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NAVY DEPARTMENT

Report

on

The Onan Gasoline Engine Installation

at the Naval Research Laboratory for Oil and Gasoline Tests

sabotage agents

NAVAL RESEARCH LABORATORY  
ANACOSTIA STATION  
WASHINGTON, D. C.

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### ABSTRACT

A description is given of the construction and operation of the one cylinder 10-LS air-cooled Onan Test Engine, a unit of four of which has been installed at the Naval Research Laboratory for tests on oils and gasolines. A standard test procedure in report form has been evolved and is described here. Future reports concerning the research carried on using these engines will refer to this report for such information. The advantages of this test engine are briefly outlined.

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## INTRODUCTION

### (a) Authorization

1. This problem was authorized by the Bureau of Ships under Project Order 1642/42.

### (b) Statement of Problem

2. A test engine unit of four small engines was created for exploratory tests on engine sabotaging agents for use in oil or gasoline, and for tests on the effects on engines of gums from gasoline and rubber gasoline tanks. It is believed that this unit will also prove useful for later tests on engine corrosion and evaluation of lubricants.

3. This report is for the purpose of making available for future reference pertinent information on the construction and operation of this engine unit and on a standard test form for use in future reports. Subsequent reports on sabotaging of oils and gasolines, for example, will refer to this report for such details.

### (c) Work Done at This Laboratory

4. During the Fall and Winter of 1941 four type 10-LS Onan test engines manufactured by D. W. Onan and Sons, Minneapolis, Minnesota, were installed in a small, well ventilated building adjacent to the Chemistry building at the Naval Research Laboratory. This model is a one cylinder, air-cooled gasoline engine rated at 2.5 horsepower. It is directly coupled to a one kilowatt A.C. generator which serves as the variable test load. For the general constructional details, see Plate 1. The exhaust gases from each engine are delivered to the outside air through a 3-foot exhaust pipe and muffler. A small overhead derrick has been installed to facilitate the rapid overhauling of these engines.

5. A number of tests have been run by the oil unit and by the gasoline unit on sabotaging oils and gasolines as well as on the effects of gums from gasoline tanks and they have been or shortly will be reported. Other tests are in progress. However, enough operating experience has been obtained to permit the development of a routine procedure, thus making it timely for the preparation of this report.

## THE TEST ENGINE

### (a) The Gasoline Engine

6. The gasoline engine is a single cylinder, 4-stroke cycle, L-head, air-cooled motor constructed with an aluminum cylinder head, a chrome nickel alloy cylinder and a cast iron crankcase. Cool air is forced over the cylinder and head by a combined flywheel blower to provide adequate cooling for constant operation. The engine is rated by the manufacturer at 2.5 H.P.

7. The engine normally operates at a constant speed of 1800 rpm. The speed constancy is obtained through a mechanical fly-ball type governor consisting of four balls retained in the cam shaft gear, which, through levers, vary the position of the carburetor throttle.

8. The piston displacement is 16.3 cu. inches and the piston speed is 825 feet per minute. The bore is 2-3/4 inches, the stroke is 2-3/4 inches, and the compression ratio is 4.8 to 1. The piston is aluminum and has one oil ring and three compression rings. The connecting rod is also of aluminum.

9. The main bearings are of high-lead bronze backed with steel and are each 1-3/4 inches in diameter and 1-1/4 inches long. Hence they are large for the horsepower rating of the engine. The cam shaft is made of cast iron and is built integral with the governor mechanism and meshes with a fiber crankshaft gear. The cam shaft bearings are of Babbitt metal backed with steel and are 1-11/16 inches diameter and 1-1/4 inches long. The connecting rod bearing is of aluminum, is 1-5/8 inches in diameter, and bears against steel.

#### (b) Lubrication

10. An internal circulating system is used. Oil is pumped from a 2-1/2 quart maximum capacity sump built in the base of the engine by a plunger-type pump worked by an eccentric on the cam shaft through a follower and a push rod. It circulates through the front main bearing, through the drilled cam shaft and is by-passed out of the rear main bearing. This provides positive lubrication to the main and connecting rod bearings. All other moving parts are lubricated by spray from the crank shaft due to an extra clearance at the connecting rod bearing. Since the engine was developed for portable use, the sump is sealed and hence, a special arrangement for the "breathing" of the oil is necessary. The volatile material in the crankcase is ejected into the air intake line on the down-stroke of the piston and is then mixed with the gasoline vapor and burned in the combustion chamber. On the up-stroke clean air is sucked into the crankcase from the air intake line. Hence no acid vapor or water can seriously accumulate in the crankcase. That is, the oil system is allowed to "breathe" through the crankcase. A fine mesh wire filter in the oil pump removes the larger particles from the oil stream, but there is no provision for further cleaning of the oil.

#### (c) The Fuel System

11. An "A.C." diaphragm-type fuel pump with a sediment bulb for removing suspended dirt and water is used to pump gasoline from the storage tank through a flexible fuel line to a float-fed fixed-jet carburetor ("Zenith" Model TR-20). The intake air is drawn through a Donaldson combined air-cleaner and purifier trap. Quick starting is insured at any temperature by the presence of a fully automatic thermo-static choke. The gasoline recommended by the manufacturer is to be free from ethyl fluid and have a low gumming tendency.

#### (d) The Electrical System

12. An electrical generator with both A.C. and D.C. windings is directly coupled to one end of the crankshaft of the gasoline engine while at the other end there is directly coupled a flywheel and fan assembly. In the vicinity of the flywheel the rotating iron core of a magneto generator is attached to the crankshaft as is also the breaker cam of a conventional type ignition system. The D.C. generator is used to charge a storage battery. It also can be used as a motor to start the gasoline engine, the necessary power being furnished by the storage battery.

13. The generator is of the 4-pole and self-excited type and its rated output is 1 K.W. at 115 volts and 60 cycles. One of its bearing surfaces is one of the two main bearings of the gasoline engine, while the other is an independently lubricated ball-bearing.

#### (e) The Revolution Counter

14. The speed of the motor in r.p.m. is measured for each engine by the use of two synchronous-type A.C., 60 cycle clocks, one of which is operated on the city 115 volt, A.C. main, and the other on the 115 volt, A.C. current supplied by the generator of the Onan engine. As the generator frequency is proportional to its speed of revolution (if the load is not too great) the difference in time in seconds shown by the two clocks when observed over, say, a 30-minute interval will be equal to the difference between the normal speed of the engine and the actual speed. For example, if the engine is revolving at 1740 r.p.m., at the end of 30 minutes the city clock will read 30 minutes, while the other clock will read 29 minutes. The difference of one minute or 60 seconds will be equal to the  $1800 - 1740$  or the difference in the two speeds in r.p.m. In addition, the total number of revolutions made by the engine in any test run can be rated from the clock reading by multiplying the total elapsed time in minutes by 1740.

#### (f) General Operational Characteristics

15. The following performance curves are supplied by the manufacturer. Figure 1, Plate 2, indicates the variation of the gasoline consumption with the electrical load on the engine when run on an unleaded gasoline. Figure 2, Plate 2, gives the variation of the A.C. output frequency of the generator with the electrical load on the gasoline engine. Figure 3, Plate 2, shows how the A.C. voltage of the generator varies with the electrical load.

16. The Onan engine has the advantage that any worn-out parts can be readily supplied and replaced. Repairs are greatly facilitated by a large stock maintained by the manufacturer of interchangeable replacement parts. Experience has already shown this to be of considerable advantage for severe tests such as in connection with trials on sabotaging agents and gasolines with high gum content. Although the manufacturer recommends intermittent operation not exceeding 12 to 13 hours per continuous run per day, it has been found necessary and practicable to run the engine for much longer continuous periods.

(g) Standard Test Conditions

17. For standard tests the engine is operated on 100 octane leaded standard Naval aviation gasoline while the lubricating oil used is #2135 (Navy Symbol) lubricating oil (SAE 20). A normal oil charge is 1.5 quarts.

18. The standard test load is an electrical output of 650 watts or, in other words, 65% of the full rated electrical load capacity of the generator.

19. In a typical operation of the engine at room temperature, the temperature of the spark plug is 213°C. (415°F.), and the temperature of the oil in the sump is 65°C. (149°F.). These temperatures can be automatically recorded if desired on a Leeds and Northrup Recorder using iron-constantan thermocouples.

20. Preparation of the engine for the standard test run involves the following procedure:

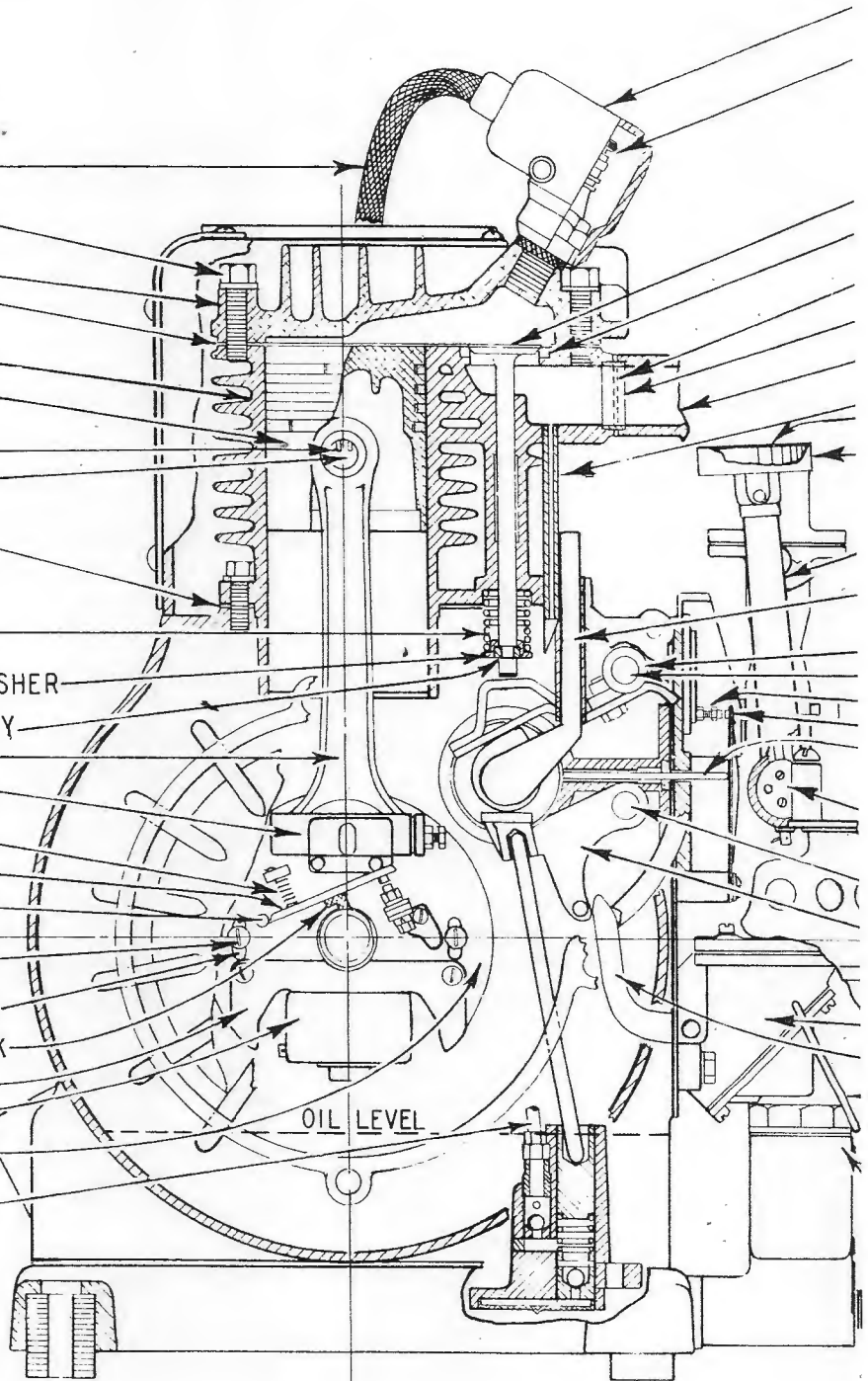
The oil from the last run is drained. The piston, the valves, and the oil pump are removed, cleaned with toluene or xylene, examined for scratches, and checked for size. The interior of the gasoline engine as well as all the bearings are washed with toluene or xylene and then dried thoroughly with a cloth and with a high pressure air jet. The valves are reset and checked and ground when needed. The spark plug is cleaned and the gap adjusted for a spacing of 0.025 inch. The breaker points are checked for a gap width of 0.020 inch. Then as the gasoline engine assembly is being completed all parts are coated with clean oil. The engine is then revolved a few times by hand and finally operated for 30 minutes on no load to run it in and to check the speed of revolution. It is then ready for its test.

21. For the purpose of making more comparable the findings of these engine tests, a check form is now being employed for all tests with this unit. See Plate 3, Sheets A and B.

CONCLUSIONS

22. The Onan Test Engine has been found well adapted and useful for exploratory tests and preliminary evaluation of fuels and lubricants for gasoline engines. However, the final criterion of the value of a sabotaging agent, for example, can only be determined by a full scale engine test. It has the great advantage, however, that it is reasonably cheap, is rugged, can be easily taken apart for repairs, and a good supply of interchangeable replacement parts is made available from the manufacturer.

- IGNITION CABLE
- CYLINDER HEAD BOLTS
- CYLINDER HEAD
- CYLINDER HEAD GASKET
- CYLINDER
- PISTON & RINGS
- PISTON PIN LOCK RING
- PISTON PIN
- CYLINDER BASE GASKET
- VALVE SPRING
- VALVE SPRING RETAINER WASHER
- VALVE SPRING RETAINER KEY
- CONNECTING ROD
- MAGNETO CONDENSER 2 MFD.
- BREAKER ARM SPRING
- MAGNETO BREAKER ARM
- BREAKER ARM STUD
- MAGNETO BACKPLATE
- ADJUSTING SCREWS
- BACKPLATE ADJUSTING SLOTS
- BREAKER ARM RUBBING BLOCK
- MAGNETO STACK ASSEMBLY
- MAGNETO COIL
- MAGNETO BACK PLATE
- OIL TUBE



DIMENSIONS

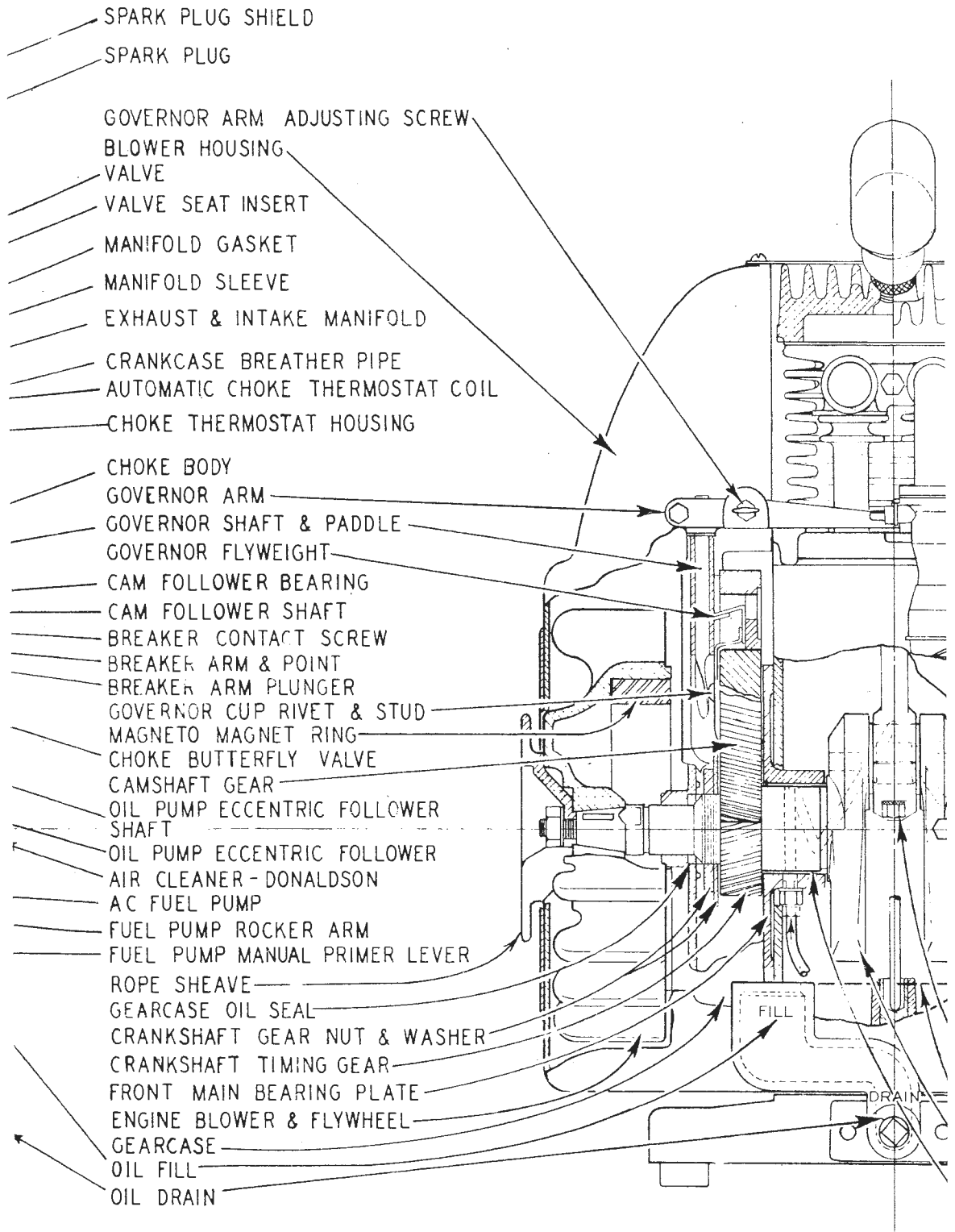
LENGTH— OVERALL— 21 1/2"

WIDTH— OVERALL— 14 5/8"

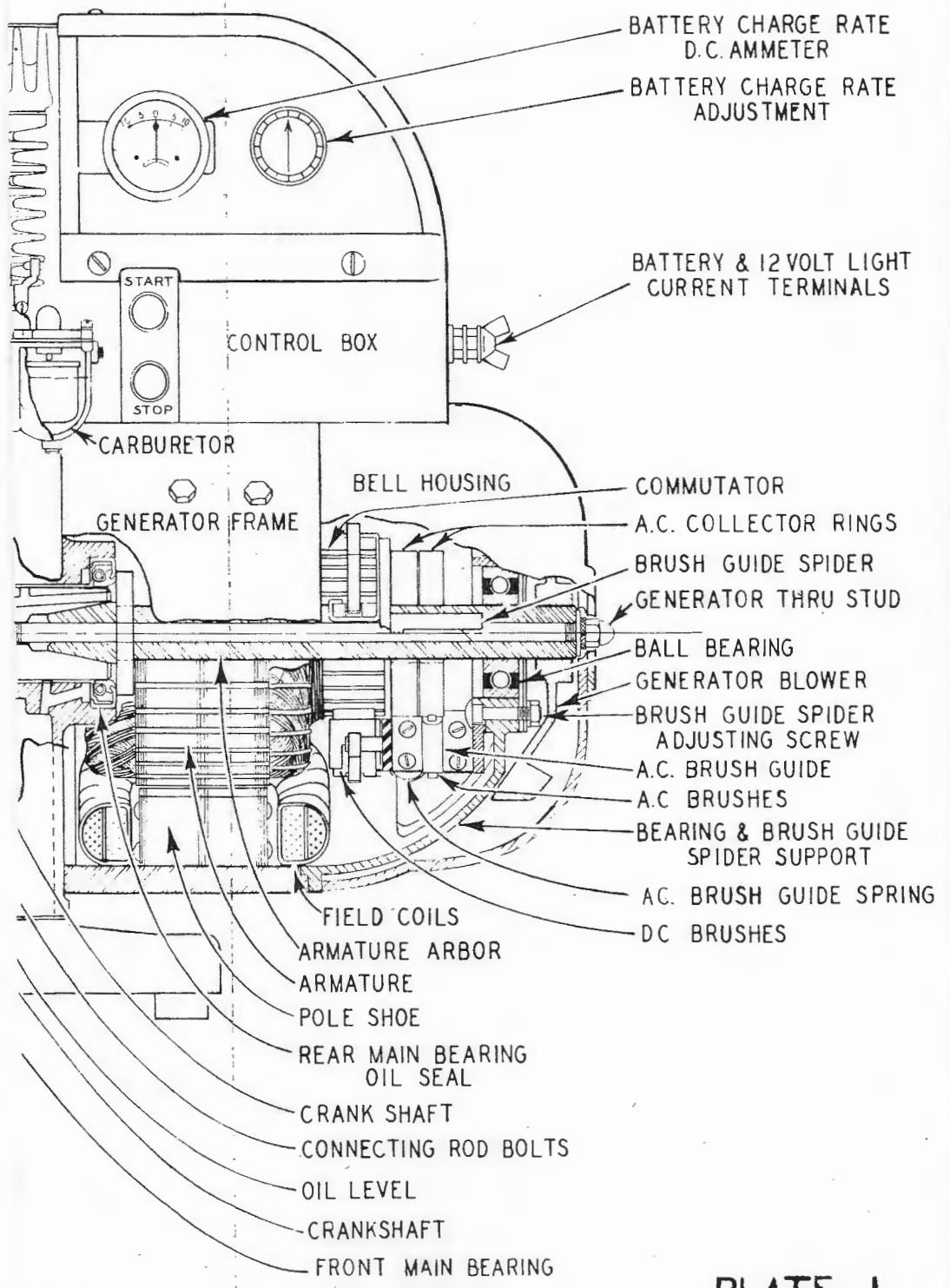
HEIGHT— OVERALL— 22"

MOUNTING HOLE CENTERS

10" WIDE      8 1/2" LONG



IB SERIES-CROSS SECTION  
500 TO 1000 W. CAPACITY



NUMBER OF HOURS OPERATION PER GALLON OF GASOLINE

6  
5  
4  
3  
2

FIG. 1

62  
61  
60  
59  
58

AC FREQUENCY IN CYCLES PER SECOND

FIG. 2

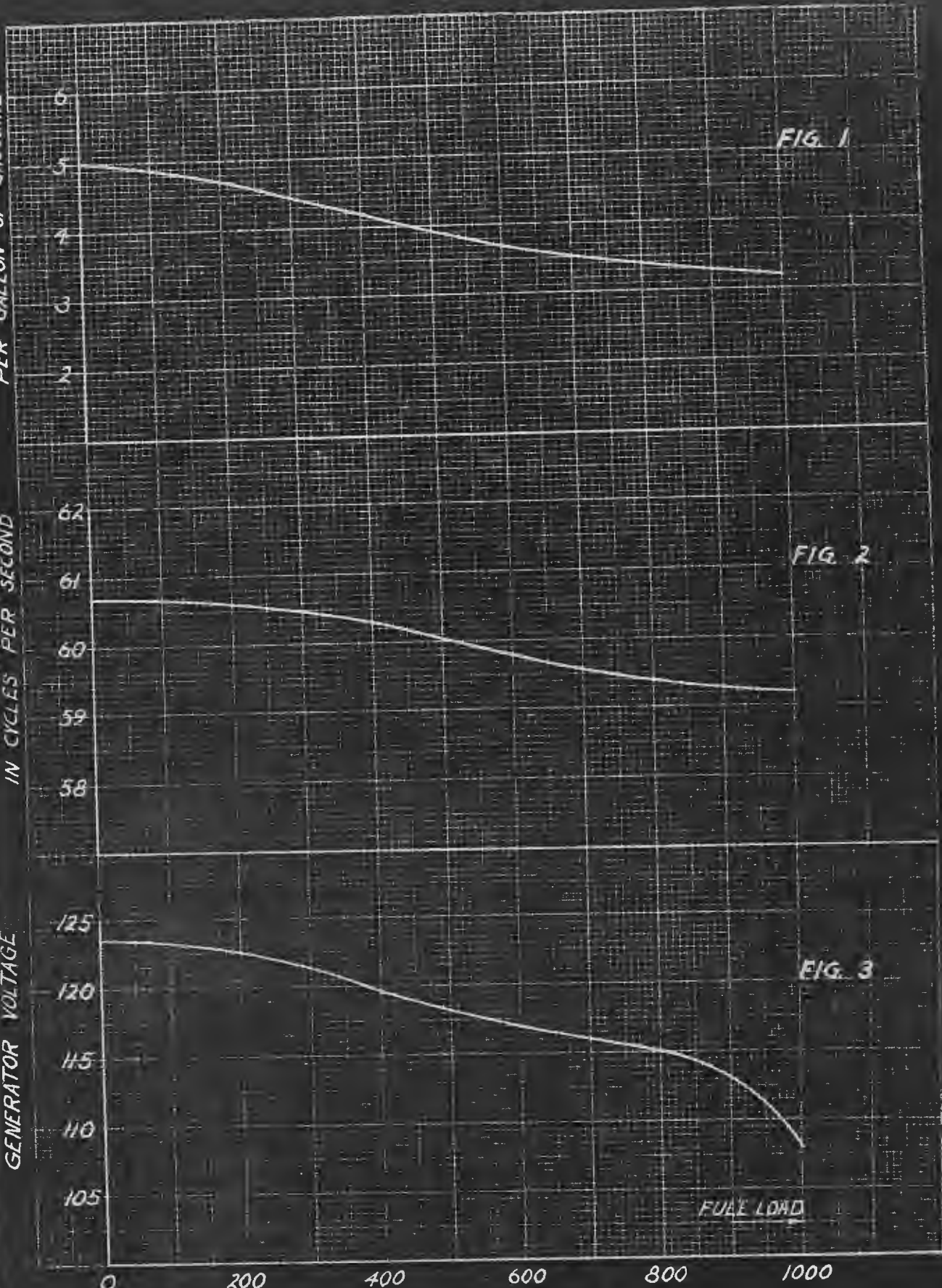
125  
120  
115  
110  
105

GENERATOR VOLTAGE

FIG. 3

FULL LOAD

0 200 400 600 800 1000  
ELECTRICAL LOAD IN WATTS



Naval Research Laboratory - Chemistry Division

	Cylinder Walls		Rings		Ring Grooves		Piston Skirt	Conn. rod bearing ring slots	valve seats	oil color	oil pump	main bearings	crankshaft	Crank-Case		Sp. plug	Carburetor	Cam. shaft
	@ valves	opp. valves	Oil	Comp.	Oil	Comp.								bottom	sides			
Polished	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Discolored	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Scratched	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Scored	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Dry	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Moist	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Sl. burnish							( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Burnish							( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Free			( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Tight			( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Stuck			( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
OK								( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Fair								( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Pitted								( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Clean					( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Dirty					( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Plugged					( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Gummy					( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Carbon					( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Light					( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Medium					( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Heavy					( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Poor								( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Sludge								( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Grit								( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Good								( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
Fine													( )	( )	( )	( )	( )	( )
Coarse													( )	( )	( )	( )	( )	( )
Hard													( )	( )	( )	( )	( )	( )
Soft													( )	( )	( )	( )	( )	( )
Slight													( )	( )	( )	( )	( )	( )
Misc.													( )	( )	( )	( )	( )	( )

Remarks:

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Naval Research Laboratory - Chemistry Division

Engine Inspection

Engine Test No. Oil Fuel

Subject

Inspected by Date

Cylinder	block		piston		head		intake valve			exhaust valve		
	@ valves	opp valves	@ valves	opp valves	over valves	over pistons	top	under -side	stem	top	under -side	stem
Clean												
Sooty												
Carbon												
Slight												
Light												
Medium												
Heavy												
Smooth												
Granular												
Scaly												
Fine												
Coarse												
Uniform												
Irregular												
Dry												
Moist												
Wet												
Gummy												
Misc.												

Remarks:

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