

A-65 TANK ENGINE

HISTORY

AND

PROPOSED BUILDING PROGRAM

October 19, 1943

## INTRODUCTION

This report contains engine specifications, engine performance curves, and a brief history of the engine tests up to the present time.

Included in this report is a weight analysis giving the reduction in engine weight that can be made by using aluminum instead of cast iron.

A cost estimate for building three new complete engines ready for test and development, has been prepared based on the experience in building the first engine.



## SPECIFICATIONS

### OF

## CHRYSLER A-65 TANK ENGINE

### GENERAL

The A-65 engine is a 12 cylinder sixty-degree Vee type with 2 overhead valves and side-by-side connecting rods with bearings clamped in the rods.

Bore	5.5 inches
Stroke	5.5 inches
Displacement	1568 cu. in.
Compression ratio	7.1 to 1
Gross horsepower (actual)	650 @ 2600 r.p.m.
Maximum torque	1485 @ 1600 r.p.m.
Maximum B. M. E. P.	143 @ 1600 r.p.m.
Dry weight of first experimental engine (with fans)	3839.5#
*Approximate dry weight (iron block and head balance aluminum)	3400.0#
*Approximate dry weight (all aluminum)	2563.7

### CYLINDER BLOCK

60° "V"-Twelve cylinder wet sleeve construction cast iron sleeves and block.

### CYLINDER HEAD MATERIAL

Cast iron

### CRANKSHAFT

Forged steel

### IGNITION

Twin ignition - battery

### VALVES

Exhaust - 1 per cylinder sodium-cooled stem and head.  
Intake - 1 per cylinder sodium-cooled stem.

### VALVE GEAR

Single overhead cam - rocker arms - bevel gear drive

\* See Appendix #1 for detail weight analysis



## ESTIMATED BUILDING SCHEDULE

The following are the prospective dates submitted for completing three of the A-65 engines, to be used for test purposes. A schedule shown below for the time required to bring in the engines for this program is based on the experience with the first engine. It must be remembered that it may be altered by conditions beyond our control, delays in releasing changes in design, also the capacities of our Corporation tool rooms and the outside vendors to make the parts. These estimates are as firm as can be given at this time.

Material for the first engine to be in our possession approximately eight months from date of advance prints.

Material for the second and third engines to be in our possession in two months additional.

No dies will be created for making the crankshafts and camshafts, as these parts can be machined from solid stock more economically.

The pattern equipment for this Program will be made from wood, and cannot be used for any length of time for the Production activities.



ESTIMATE ON BUILDING THREE (3) A-65 ENGINES

The following estimate of the cost of building three (3) Model A-65 Tank Engines has been prepared after a conference with the interested parties.

It is understood that this estimate includes only the necessary amount of redesign work to incorporate in the design certain modifications in the engine agreed upon at the Laboratory Design Meeting previously held, and only to the release of the design for the building program; that no provision is made for laboratory or development projects, extended dynamometer work, or installation of the engines in tanks. It is limited strictly to the work necessary to build three (3) additional engines.

	<u>Material</u>	<u>Labor</u>	<u>Burden</u>	<u>Total</u>
Design Work		\$30,000	\$30,000	\$60,000
\$50,000 Mech.				
\$10,000 Electrical				
Procure Material for -	\$224,000	\$22,000	\$22,000	\$268,000
Three (3) Engines and				
assemble the same (includes				
certain spare material to				
provide for spoilage)				
Miscellaneous				\$30,000
(Preparation of notes on				
material, run-in of engines				
and contingencies)				
	<u>\$224,000</u>	<u>\$52,000</u>	<u>\$52,000</u>	<u>\$358,000</u>

Any extension of the program beyond that limited above will require a revision upward of this estimate.



## A-65 ENGINE #1 - LABORATORY HISTORY

The operating history of the No. 1 A-65 engine in the laboratory and in a medium tank at the Proving Ground is listed below.

This engine was first installed on the dynamometer on February 15, 1943. The engine was operated under a break-in schedule, followed by many W.O.T. power runs. At the end of 110.9 hours of operation a failure occurred in the fan drive gear train. The engine was removed from the stand and reinstalled on the dynamometer on April 11, 1943, after replacing all damaged parts on the gear train. The changes made at this time consisted of opening up bearing clearances and modifying the oil grooving and bushings in the fan drive gear train.

During the second dynamometer installation, the engine ran 18.7 hours, at which time the fan drive gear train failed for the second time. The engine was removed and reinstalled on the dynamometer on May 9, 1943, after needle bearings had been used to replace all of the bronze bushings in the fan drive gear train. All thrust washers were changed from hardened steel to a steel core with silver plating. These thrust washers at this time were doweled to the case instead of being allowed to float.

During this run on the dynamometer the engine ran a total of 25.3 hours. This run consisted of breaking in schedule followed by many power runs. The engine was removed from the dynamometer and installed in a converted M4A4 medium tank on May 20, 1943.

Curve No. 1 attached shows the W.O.T. performance of this engine at the time of making the first installation in the medium tank. During this time the engine operated the tank for a total of 413 miles at the Proving Ground. The engine was removed from this tank on June 21, 1943, and reinstalled on the dynamometer to check the performance of the engine using a modified camshaft. During this test the engine ran a total of 7.6 hours. The engine was removed from the dynamometer and built up with new pistons to give a compression ratio of 7.1:1, instead of the original compression ratio of 6.3:1. The engine was then installed on the dynamometer on July 1, 1943 and operated for 5 hours, during which time the performance was checked with the higher compression ratio.

The engine was removed and reinstalled in the converted M4A4 tank on July 5, 1943. Curve No. 2 shows the performance of the engine at this time. After the second installation of the engine in the medium tank, it operated the vehicle for 112 miles. The engine



was removed again from the tank on August 19, 1943, and installed on the dynamometer for performance check, during which time the engine ran for 6 hours.

The engine was then removed, and the heads were modified to such an extent that it was possible to incorporate a different design intake manifold. This was completed, and the engine was reinstalled on the dynamometer on September 20, 1943. During this time the engine was run in, followed by many W.O.T. power tests, obtaining information on the performance with the new manifold and various carburetor combinations. During this run the engine has operated for 41 hours. Curve No. 3 indicates the performance of this engine with the modified manifold.

It will be noted that the performance of the engine as indicated by this last modification of the manifold produced 6-1/2% greater maximum torque than the laboratory predicted at the beginning of this program. The horsepower at 2400 RPM is about 7 horsepower greater than that predicted. Summing up the total operation of this engine, it is apparent that dynamometer operation has accounted for 211.5 hours of operation; operation in the medium tank has accounted for 525 miles. While little or no running has been done at high speeds for sustained periods of time, an appreciable amount of the operation has been done at high load factor, even though it has been intermittent. This operation has been accomplished with remarkably little difficulty. Other than the failures of the fan drive gear train, no serious mechanical difficulty has been encountered to date. Several of the minor difficulties that have arisen have been eliminated thus far.

To date, looking at this engine from all viewpoints, it appears that the performance obtained is exceptionally good and that the endurance characteristics, while not definitely established, appear very good. In order to obtain as much information as possible from this one engine to aid in modifying the present design for possible later engines, it is recommended that this engine be torn down, all parts inspected and accurately measured, the engine then to be rebuilt and installed on the dynamometer for running a prolonged endurance test under controlled conditions. Running the engine in the laboratory on this sort of an endurance test, it will not be necessary to operate with the cooling fans. The cooling fan gear train is not designed in this engine as it would be in later engines, and it does not appear desirable to jeopardize operation of the engine by operation with the cooling fans. If this engine were to be run on endurance in a medium tank, the cooling fans, of course, would have to be installed.



It is further recommended in this endurance test that the new connecting rods with the separate bolt be incorporated at the time of building up the engine. These rods are now available.

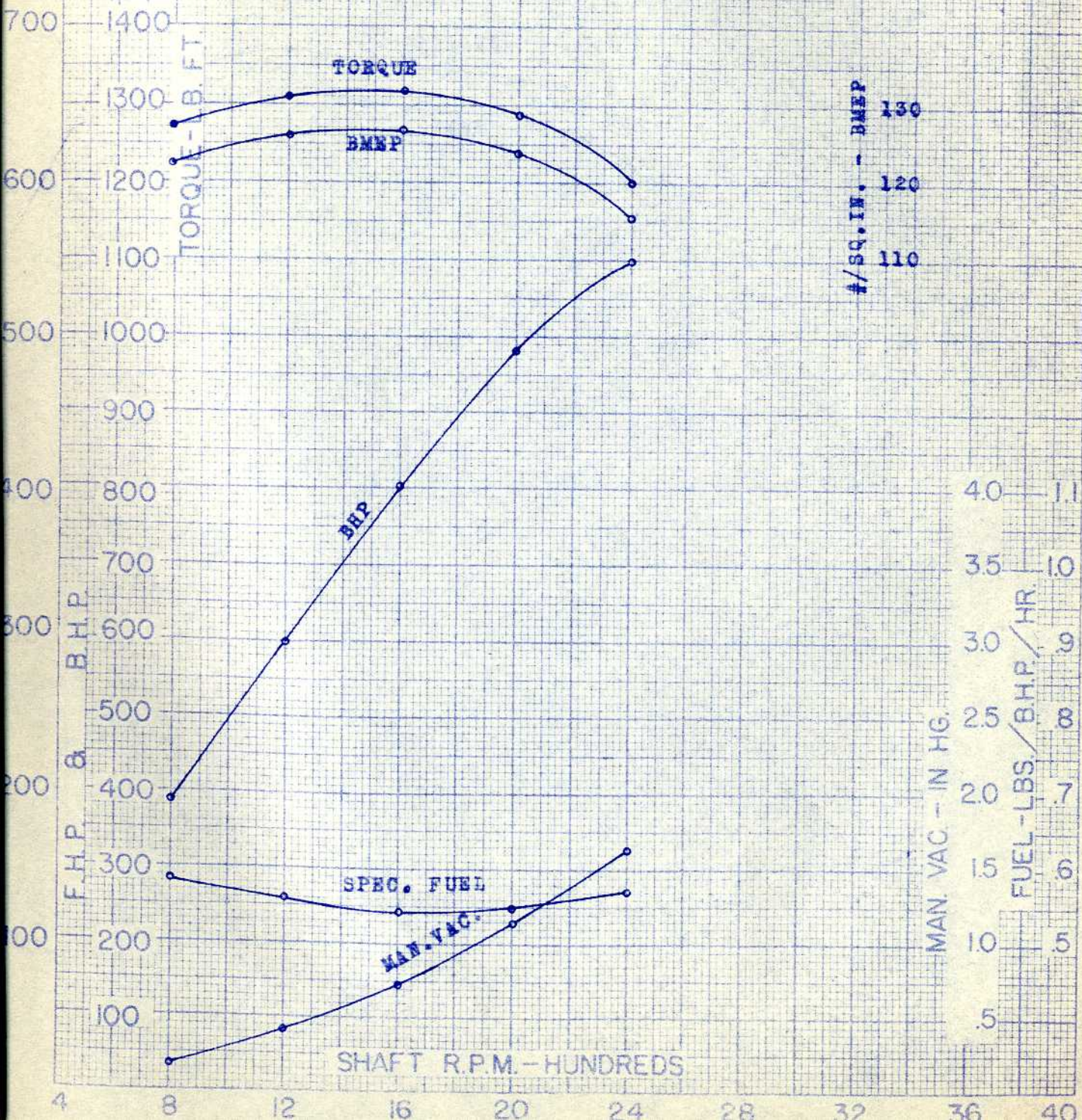
Of the initial \$25,000.00 allocated for testing this engine in the laboratory, there remains approximately \$1,000.00. Most of this money will be used in modifying a few minor details in the engine previous to the endurance test. Therefore, if the endurance test is to be carried out, it will be necessary to obtain a specific project for this work. A project covering this cost is now being processed, and if approved the work will proceed with all possible speed.



DATE 3-19-43 ENG. #A-65 1  
BORE  $5\frac{1}{2}$ " STROKE  $5\frac{1}{2}$ " 1568 cu.in.  
CARB 2 Strom. with  $1\frac{1}{2}$ " venturi; #46 MJ  
COMP 6.3-1 PLUGS Champion

OBJECT: Performance with 1" spacer under carburetors; no divider in intake manifold; valve timing  $7^\circ$  advance from std.

FIRST TANK INSTALLATION

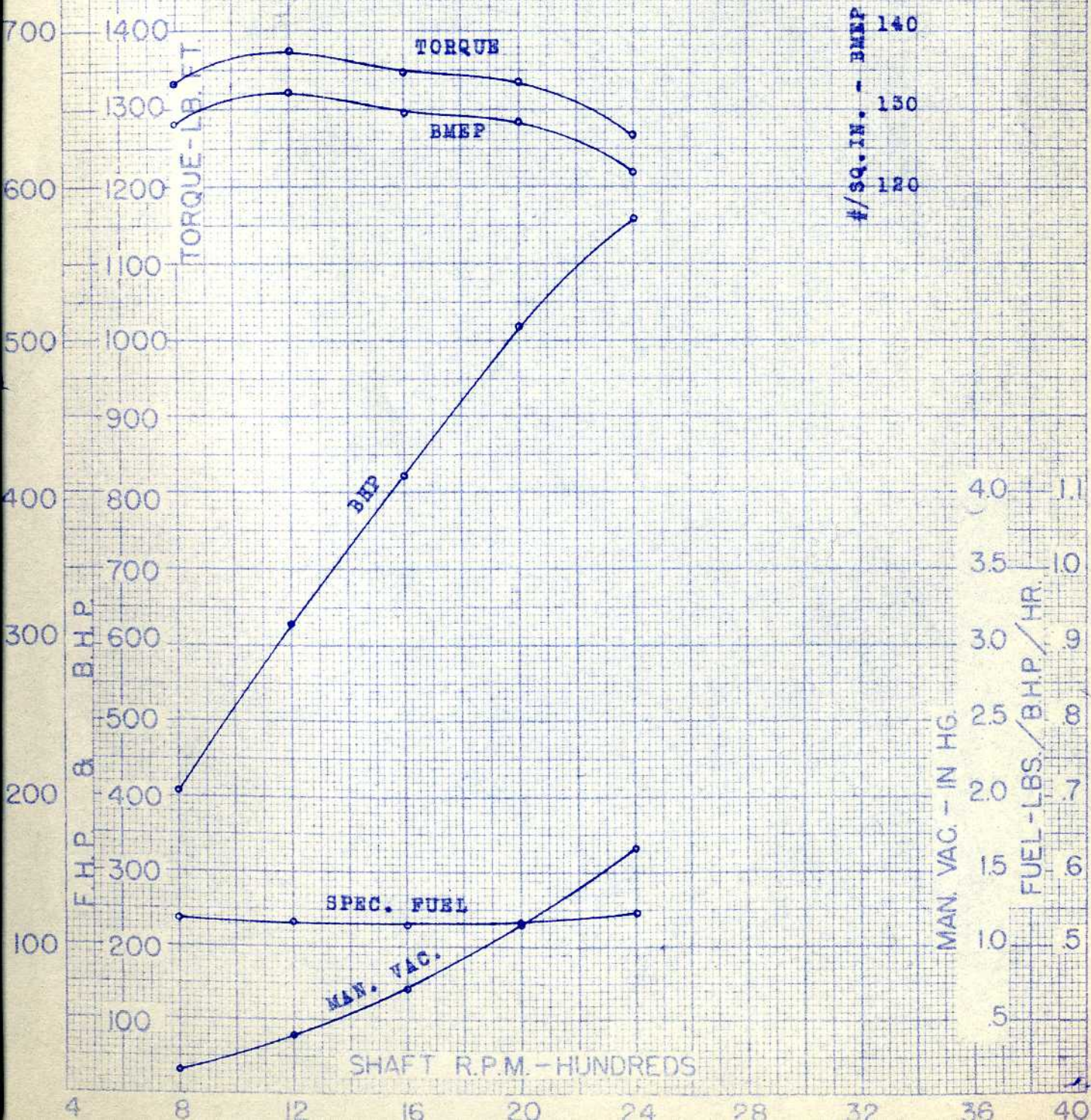




DATE 7-3-43 ENG. # A-65 1  
 BORE 5½" STROKE 5½" 1568 cu.in.  
 CARB. 2 Strombergs  
 COMP. 7.1-1 PLUGS Champion

OBJECT: Performance with original intake manifold; interconnection between barrels; cam advanced 70; governors disconnected; new distributors; hot spot between barrels removed

SECOND TANK INSTALLATION

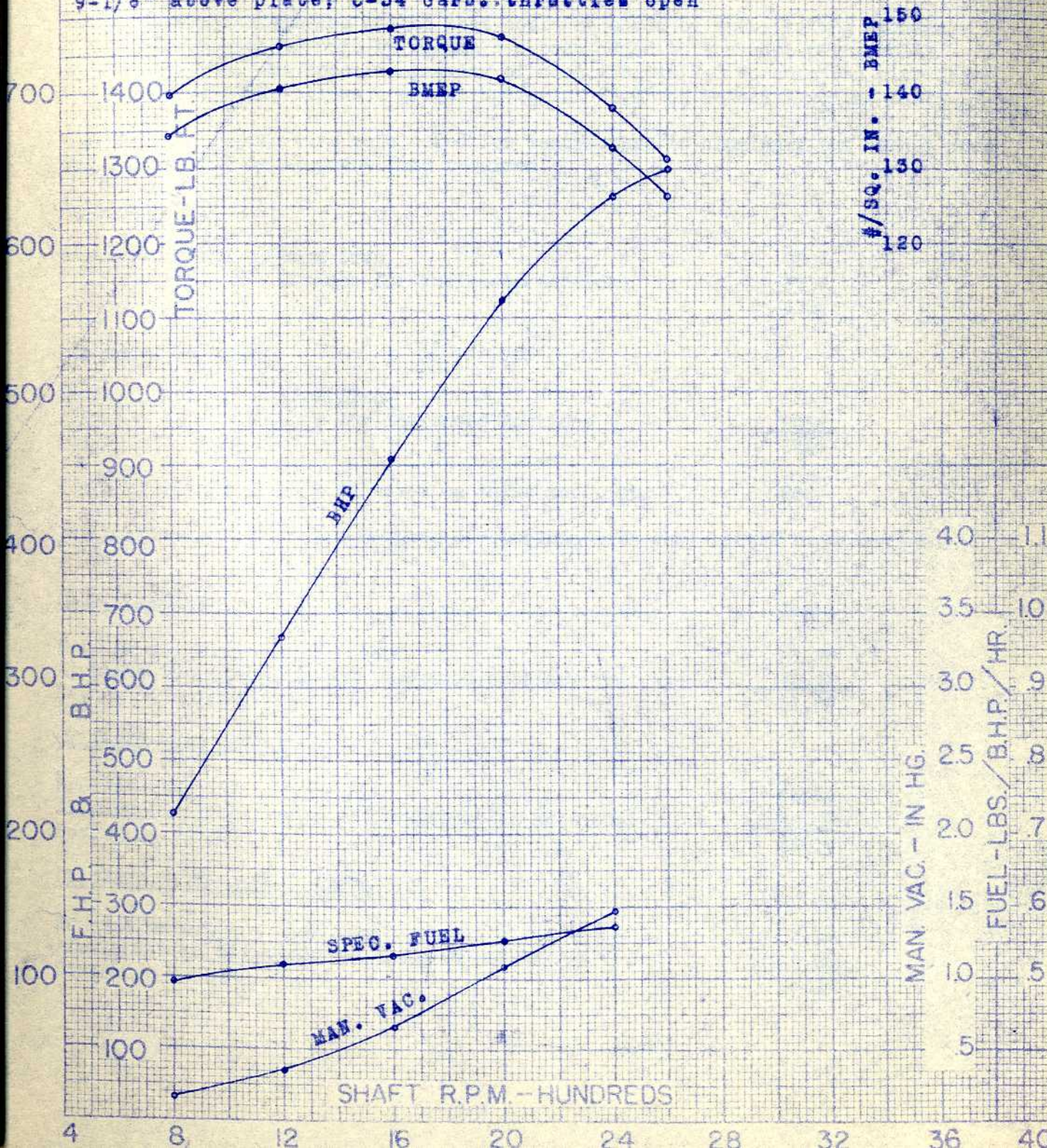




DATE 9-30-43 ENG. #A-65 1  
BORE  $5\frac{1}{2}$ " STROKE  $5\frac{1}{2}$ " 1568 cu.in.  
CARB. 2 Strom., #43 MJ & #35 step-up jets  
COMP. 7.1-1 PLUGS Champion

MAX. POWER TO DATE

OBJECT: Performance with 4 auxiliary C-34  
carbs. having 346cc MJ & std. step-up jets;  
cams set std.; new wooden intake manifold;  
old exhaust manifold; interconnection  
between barrels and carburetors; carb. flanges  
9-1/8" above plate; C-34 carb. throttles open





## APPENDIX #1

### A-65 WEIGHT SAVING

The data shown in this table was prepared by the Dynamometer Laboratory, and it is felt that the estimate is as fair an approximation as can be made at this time.

In order to calculate the weight that could be saved by substituting aluminum for cast iron, 15% or more by volume has been added to the cast parts which are under load. The specific gravity of cast iron is 7.2 as compared with 2.7 for aluminum. This allows a weight saving of 62.5% on an equal volume basis.

The following parts were considered for manufacture in aluminum, but turned down due to the long development time required.

#### CYLINDER BLOCK

Present material - cast iron	860#
Aluminum and 15% allowance for increased sections	<u>370#</u>
Saving in weight	490#

#### CYLINDER HEADS (2)

Present material - cast iron	554#
Aluminum - no allowance for increased sections	<u>208#</u>
Saving in weight	346#

Total weight that could be saved on these two parts	836#
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The following parts could be made of aluminum with very little experimental work:

#### CLUTCH HOUSING

Present material - cast iron	81.7#
Aluminum, no allowance for increased section	<u>30.7#</u>
Saving in weight	51.0#

#### CYLINDER HEAD COVERS (2)

Present material - cast iron	89.0#
Aluminum - 25% allowance for increase in sections	<u>40.0#</u>
Saving in weight	49.0#

#### CYLINDER WATER OUTLET ELBOWS (2)

Present material - cast iron	7.9#
Aluminum - no allowance for increased sections	<u>2.9#</u>
Saving in weight	5.0#



CYLINDER WATER OUTLET MANIFOLD (2)

Present material - cast iron	39.4#
Aluminum and 15% allowance for increased sections	<u>17.0#</u>
Saving in weight	22.4#

EXHAUST MANIFOLD (2)

Present material - cast iron	102#
Steel stamping - .059" thick	<u>40#</u>
Saving in weight	62#

GEAR CASE COVER

Present material - cast iron	16.0#
Aluminum - no allowance for increased sections	<u>6.0#</u>
Saving in weight	10.0#

INTAKE MANIFOLD (2)

Present material - cast iron	41.9#
Aluminum - 15% allowance for increased sections	<u>18.1#</u>
Saving in weight	23.8#

OIL PAN

Present material - cast iron	201.0#
Aluminum, plus 15% for increased section	<u>86.7#</u>
Saving in weight	114.3#

WATER PUMP ASSEMBLY

Present material - cast iron	24.85#
Aluminum, plus 15% for increased sections	<u>10.7 #</u>
Saving in weight	14.1 #

WATER PUMP INLET ELBOW

Present material - cast iron	5.5#
Aluminum - no allowance for thicker sections	<u>2.1#</u>
Saving in weight	3.4#

WATER PUMP OUTLET ELBOW (2)

Present material	7.7#
Aluminum - no allowance for thicker sections	<u>2.9#</u>
Saving in weight	4.8#

Saving in weight from the above parts	359.8#
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# WEIGHT SUMMARY

Weight of First Experimental Engine 3839.5

Estimated weight of proposed engine with cast iron cylinder block and cylinder heads, balance of engine aluminum 3400

Estimated weight of engine with aluminum cylinder block, heads and other parts 2564

Substituting aluminum for cast iron except cylinder block and heads:-

	<u>Cast Iron</u>	<u>Aluminum</u>	<u>Saving</u>
Clutch Housing	81.7	30.7	51.0
Cylinder Head Covers (2)	89.0	40.0*	49.0
Water Outlet Elbows (2)	7.9	2.9	5.0
Water Outlet Manifolds (2)	39.4	17.0*	22.4
Gear Case Cover	16.0	6.0	10.0
Intake Manifolds (2)	41.9	18.1*	23.8
Oil Pan	201.0	86.7*	114.3
Water Pump Assembly	24.8	10.7	14.1
Water Pump Inlet Elbow	5.5	2.1	3.4
Water Outlet Elbows (2)	7.7	2.9	4.8
Exhaust Manifolds (2)	102.0	40.0**	62.0
Parts listed below ***			30.0

Using metal patterns instead of wood patterns 50.0

TOTAL SAVING -

439.8

Substituting aluminum for cast iron cylinder block and heads:-

Cylinder Block	860	370	490
Cylinder Heads	554	208	346

TOTAL SAVING -

836

\* Includes allowance for increased section (by volume) in changing to aluminum for parts under load.

\*\* Stainless steel manifolds.

\*\*\* Parts suggested as suitable for aluminum, estimated savings - 30 lbs.

Oil Pump Bodies	Air Intake Tubing on Carburetors
Air Intake Elbows	Fuel Pump Housing
Fan Gear Housing	Governor Housing
Fans	Distributors
Starting Motor Gear Housing	Distributor Covers