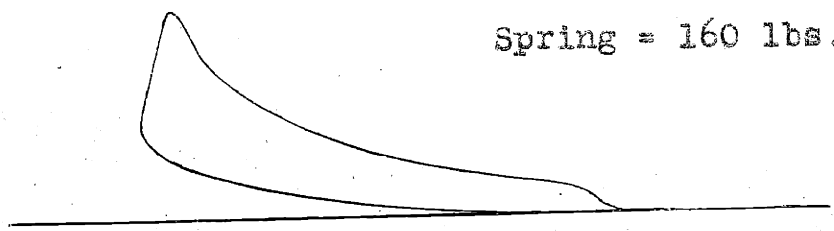


Fig. 7.

M.E.P. = 40.45

H.P. = 11.28

Spring = 160 lbs.

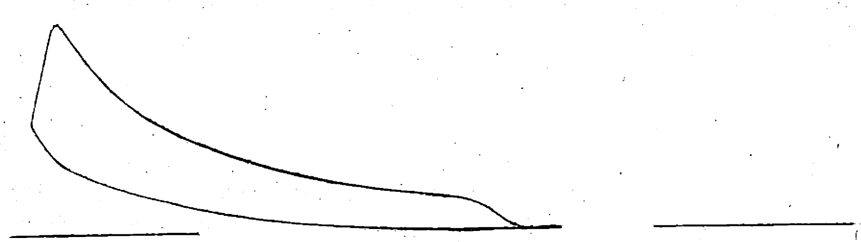


Fig. 8.

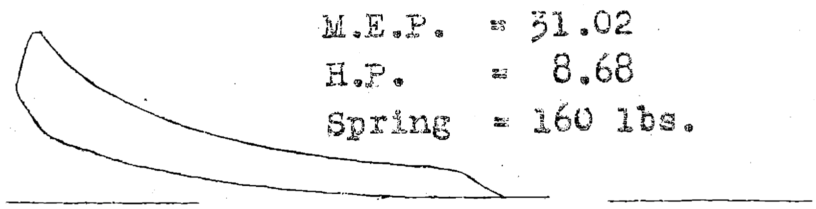


Fig. 9.

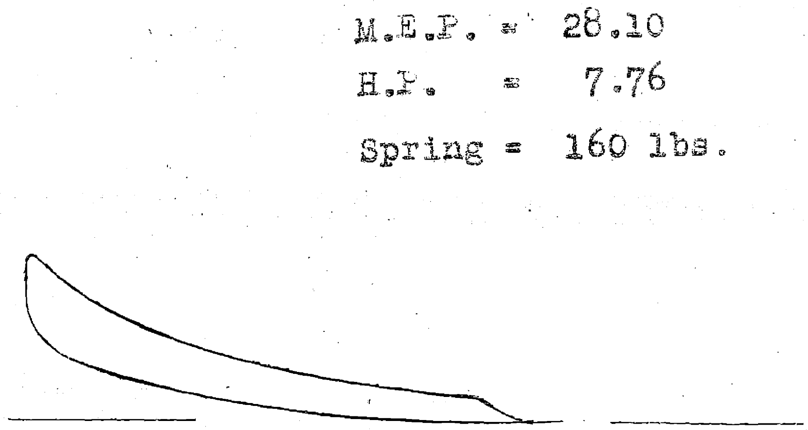


Fig. 10.

M. E. P. = 20.4
H. P. = 5.64
Spring = 160 lbs.

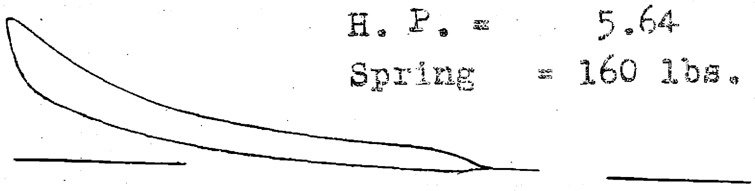


Fig. 11.

M. E. P. = 18.73
H. P. = 5.28
Spring = 160 lbs.

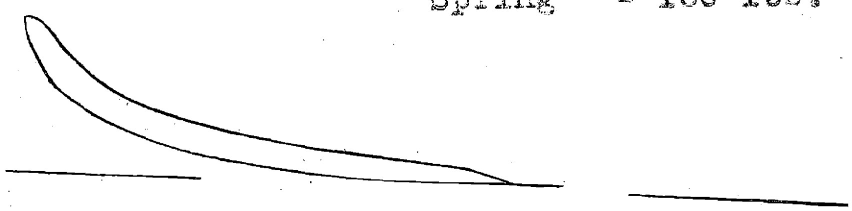


Fig. 12.

M. E. P. = 8.81
H. P. = 2.48
Spring = 160 lbs.

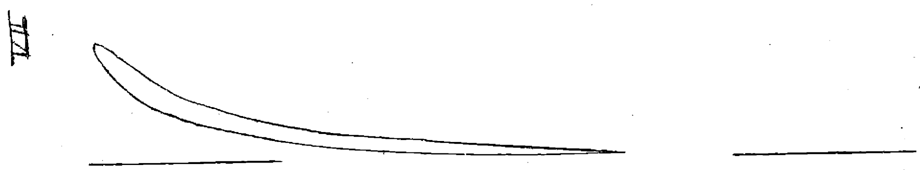


Fig. 13.

M. E. P. = 3.515
Maximum pressure = 4.20 lbs.
H. P. = 0.970
Spring = 6 lbs.

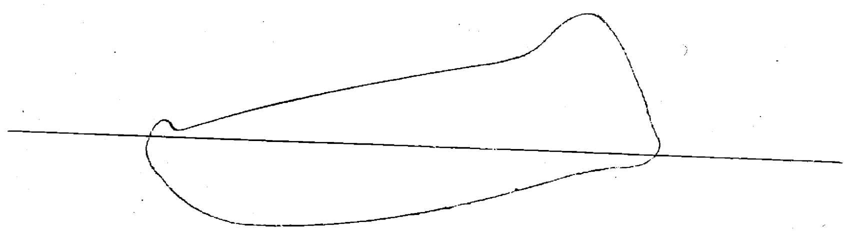


Fig. 14.

M.E.P. = 3.640
Maximum pressure = 4.25 lbs.
H. P. = 1.005
Spring = 6 lbs.

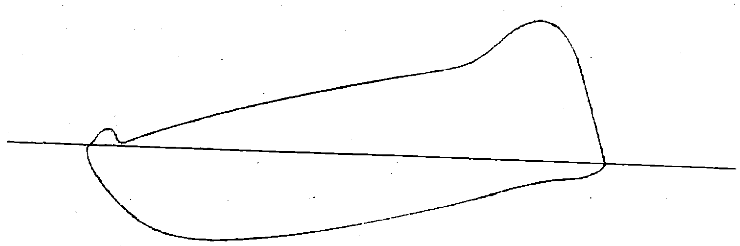


Fig. 15.

M. E. P. = 1.992
Maximum pressure = 3.60 lbs.
H. P. = 0.551
Spring = 6 lbs.

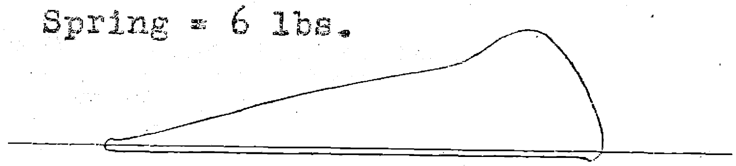


Fig. 16.

M. E. P. = 2.088
Maximum pressure = 3.67
H. P. = 0.578
Spring = 6 lbs.

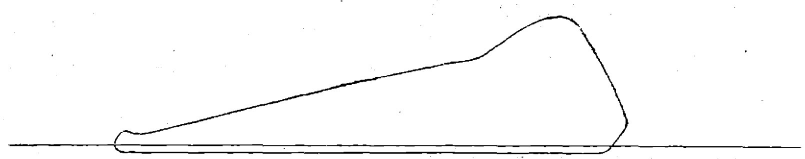


Fig. 17.

DISCUSSION OF CARDS.

Figures #7 to #13 inclusive are a sample set of indicator cards taken throughout the tests. Due to vibratory irregularities of the cards, it was impossible to detect any constant difference in the mean effective pressures of those taken with the valve and those taken without. For this reason there was no attempt made to secure information as to the economy of the valve by means of them, and they are included purely as an exhibit of interest.

Figures #14 and #15 are two of the cards best representing the phenomena occurring in the crank chamber when the engine was running without the valve.

Similarly, figures #16 and #17 are cards taken while the engine was running with the valve. As will be readily seen, the suction stroke has been greatly reduced, and likewise the total mean effective pressure due to the suction and compression strokes in the crank case has been reduced approximately forty per cent. This means that the horsepower expended in useless work on the air before it is admitted to the cylinder has been reduced in the same proportion.

From the indicator cards taken in the crank chamber, it will be seen that the maximum pressures, obtained before the port leading to the cylinder opens, are greater when the valve was not being used. This fact is very significant in studying the reasons for the falling off in economy when engine was running with the valve. A discussion in detail will be given in the conclusions.

TABULATION OF RESULTS.

The following obtained when engine was running without valve.

Test.	B.H.P.	lbs. fuel per hour.	lbs. fuel per H.P./hr.
I	8.90	7.32	0.822
II	7.80	6.68	0.856
III	6.55	5.94	0.906
IV	5.06	5.18	1.021
V	3.64	4.81	1.321
VI	2.43	4.00	1.645
VII	0	3.63	-----

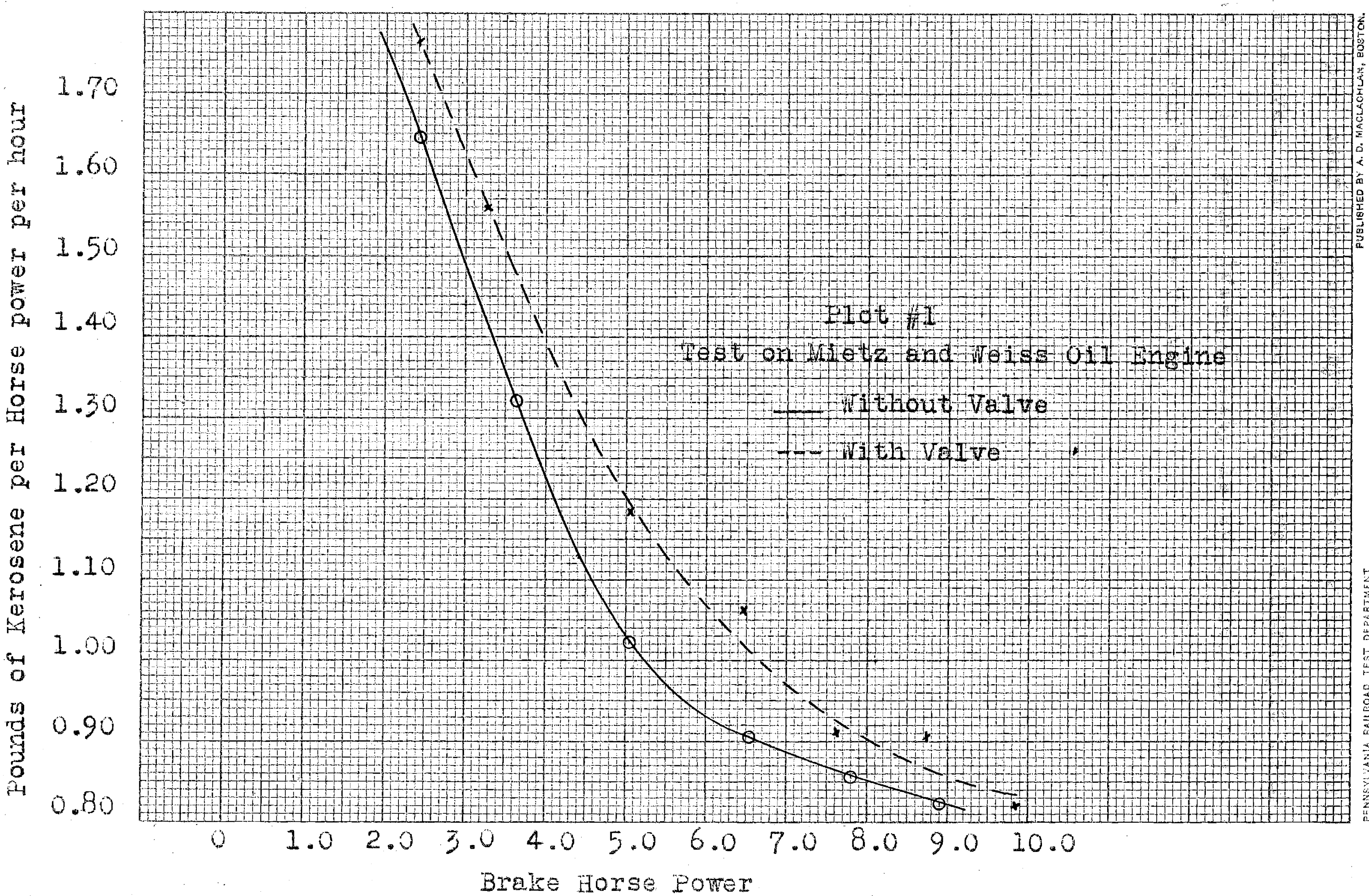
TABULATION OF RESULTS.

The following obtained when engine was running with valve.

Test.	B.H.P.	lbs. fuel per hour.	lbs. fuel per H.P./hr.
I	9.82	8.06	0.821
II	8.75	7.95	0.908
III	7.60	6.94	0.913
IV	6.47	6.87	1.061
V	5.06	6.00	1.186
VI	3.64	5.38	1.478
VII	2.41	4.25	1.763
VIII	0	3.69	-----

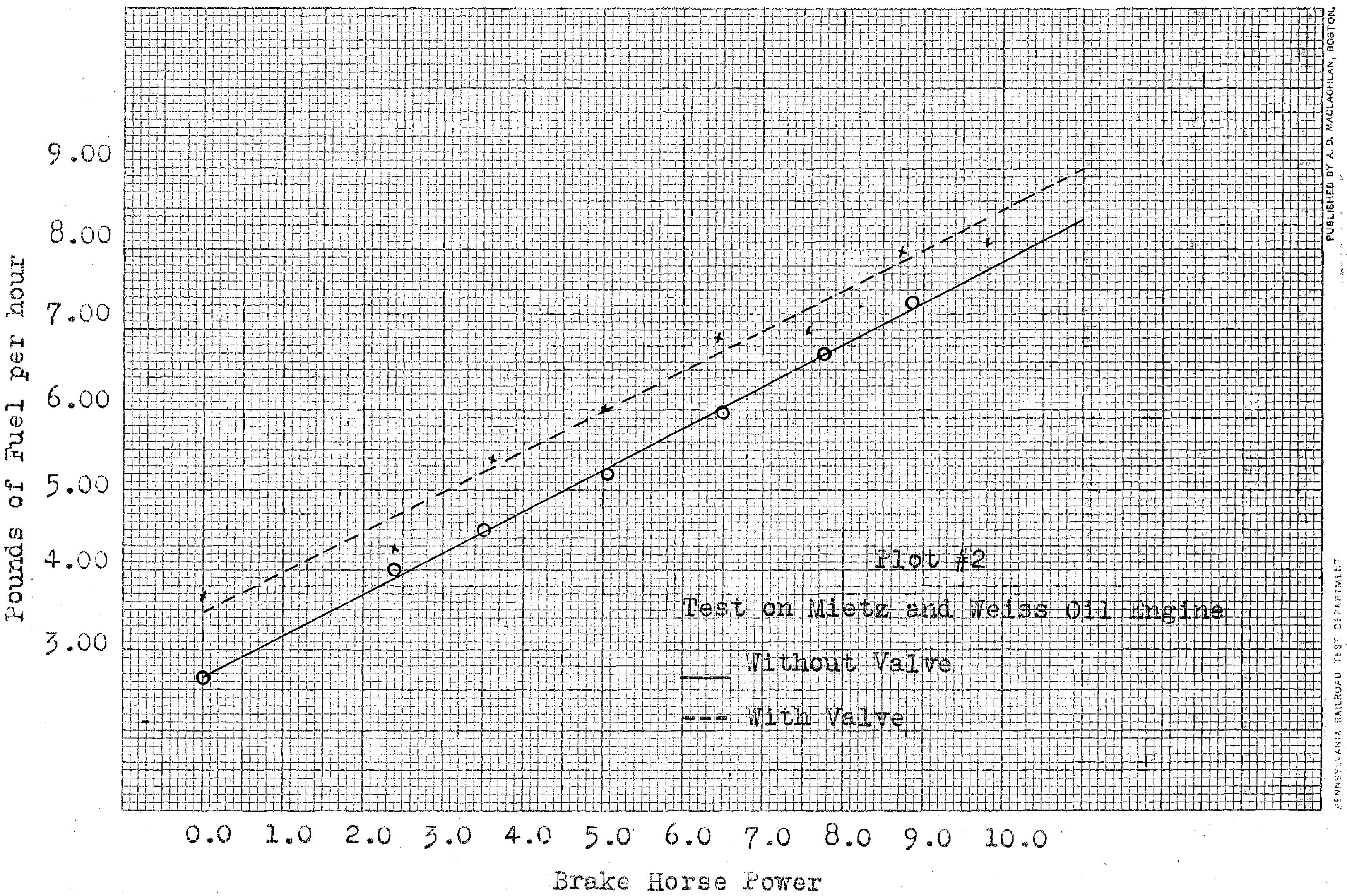
PLOTS AND DISCUSSION.

Plot #1: Shows the relation between pounds of kerosene consumed per Horse power per hour and Brake Horse power. It can be seen that the fuel consumption curve with the valve is nearly similar in shape to that without the valve and lies wholly above, thus showing a greater fuel consumption, throughout the range of the tests. The significant fact shown by these curves is the apparent irregularity of values taken while the engine was running with the valve. It is possible that this is due to the fact that the construction of the valve is such that it was not absolutely positive in its action.

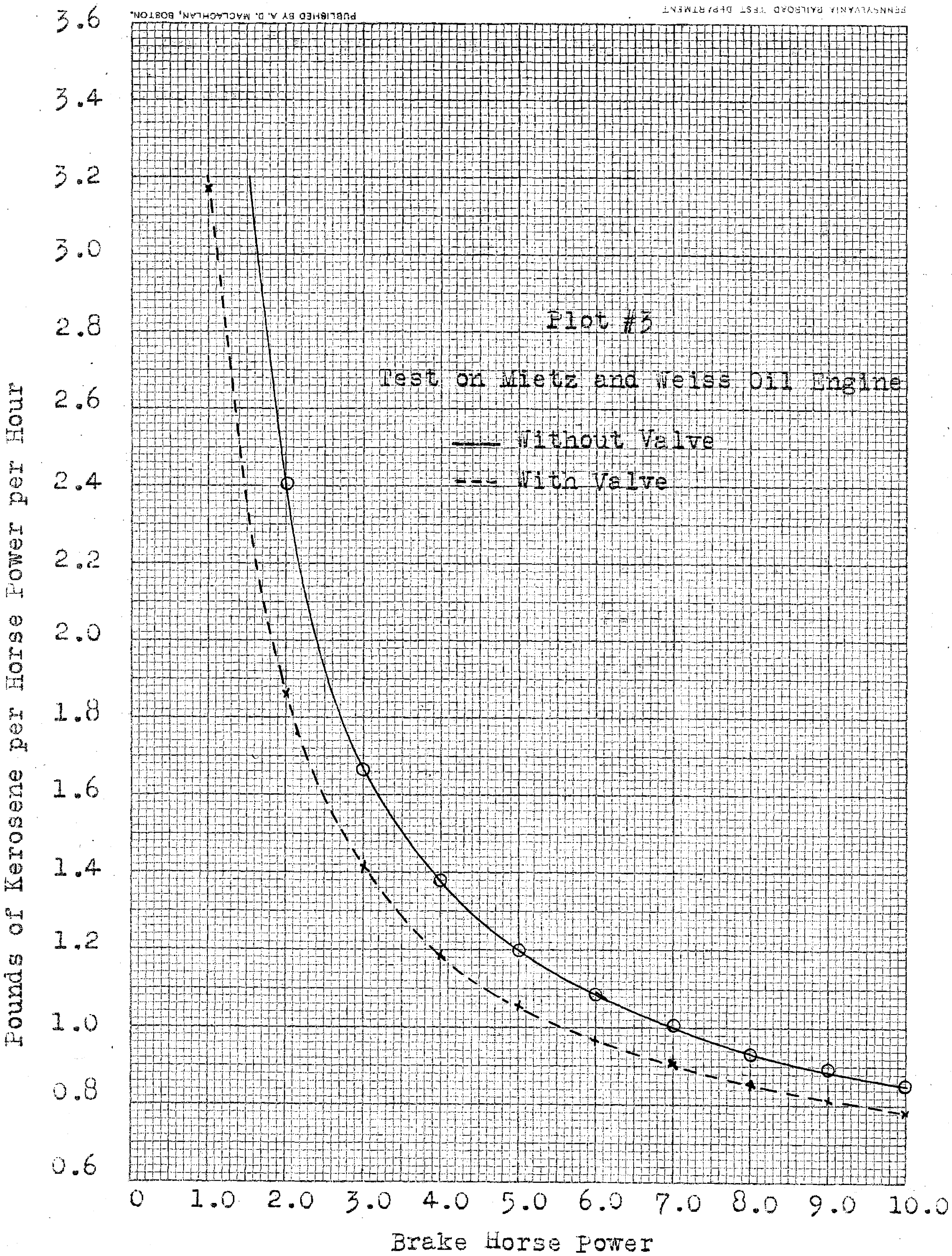


Plot #1
Test on Mietz and Weiss Oil Engine
—— Without Valve
- - - With Valve
Pounds of Kerosene per Horse power per hour
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Brake Horse Power
PUBLISHED BY A. D. MACLACHLAN, BOSTON.
PENNSYLVANIA RAILROAD TEST DEPARTMENT

Plot #2 is a comparison of the pounds of fuel per hour consumed by the engine with and without the valve. In both cases they give a straight line plot. The same irregularity is evidenced in the tests run with the valve.


Plot #2
Test on Mietz and Weiss Oil Engine
Without Valve
With Valve
9.00
8.00
7.00
6.00
5.00
4.00
3.00
Pounds of Fuel per hour
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
Brake Horse Power
PUBLISHED BY A. D. MACLACHLAN, BOSTON.
PENNSYLVANIA RAILROAD TEST DEPARTMENT

Plot #3 is similar to Plot #1, except that the fuel consumption values are obtained from Plot #2. By means of this plot the errors of observation and the irregularities of the engine have been reduced and it has been possible to continue the curves beyond the limits of experimental data.



PUBLISHED BY A. D. MACLACHLAN, BOSTON.
PENNSYLVANIA RAILROAD TEST DEPARTMENT
Plot #3
Test on Mietz and Weiss Oil Engine
Without Valve
With Valve
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Pounds of Kerosene per Horse Power per Hour
Brake Horse Power

TABULATION OF RESULTS.

Values of fuel read from Plot #2, for successive horse-powers.

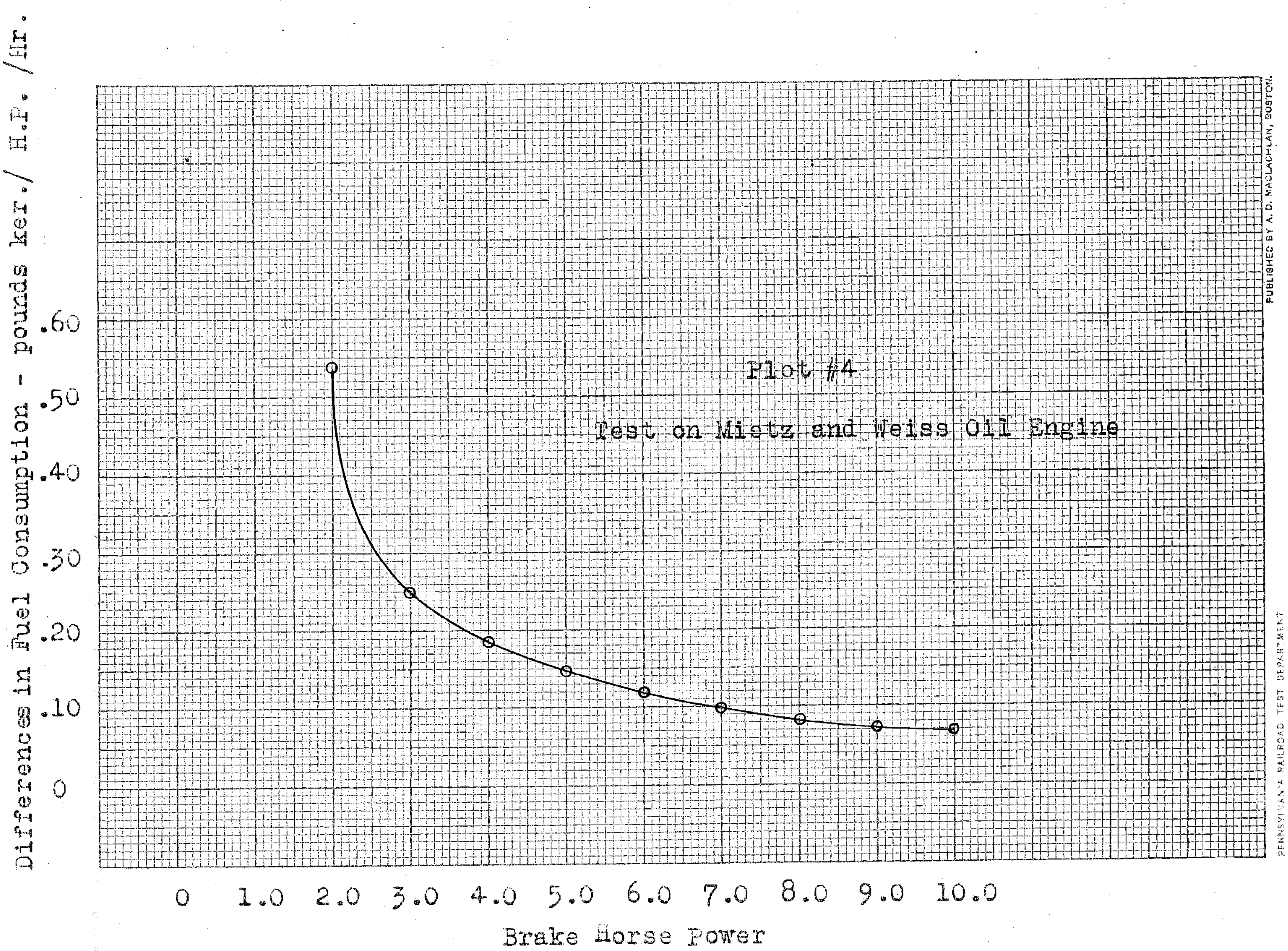
H.P.	With valve. Fuel - lbs./hr.	With valve. lbs. fuel /H.P./hr.	Without valve. Fuel - lbs./hr.	Without valve. lbs. fuel /H.P./hr.
1	3.18	3.18	---	---
2	3.70	1.85	4.48	2.24
3	4.21	1.40	4.98	1.66
4	4.73	1.18	5.50	1.38
5	5.26	1.05	6.00	1.20
6	5.78	0.96	6.48	1.08
7	6.30	0.90	7.00	1.00
8	6.81	0.85	7.49	0.94
9	7.32	0.81	8.00	0.89
10	7.85	0.79	8.50	0.85

Plot #4 is a curve showing the differences in fuel consumption per Horse-power per hour between the two series of tests. This curve shows a marked decrease in differences at lower horse-powers, and becomes asymptotic to a horizontal line which corresponds to a fuel consumption difference of .05 lbs. per Horse-power per hour.

TABULATION OF RESULTS.

Differences in fuel consumption in lbs. per Horse-power per hour between tests with and without valve taken from Plot #3.

H. P.	Differences lbs. per H.P. per hour.
1	-----
2	0.540
3	0.250
4	0.200
5	0.150
6	0.120
7	0.090
8	0.075
9	0.070


Plot #4
Test on Mietz and Weiss Oil Engine
Differences in Fuel Consumption - pounds ker./ H.P. /Hr.
.60
.50
.40
.30
.20
.10
0
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Brake Horse Power
PUBLISHED BY A. D. MACLACHLAN, BOSTON.
PENNSYLVANIA RAILROAD TEST DEPARTMENT

CONCLUSIONS.

(1) The actual economy of the engine was not improved by the use of the automatic check valve, as designed for this thesis.

(2) The engine was capable of developing a higher horse-power when running with the valve.

DISCUSSION OF CONCLUSIONS.

From the fact that the maximum pressure built up in the crank case is smaller when the valve was used, we are led to believe that the reduction of economy was brought about by insufficient air being forced into the cylinder. With the speed kept constant, the amount of air entering the cylinder depends solely on the maximum pressure in the crank-case, with the result of giving a mixture that was too rich.

While this gives worse economy, it also accounts for the fact that the horse-power output of the engine was increased.

This decrease in pressure was no doubt due to a gradual backward leakage of air through the ports of the valve on the return stroke of the piston.