FOREST FIRE RESEARCH INSTITUTE

Canadian Forestry Service

Department of Fisheries and Forestry

PERFORMANCE TESTS ON WAJAX MARK 26 CENTRIFUGAL PUMP

G.S. Ramsey, D. Higgins,
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Performance Tests on Wajax Mark 26 Centrifugal Portable Forestry Fire Pump

INTRODUCTION

At the request of the National Research Council's Associate Committee on Forest Fire Protection, the Forest Fire Research Institute of the Department of Fisheries and Forestry conducted a series of standard tests on two Wajax Mark 26 portable forestry fire pumps. The tests were undertaken in compliance with the Canadian Government Specification Board specification, *Standard Methods of Test for Portable Forestry Fire Pumps*, 28-GP-5, dated February 14, 1964.

The specification covers procedures for conducting type and qualification tests on portable forestry fire pumps, powered by internal combustion engines. It is the intent of these methods of test that the laboratory make such minor adjustments, repairs and replacements as may be needed to complete the whole series of tests rather than discontinue the tests at the first malfunction or failure.

The tests were conducted at the Institute's temporary Hydraulics Laboratory located on the Petawawa Forest Experiment Station, Chalk River, Ontario. Instrumentation for monitoring data was identical to that used on previous tests in this series. (Photo No. 7) A tower constructed of scaffolding was erected to obtain actual suction lifts up to the recommended level of 25 feet. (Photo No. 8) Additional measurements were also obtained during the tests which will be used later in research projects dealing with fire pump operation.

In 1968, the National Research Council analyzed several commercially available samples of regular gasoline from the Ottawa area. The results showed that the amount of Tetraethyl lead contained in the samples ranged from 2 to 3 ml/Imp. Gal. However, no oil company could offer gasoline on a continuing basis which exactly meets CGSB specification 28-GP-5. Therefore, it was agreed at the Associate Committee executive meeting that a regular grade No. 2 automotive gasoline would be purchased for the tests from a local supplier.

Thanks to the cooperation of Dr. R.B. Whyte of the Fuels and Lubricants Laboratory, National Research Council, tests were performed on a one gallon sample of Esso gasoline. The analysis showed that the sample fell within the limits of CGSB specification 3-GP-1d, Gasoline Type 2 Summer. The gasoline had a vapour pressure of 10.2; boiling range 90° - 444°F; existent gum, 0.2 mg/100 ml.; and a lead content of 3.50 ml. TEL/Imp. Gal. However, the distillation final boiling point (444°F) was considered high as well as the unwashed gum content. The Tetraethyl lead content of 3.50 ml. TEL/Imp. Gal. exceeded the limit of 2.5 ± 0.2 ml. TEL/Imp. Gal. indicated in CGSB specification, 28-GP-5. To the gasoline was added Esso Outboard Motor Oil in the quantity recommended by the manufacturer.

Since the Mark 26 pump has only recently been on the market two unused units were unavailable from any of the Associate Committee members. Therefore, the Forest Fire Research Institute purchased two units plus accessories from Wajax Equipment Limited in Ottawa in order to conduct the tests. Prior to testing a representative of Wajax Equipment Limited was invited to perform initial minor adjustments to both test units and to instruct on the proper procedure for operating the pumps.

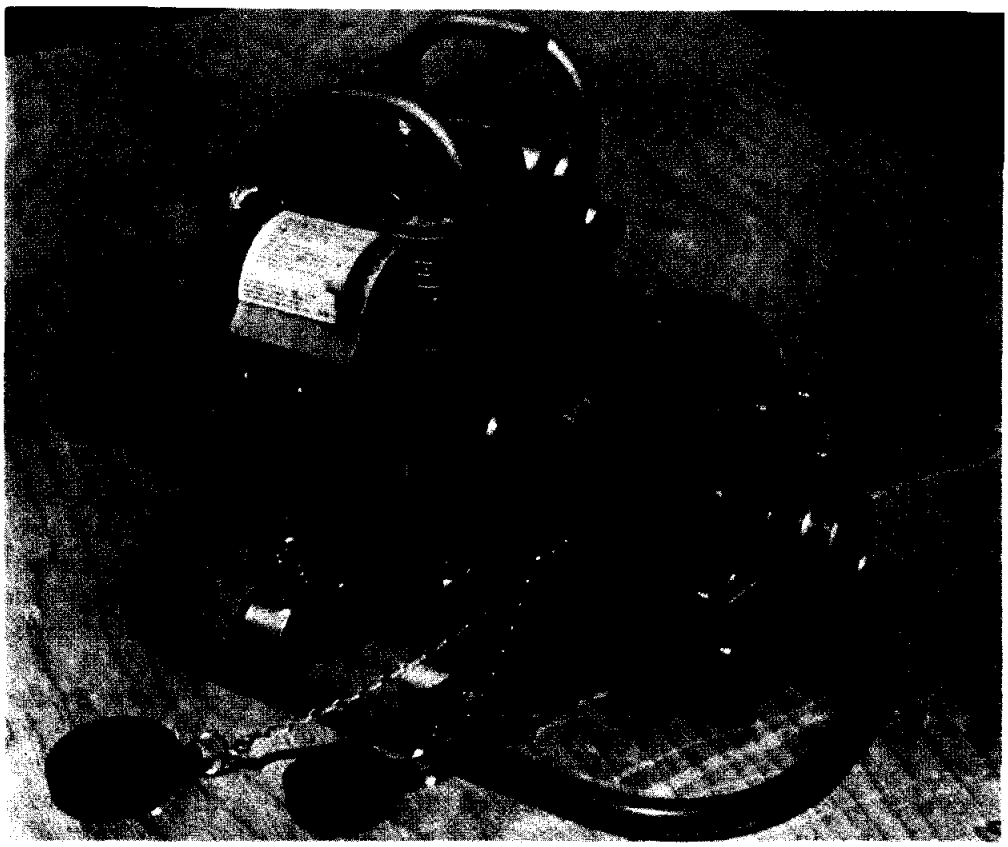


Photo No. 1 *General view of Wajax Mark 26 Centrifugal pump.*

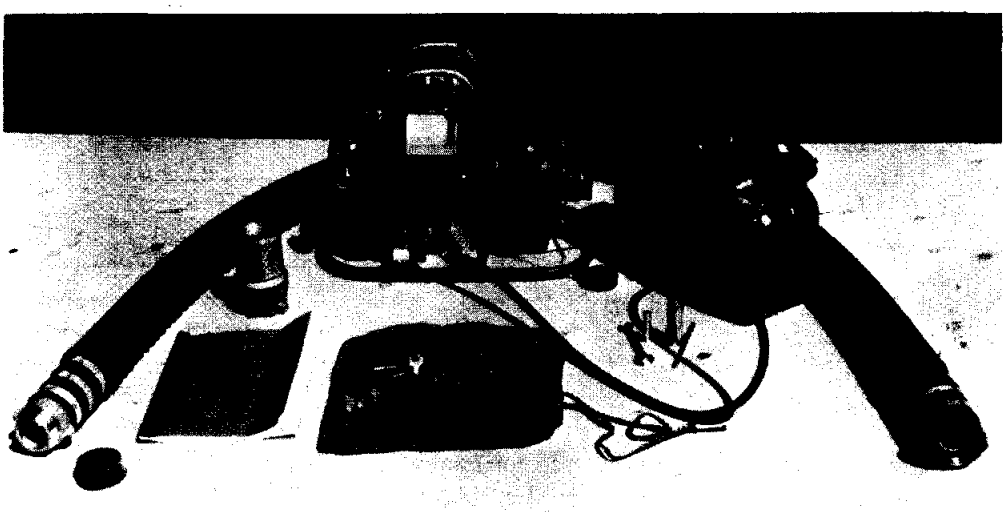


Photo No. 2 *Accessories provided with the Wajax Mark 26.*

GENERAL DESCRIPTION (Photo Nos. 1, 3, 4)

The type of pump selected for testing was designated by its manufacturer, Wajax Equipment Limited, as the Wajax Mark 26 Centrifugal. The pump end is a horizontal 2-stage centrifugal pump. Inlet (suction) connection and outlet (discharge) connection are both made to standard forestry thread specifications. The Mark 26 engine (Rotax) is a one cylinder, two-cycle, 5 HP (approx.) air-cooled engine. It is equipped with rewind, pull-cord starter; manual starter rope pulley; self-sealing, quick-connect fuel supply line; separate fuel supply tank (2 Imp. Gal.) and an automatic cutout switch.

The Units were designated "A" and "B" and the report will distinguish between them in this manner.

GENERAL EXAMINATION (Unit "A")

Unit "A" plus major accessories were examined as to weight, dimensions, conformity to plans, etc.

(a) Weight of pumping unit and major accessories (Photo No. 2)

Dry pumping unit	37 lb.	7½ oz.
Suction hose (8')	17 lb.	8 oz.
Foot valve and strainer	1 lb.	9 oz.
Hand primer (Photo No. 5)	2 lb.	8 oz.
2 gallon capacity fuel supply tank (including fuel supply line)	7 lb.	3 oz.
Maintenance tool kit (including grease gun)	1 lb.	15½ oz.
Pump carrying pack (Photo No. 6)	3 lb.	2 oz.
Spring mounted base (Photo No. 5)	13 lb.	10 oz.
Total	84 lb.	15 oz.

(b) Dimensions of pumping unit

Height	13½"
Width	10 3/4"
Length	18½"

(c) Pumping unit protrusions

The pump is free of protrusions or other features which might cause damage or be damaged when reasonable care is used while handling the unit. Safety features that protect the unit from damage include the following:

1. Plastic slip-on caps protect the suction and discharge threads.
2. The carburetor is enclosed by a carburetor shroud.
3. The stop switch is covered by a rubber cap.
4. The muffler is designed to serve as a spark arrestor.
5. The fan cowl assembly shields a portion of the cylinder.
6. The carrying handle protects the cylinder and spark plug.
7. An automatic cutout switch stops the engine instantly when the engine speed exceeds a recommended rpm.

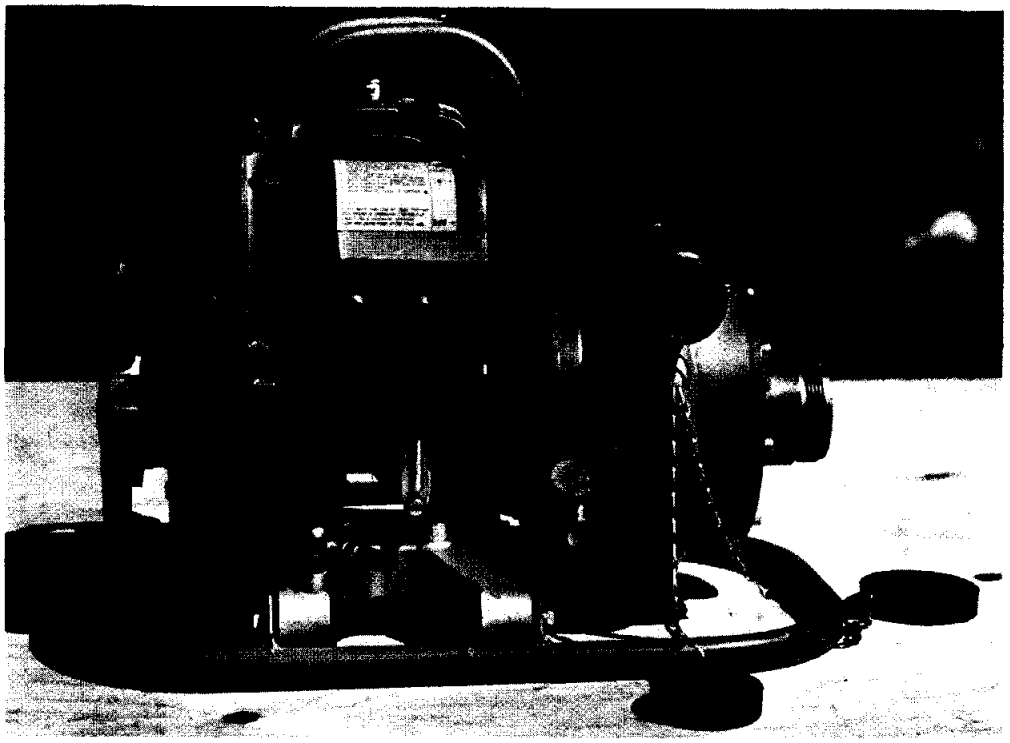


Photo No. 3 *Fuel inlet and control side of Wajax Mark 26 Centrifugal pump.*

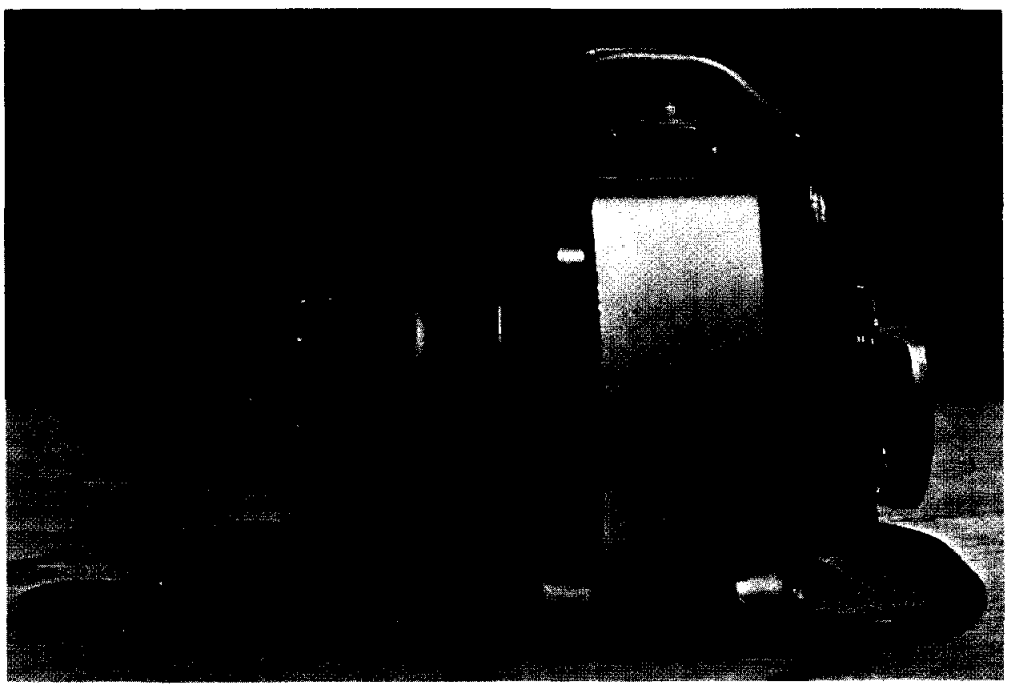


Photo No. 4 *Exhaust side of Wajax Mark 26 Centrifugal pump.*

(d) Arrangements for carrying and back-packing

The Mark 26 is provided with a convenient handle for carrying the unit over short distances. The carrying handle which is located above the cylinder also acts as a roll bar to protect the cylinder and spark plug from damage should the unit be inadvertently tipped over. The unit's tubular base frame may also be used for lifting, positioning or carrying.

The manufacturer has provided a padded carrying pack for back-packing the pump over a considerable distance. It is made from heavy canvas duck and equipped with clip-on $1\frac{1}{2}$" shoulder straps and a 2" waist belt. The unit's base frame slips into a pouch and is further secured by two safety straps. It was found that the upper safety strap failed to secure the base frame adequately since it was possible for the strap to slip over the frame and allow the pump to fall. However, the unit may be secured to the carrying pack by placing the top of the base frame under the shoulder straps where they fasten to the top of the pack. Some modification to the carrying pack will be required before it can be safely used in the manner in which it was designed. (Photo No. 6)

The standard 2 gallon fuel supply tank is provided with a carrying handle. There are no carrying straps for back-packing the fuel tank.

(e) Adequacy of nameplate instructions

The pump is provided with adequate nameplate instructions to operate the unit correctly. Basic operating instructions are listed on the carburetor shroud. Decals indicate the following: type of pump, choke lever position, throttle lever position, and how and where to reset the automatic cutout switch. The procedure for stopping the pump or the location of the stop switch is not indicated on the unit.

Pump-end serial and issue numbers are stamped on a nameplate located on the top of the pump body and the engine serial number is stamped on a nameplate attached at the bottom of the fan cowl.

Decals placed on the standard 2 Imperial gallon fuel tank describe the proper fuel mixture ($\frac{1}{2}$ pint of oil to 1 Imp. gallon of gasoline) and indicate the location of the air vent.

(f) Conformity to plans, specifications and manuals

The Mark 26 conforms well to all literature supplied with the pump. An Instruction and Service Manual contains detailed operating, maintenance and servicing instructions, trouble charts and a completely illustrated parts list. Pump performance data given in the manual compares favourably with figures obtained during testing. No problems were encountered throughout the tests with interpretation of instructions in the manual.

ORIENTATION TEST (Unit "A") Spec. No. 5

(a) Horizontal Test

Unit "A" was started and run at various discharge pressures and flow rates with the base in a horizontal position for 45 minutes. The engine started on the second pull of the rewind starter and operated very well without undue vibration or tendency to creep. A momentary fluctuation in discharge pressure

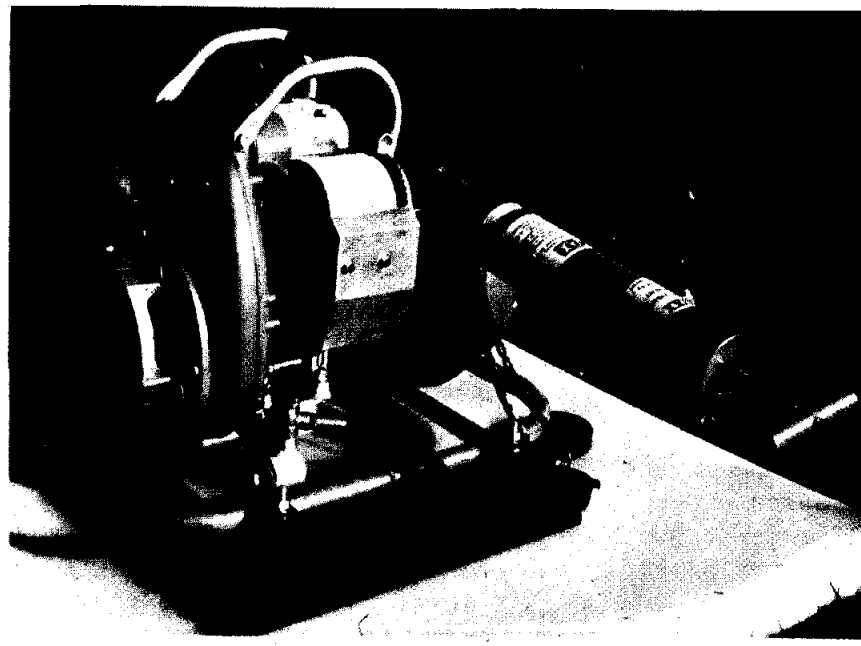


Photo No. 5 *Wajax Mark 26 fitted with hand primer and spring mounted base.*

Photo No. 6 *Pump carrying pack.*

Photo No. 7 *Instrument panel.*

Photo No. 8 *Tower for suction lift test.*

occurred when a large bubble entered the carburetor from the plastic line. This will be discussed later in the report. (p. 16)

Priming the unit presented no particular problem even though the pump does not have a fill hole in the top of the pump casing. The pump can be conveniently primed by first filling the suction hose with water before connecting it to the pump and then by jabbing the suction hose and foot valve repeatedly into the water source until the system is full. An alternate method would be to use a hand primer which is available from the manufacturer (Photo No. 5).

(b) Tilt Test

Unit "A" was run with the base tilted from the horizontal approximately 20° for eight five-minute periods, each edge and corner of the base being in the "down" position successively. The unit ran equally well at all tilt positions with no irregularities in pump performance. However, there were periodic fluctuations in discharge pressure at each position. This appeared to be due to a greater than normal quantity of bubbles entering the carburetor from the plastic fuel line. (See page 16)

SHUT-OFF TEST (Unit "A") Spec. No. 6

The unit was run at zero feet suction lift and full throttle with an initial water temperature of 20°C. The rate of flow was slowly decreased to zero by closing a ball valve located three feet from the pump outlet and run for five minutes. A shut off pressure of 175 psi was maintained for the full duration of the test. No unusual behaviour was noted other than the pump body becoming too hot to touch.

PERFORMANCE TEST AT MINIMUM SUCTION LIFT (Unit "A") Spec. No. 7.1

The test was performed to determine the relation between discharge pressure in pounds per square inch and discharge flow rate in gallons per minute for at least ten points between zero and shut-off pressure at minimum suction lift. Fuel consumption in gallons per hour was determined for each point on the curve.

The discharge pressure was obtained at each point by regulating the pressure with a 1½-inch ball valve located at the end of a 10-ft. length of 1½-inch rubber-lined discharge hose. The discharge flow rate was then determined at each point by weighing the quantity of water pumped in a predetermined time interval.

The Unit produced a maximum discharge flow rate of 70 Imp. gpm between 0-13 psi. As the discharge pressure was increased beyond 13 psi, the discharge flow rate decreased in an approximate linear relationship until shut-off pressure of 178 psi was reached.

Fuel consumption was determined for each point in the test by measuring the amount of fuel consumed from a 50 ml. burette in a predetermined time. The burette was attached to the pump tank fuel line by means of a three-way valve to enable fuel to be drawn directly to the unit from either the pump fuel tank or the burette. (Photo No. 9)

The results showed that there was a general increase in fuel consumption for discharge pressures up to 130 psi and then a slight decrease. The rate of fuel consumption ranged from 0.48 - 0.59 Imp. gallons per hour. Performance curves are given in Fig. No. 1.

SUCTION LIFT PERFORMANCE TEST (Unit "A") Spec. No. 7.2

This test was performed to determine the relation between discharge flow rate in gallons per minute, and suction lift, at at least five points between minimum and 25 feet, for at least three well-spaced different levels of discharge pressure (50, 75, 100, 125 and 150 psi).

Construction scaffolding was used to erect a tower to provide actual suction lifts for the unit at 5, 10, 15, 20 and 25 feet. (Photo No. 8) At each level, a series of calibrated nozzles were used to determine the pump's performance. The nozzles were attached, in succession, a short distance (2') from the pump outlet and the average discharge pressure was noted over a five-minute interval for each tip. A bypass valve situated close to the pump outlet enabled the operator to change nozzles without interrupting engine operation. Eight-foot lengths of suction hose were coupled together as required and the water source was located directly below the tower.

The results showed that there was little loss in discharge flow rate for pressures of 50, 75 and 100 psi below a suction lift of 15 feet and that there was a negligible loss in discharge flow rate for discharge pressures of 125 and 150 psi at all levels. The results are plotted in Fig. No. 2.

SERIES (TANDEM) OPERATION (Unit "A") Spec. No. 8 (Photo No. 9)

Pump Units "A" and "B" were joined in tandem by a three-foot length of latex lined hose. Pump Unit "B" was operated at a discharge pressure of 152 psi or approximately 85 per cent of Unit "A"'s shut-off pressure. Supplied with water from Unit "B", Unit "A" was run at a discharge pressure of 295 psi or approximately 170 per cent of its individual shut-off pressure. During the one hour test both units operated satisfactorily with no unusual irregularities or signs of distress. Unit "A" produced a discharge flow rate of 14.6 Imp. gpm at the discharge pressure of 295 psi.

HYDROSTATIC TEST (Unit "A") Spec. No. 10 (Photo No. 10)

Pump Unit "A" was subjected to a hydrostatic pressure of 438 psi or 250 per cent of shut-off pressure. This was achieved by using a static pressure accumulator. The hydrostatic pressure was increased in increments of 50 psi and held for one minute intervals until the required pressure was attained. The hydrostatic pressure of 438 psi was maintained for a period of five minutes. There was no evidence of water leakage or damage to the pump.

MUDDY WATER TEST (Unit "A") Spec. No. 12

Two hundred gallons of water were combined with 20 pounds of standard sand of the following composition:

20% less than 30 mesh
30% less than 40 mesh
30% less than 60 mesh
20% less than 100 mesh

Unit "A" was operated at near minimum suction lift and full throttle with both the suction hose (foot valve strainer removed) and discharge hose immersed in the muddy water tank. The pump discharge was used in conjunction with a mechanical mixer (Lightin Mixer) to prevent the formation of stagnant pockets of sand in the

Photo No. 9 *Series (tandem) test -- Units "A" and "B".*

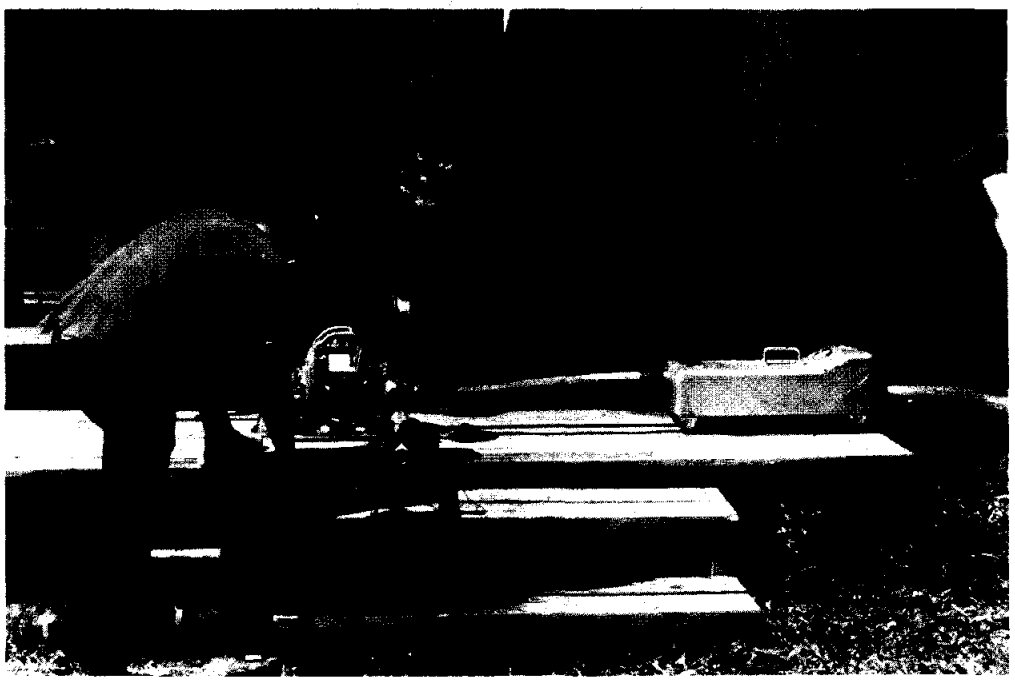


Photo No. 10 *Hydrostatic test -- Unit "A".*

tank (Photo No. 11). The muddy water was circulated continuously through the pump for 8 hours, 4 hours at a discharge pressure of 35 psi (1/5 of the shut-off pressure) and 4 hours at a discharge pressure of 117 psi (2/3 of the shut-off pressure).

The initial muddy water temperature was 21°C (70°F) and this gradually increased to a maximum temperature of 41°C (106°F) at the conclusion of the 8-hour test. The increase in temperature did not appear to have any adverse effect on the unit as no unusual behaviour in pump operation was noted throughout the test.

PERFORMANCE AT 5-FT. SUCTION LIFT BEFORE AND AFTER MUDDY WATER TEST (Unit "A")
Spec. No. 7.3

Unit "A" was operated at a 5-ft. suction lift to determine the relation between discharge pressure in pounds per square inch and discharge flow rate in gallons per minute, both before and after the muddy water test.

Discharge flow rates obtained at a 5-ft. suction lift during Test 7.2 were greater than those recorded before the muddy water test in Test 7.3. Results are separately plotted for both Test 7.2 and 7.3 since engine fluctuations throughout Test 7.3 may have lessened the efficiency of the pump to a degree where its operation may not have been representative of actual pump performance. The fluctuations were caused by bubbles entering the carburetor from the fuel line. (p. 16) The unit operated satisfactorily throughout the 5-ft. suction lift test performed after the muddy water test.

A loss in discharge flow rate after the muddy water test of approximately 10 Imp. gpm was recorded at free flow. However, a comparison of discharge flow rates for both before and after the muddy water test showed no substantial difference in flow rate above a discharge pressure of 70 psi. The results are plotted in Fig. No. 3.

DISASSEMBLY EXAMINATION (Unit "A")

Prior to performing test 7.3 and following a total accumulated operating time of 23 hrs. 7 min. the pump was disassembled. The pump parts were examined for wear or damage and measurements of the component parts were recorded to be later used for comparison purposes following the muddy water test. This initial examination revealed no apparent wear or damage to any of the component parts. However, during reassembly the following day it was found that the shaft bearing would not rotate. There appeared to be an absence of grease in the bearing and evidence of corrosion on the ball bearing retainer ring. Penetrating oil was used to free the bearing.

The disassembly and reassembly time was approximately 12 min. and 18 min. respectively. A greater time was required for reassembly because of the care which must be taken when lining up the shaft pins with the slots in the rotary seal. A number of specialized tools and a bench press are required when either disassembling or reassembling the pump.

Following the muddy water test and a final performance test the pump was again disassembled (9 min.) and examined for wear or damage. The examination showed:

Photo No. 11 *Muddy water test -- Unit "A".*

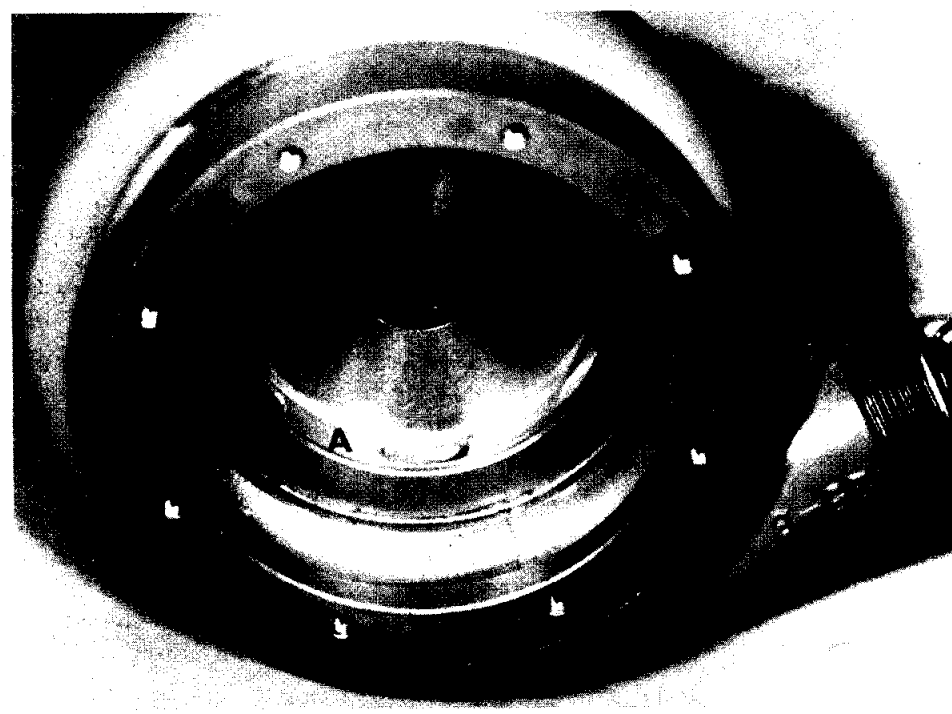


Photo No. 12 *Pump body after muddy water test -- Unit "A". Note groove (A) around rim of discharge channel.*

Pump Body:

The inside of the pump body was smoothed and polished from the abrasive action of the sand particles. There was noticeable wear around the rim of the discharge channel where a pronounced groove had formed (Photo No. 12).

Suction Nozzle:

There was noticeable wear to all exposed areas of the suction nozzle and some wear to the inside of the brass bearing (Part No. 12-40) in which the end of the shaft rotates (Photo No. 13).

Impellers:

All sharp edges on the vanes of impeller Nos. 1 and 2 were smoothed and rounded. On impeller No. 2, the outside diameter of the shaft collar had decreased .025 inches. The muddy water caused a slight amount of wear to the outer rim of each impeller as well as decreasing the outside diameter of each impeller collar (Photo No. 15).

Distributor:

Slight wear was evident on both inner and outer distributor vanes as well as on the inside face. There was a considerable decrease in the thickness of the distributor collar. The inside diameter had increased by .020 inches and the outside diameter by .022 inches (Photo No. 16).

Shaft:

There was a slight amount of wear to the end of the shaft and the ball bearing retainer ring was found to be quite loose.

Rotary Seal:

All of the component parts of the rotary seal were in good condition.

UNIT "A" ADJUSTMENTS, REPAIRS AND REPLACEMENTS

An accumulated time of 33 hours and 47 minutes was needed to complete the required tests for Unit "A". A problem of excessive bubbles in the fuel line existed at the beginning of the tests and caused the unit to stop prematurely a number of times (p. 16). The fuel supply assembly was exchanged for a clear plastic fuel line which was connected directly between the fuel supply tank and the carburetor. The unit then maintained a steady pressure for all tests and operated with a minimum of trouble. The engine started consistently with less than five pulls on the rewind starter from a cold start. The spark plug was checked prior to the beginning of each test.

Repairs, adjustments and replacements included the following:

- the plastic fuel line leading from the body quick connect to the carburetor was replaced when a hole was discovered in the original line (accumulated time -- 2 hrs. 27 min.) (See page 17)
- installed a new carburetor in an attempt to solve the fuel line problem and then replaced it with the original when no improvement was obtained.

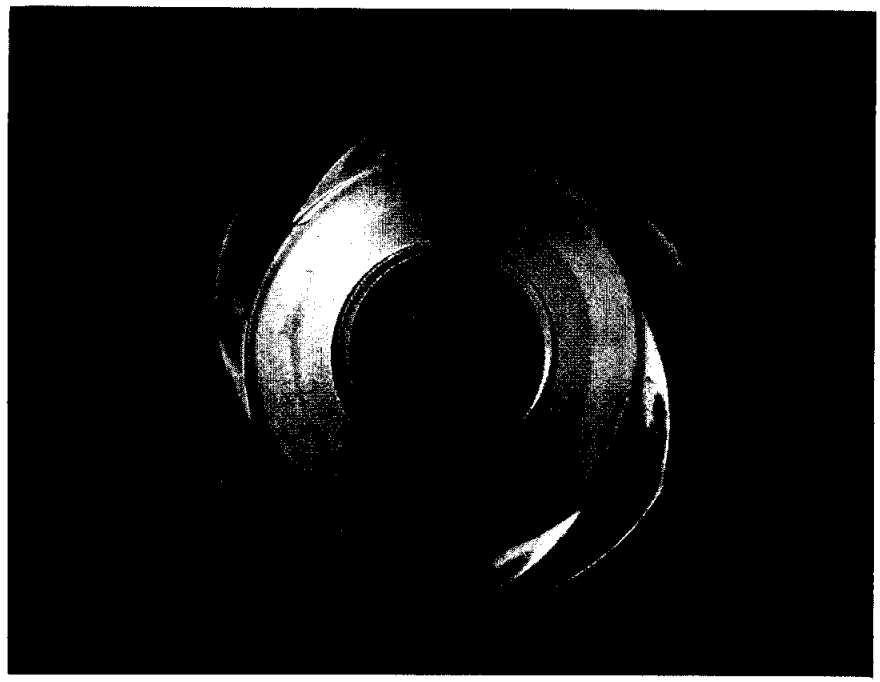


Photo No. 13 *Suction nozzle after muddy water test -- Unit "A". Note worn areas.*

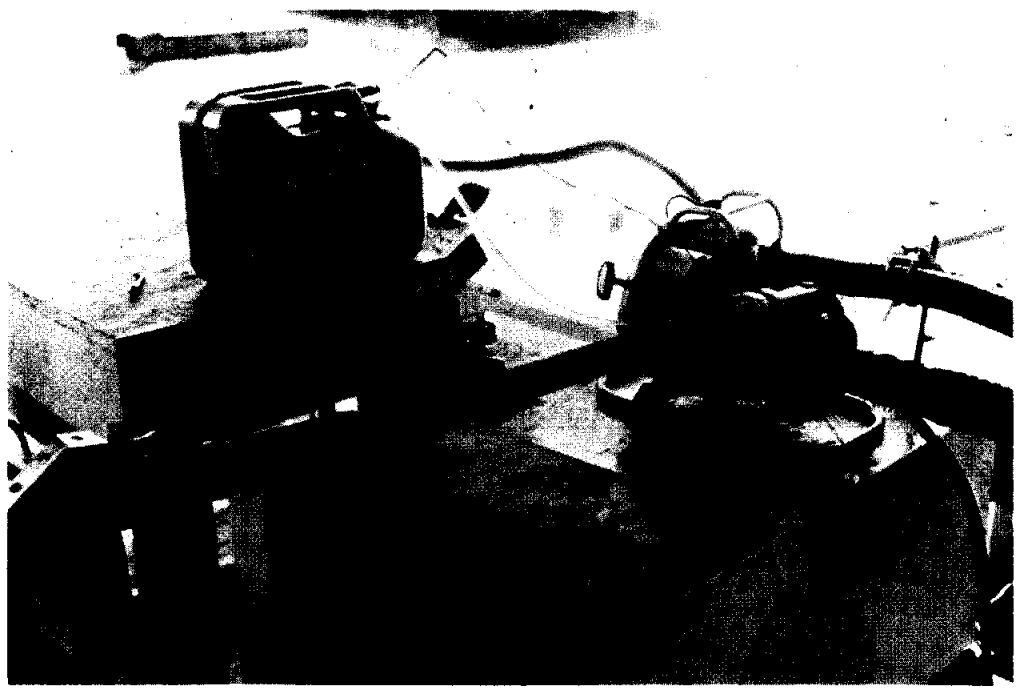


Photo No. 14 *Endurance test -- Unit "B". Note clear plastic fuel line.*

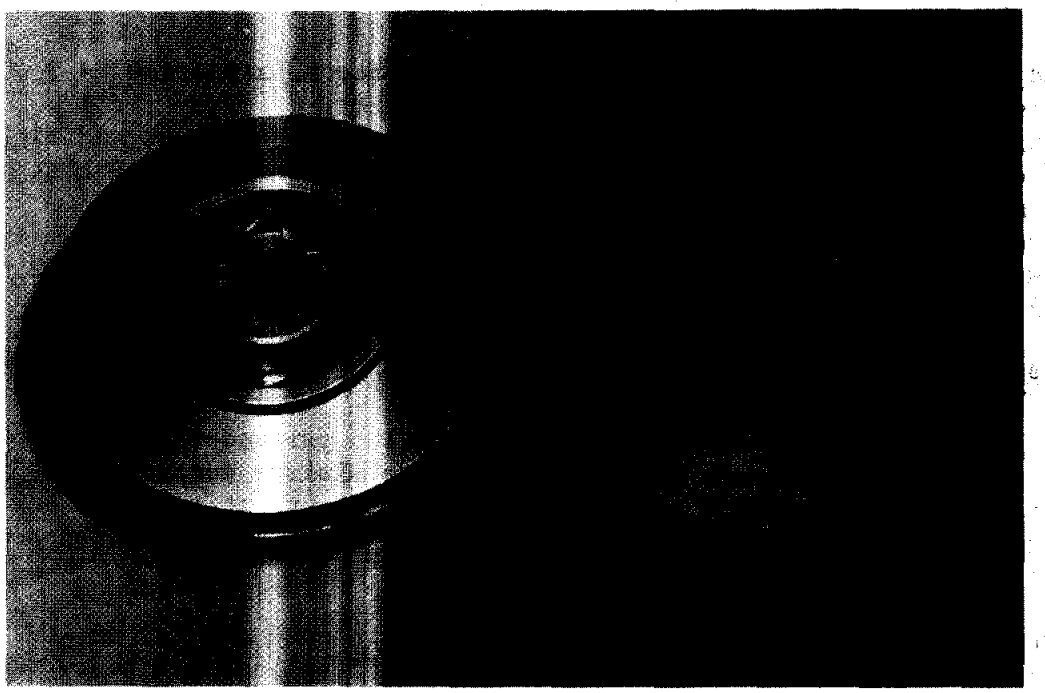


Photo No. 15 *Impeller #1 -- Unit "B" (left), no visible wear after endurance test. Unit "A" (right), showing wear resulting from muddy water test.*

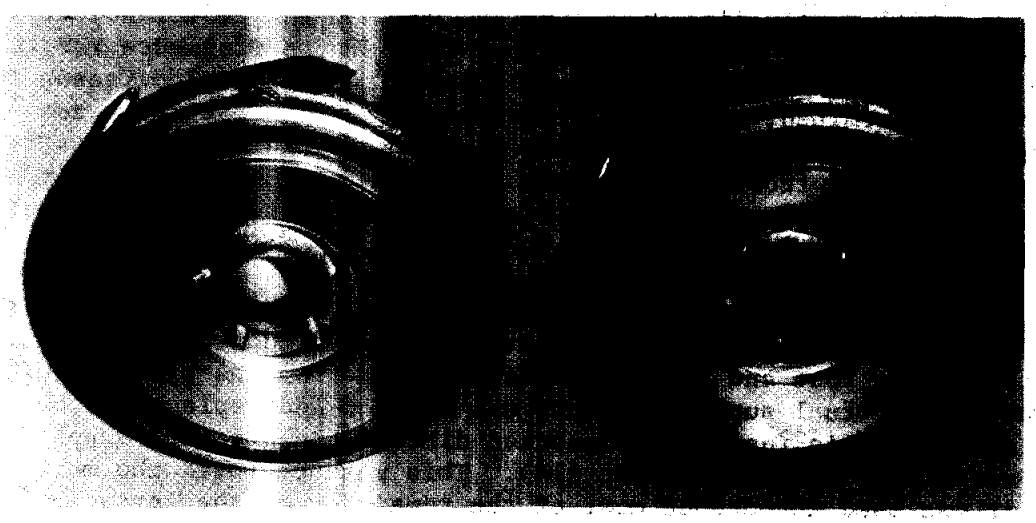


Photo No. 16 *Distributor -- Unit "B" (left), no visible points of wear after endurance test. Unit "A" (right), wear after muddy water test.*

- adjusted main and idle adjustment screws (accumulated time -- 3 hrs. 3 min.)
- tightened carburetor bolts, cleaned fuel strainer screen, and tightened fuel strainer cover retention screws (accumulated time -- 9 hrs. 8 min.)
- greased pump bearing and replaced the rewind starter rope since it had become frayed at the end closest to the pulley (accumulated time -- 23 hrs. 7 min.)

200 HOUR ENDURANCE TEST (Unit "B") Spec. No. 11 (Photo No. 14)

Unit "B" was run at a discharge pressure of 105 psi and 131 psi or 60 and 70 percent of shut-off pressure respectively with a minimum suction lift. The pressure was alternated every 4 to 8 hours until 100 hours at each pressure was accumulated. The pressure was regulated by a 1 1/2" ball valve located near the pump outlet.

During the 200 hour endurance test the unit consumed a total of 109.3 gallons of fuel at an average rate of consumption of 0.55 gallons per hour. This quantity included 6.4 gallons of oil combined with 102.9 gallons of gasoline.

Generally the unit performed very well throughout the test. The engine started regularly on less than 5 pulls on the rewind starter from either a cold, warm or hot start. Also the pump pressure did not vary appreciably from the two assigned discharge pressures.

ENDURANCE TEST PROBLEMS (Unit "B")

Early in the tests it was found that large bubbles entering the carburetor from the fuel supply line were greatly reducing the efficiency of the pump. They would periodically cause fluctuations in engine performance varying from a few psi to a point where the engine would actually stall. The reason for the bubbles was not determined, although it was suspected that the fuel was vaporizing near the quick connect coupling due to a combination of engine vibration and heat transfer from the pump foot to the quick connect assembly. When operating at night with low ambient air temperatures there was less trouble with bubbles.

Many methods were used to try and pinpoint the cause and eliminate the large bubbles. Some success was obtained when the quick connect assembly was unbolted from the engine foot and allowed to hang freely from the plastic fuel line. Later the regular fuel supply assembly was removed and replaced with a 3 foot length of clear plastic fuel line connected directly to the fuel supply tank outlet and the carburetor inlet (Photo No. 14). This method proved the most successful and it was used throughout most of the remainder of the tests in order to complete them in the time available.

During the test, the unit's spark plug was either regapped or replaced a total of eleven times. On each occasion the spark plug was suspected of causing eratic engine performance or the unit to stop. The electrodes on four plugs had become encrusted with a lead deposit and the electrodes on the remainder had burned sufficiently to increase the gap well beyond that recommended by the manufacturer. This may well have been caused by the fuel used (see page 1) although in some cases plugs were used for 39 hours with no apparent trouble while at other times the plug caused problems after 2 hours of operation. Generally the faulty plug was replaced instead of cleaning or regapping even

though each used plug was still in good condition.

After an accumulated endurance test time of 123 hrs. 31 min. difficulty was experienced while replacing a spark plug and in the process the cylinder head threads were damaged. Therefore, in order to continue the test it was decided to place the cylinder head from Unit "A" on Unit "B" since all tests assigned to Unit "A" had been completed.

PROBLEMS WITH PARTS AND ACCESSORIES (Units "A" and "B")

(1) Plastic Fuel Line

Shortly after the beginning of the tests a hole was discovered in the plastic fuel line of both "A" and "B" units. Each hole was located adjacent to a corner of the engine crankcase and just above the clamp which secures the transparent fuel line onto the copper fuel line. Engine vibrations caused a hole to be worn at this point because the fuel lines had been pressing against the crankcase. The fuel lines were replaced and the fuel line elbow on each unit was turned slightly to allow the lines to pass freely to the carburetor.

(2) Fuel Supply Tank

Fuel escaped from both fuel supply tanks provided with the pumps when they were filled to capacity. One tank leaked around the gasket at the tank outlet and the other around the air vent screw when it was tightly closed.

(3) Idle Speed Regulating Screw

On both units, the idle speed regulating screw on the carburetor proved to be nonfunctional since it would not reach the throttle shutter. However, contact between the screw and the shutter can be made by either removing or shortening the idle speed regulating screw spring.

(4) Bubbles in Fuel Supply Line

See description on page 16.

(5) Automatic Cutout Switch

During the 200 hour endurance test this switch stopped the engine several times for no apparent reason. The Instruction Manual outlines a procedure for recalibrating this device and when this was followed the switch gave no further trouble. The manufacturer later suggested that the calibration of the switch be checked from time to time.

(6) Grease Gun

The grease gun supplied with the pumps had a tendency to ooze grease from between the shaft and lower collar whenever pressure was applied. This made greasing the pump rather difficult since more grease would escape from around the collar than would pass through the nozzle.

(7) Muffler Wrench

A specially designed wrench was provided to facilitate the removal of the muffler nuts. However, the wrench, which has a bend in its shaft would not

remove the upper muffler nut closest to the fan cowl since the bend was in the wrong position or at an incorrect angle. Therefore, it was necessary to detach the fan cowl in order to remove the muffler.

PERFORMANCE AT FIVE-FT. SUCTION LIFT BEFORE AND AFTER THE 200-HOUR ENDURANCE TEST (Unit "B") Spec. No. 7.3

Unit "B" was operated with a 5-ft. suction lift to determine the relation between discharge pressure in pounds per square inch and discharge flow rate in gallons per minute, both before and after the 200-hour endurance test.

The results of the two tests showed that there was an increase in pump efficiency after the 200-hour endurance test for pump discharge pressures above 82 psi. A loss in discharge flow rate of approximately 1 Imp. gpm was recorded at free flow in the second test. There was an increase in shut-off pressure from 178 psi to 193 psi between the start and end of the endurance test. The results are plotted in Fig. No. 4.

DISASSEMBLY EXAMINATION (Unit "B") (Photo No. 15 and 16)

Pump Unit "B" was disassembled following a total accumulated operating time of 208 hours 27 minutes. No wear or damage was visible on the pump's component parts. The time required to disassemble the pump was approximately 9 minutes.

Unit "B" operation record

Date 1970	Daily Hours	Accumulated Hours	Stoppage and Reason	Adjustments, repairs and replacements	Ease of Start 2/
	hr. min.	hr. min.			
			OPERATION RECORD BEFORE ENDURANCE TEST		
June 25		0		Adjusted breaker points and carburetor.	2
	0:14	0:14	Daily shut-off		
Jul. 15		0:14		Replaced defective plastic fuel line.	2
	1:00	1:14	Daily shut-off		
Jul. 16		1:14			4
		1:52	Temporary shut down -- bubbles in fuel line.	Replaced regular fuel line with a clear plastic line connected directly between the carburetor inlet and the fuel supply tank outlet.	
		2:00	Temporary shut down.		2
	0:54	2:08	Daily shut-off.		
Jul. 20		2:08		Installed regular fuel line.	4
	2:35	4:43	Daily shut-off.		
Aug. 5		4:43		Installed new carburetor, checked ignition timing and set breaker point gap at .017" from .015".	5
	1:14	5:57	Temporary shut down.		
			ENDURANCE TEST OPERATION RECORD		
Aug. 5		0			5
	0:35	0:35	Daily shut-off		
Aug. 6		0:35			3
		3:25	Engine stopped-reason unknown.	Reinstalled original carburetor.	5
		4:14	Engine stopped-bubbles in fuel line.		7
		5:51	Engine stopped-bubbles in fuel line.	Installed new fuel line and quick connect assembly.	4
	5:43	6:18	Engine stopped-bubbles in fuel line.		

Aug. 7		6:18		Replaced fuel line with clear plastic line connected between the fuel supply tank and the carburetor inlet.	
	2:58	9:16	Daily shut-off.		3
Aug. 10		9:16			5
		16:07	Spark plug fouled.	Spark plug replaced.	
	7:46	17:02	Daily shut-off.		2
Aug. 11		17:02		Greased pump & decarboned cylinder exhaust port.	3
		17:11	Automatic cutout switch-reason unknown.		1
	7:03	24:05	Daily shut-off.		
Aug. 12		24:05			5
		30:10	Bubbles in fuel line.	Spark plug dry -- poured fuel into cylinder.	10 +
	6:21	30:26	Daily shut-off.		
Aug. 13		30:26			3
	15:44	46:10	See Note 1/		
Aug. 14		46:10			
		53:41	Engine stopped-reason unknown.		1
		55:17	Engine stopped -- spark plug gap .031"	Reset spark plug gap to recommended .018".	1
	16:23	62:33	Daily shut-off		
Aug. 17		62:33			3
		71:24	Temporary shut-down -- spark plug fouled.	Greased pump, replaced spark plug.	1
	15:19	77:52	Daily shut-off.		
Aug. 18		77:52			3
	18:00	95:52	Daily shut-off.		
Aug. 19		95:52			5

Aug. 19		102:30	Engine stopped-spark plug was partially fouled and gap had increased to .032".	Replaced spark plug.	2
		102:58	Temporary shut-down -- 100 hour check.	Decarboned cylinder head and exhaust port. Cleaned air filter screen, fan housing and starter cup assembly. Greased pump and checked breaker points.	2
		104:19	Engine stopped -- spark plug fouled.	Replaced spark plug.	4
	13:38	109:30	Daily shut-off.		
Aug. 20		109:30			5
		113:06	Temporary shut down.	Retorqued cylinder head bolts.	3
	12:33	122:03	See Note 1/		
Aug. 21		122:03			
		123:31	Engine stopped -- spark plug fouled.	Replaced spark plug.	1
		125:40	Engine stopped -- loose spark plug and cylinder head threads stripped.		
	3:37		See Note 1/		
Aug. 24		125:40		Cylinder head from Unit "A" was placed on Unit "B" in order to continue test.	3
		133:45	Temporary shut down to change spark plug.	Replaced spark plug.	1
		134:51	Automatic cutout switch stopped engine.		1
		136:57	Automatic cut-out switch stopped engine at 6150 rpm.	Adjusted automatic cutout switch.	1
	12:06	137:46	See Note 1/		

Aug. 25		137:46			
	16:24	154:10	Daily shut-off.		
Aug. 26		154:10		Replaced spark plug, checked breaker points, cleaned magneto area and automatic cutout switch assembly. Reinstalled regular fuel line.	2
		154:38	Bubbles in fuel line.	Greased pump.	1
		156:00	Bubbles in fuel line.		1
		158:51	Bubbles in fuel line.	Removed regular fuel line and replaced with clear plastic fuel line.	3
	12:23	166:33	See Note 1/		
Aug. 27		166:33			
		166:46	Temporary shut down.	Regapped spark plug.	3
		166:58	Engine stopped -- reason unknown.		1
		174:38	Temporary shut down.	Installed new spark plug.	3
		174:54	Engine stopped -- reason unknown.		1
	10:17	176:50	See Note 1/		
Aug. 28		176:50			
		189:04	Engine stopped -- reason unknown.		1
		193:21	Engine stopped -- fuel line closed.	Reinstalled regular fuel line.	2
		194:07	Temporary shut down to replace spark plug (gap .030")	Installed new spark plug.	3
	20:39	197:29	Daily shut-off.		
Aug. 31		197:29			3
	3:13	200:42	SHUT DOWN -- END OF TEST.		

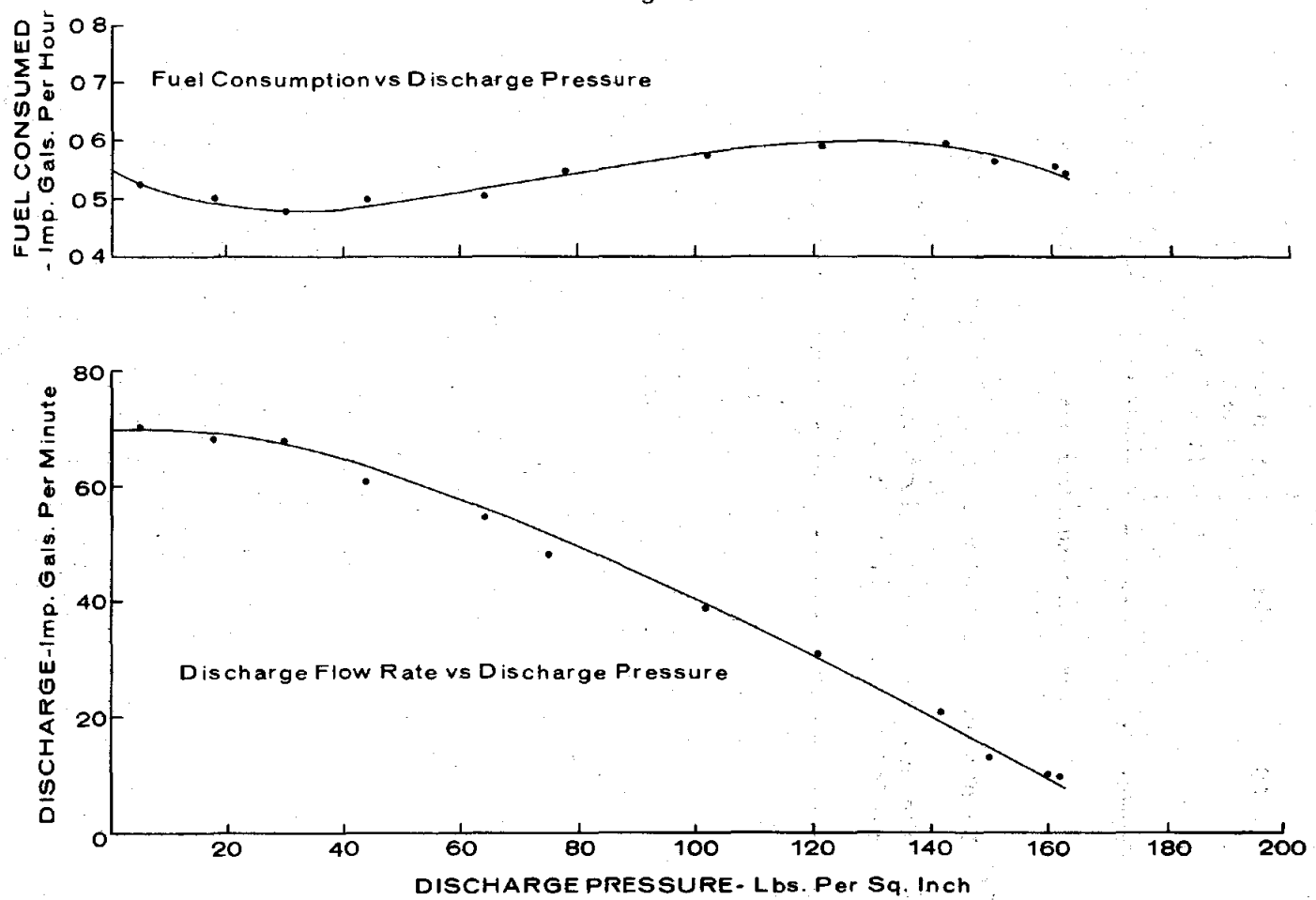
OPERATION RECORD AFTER ENDURANCE TEST					
Aug. 31		0		Greased pump, checked points, decarboned exhaust port, installed new spark plug.	2
	1:48	1:48	Shut-down -- End of Test 7.3		

Total accumulated operating time 208 hr. 27 min.

Note 1/ No stoppage is listed as the unit was operated past midnight.

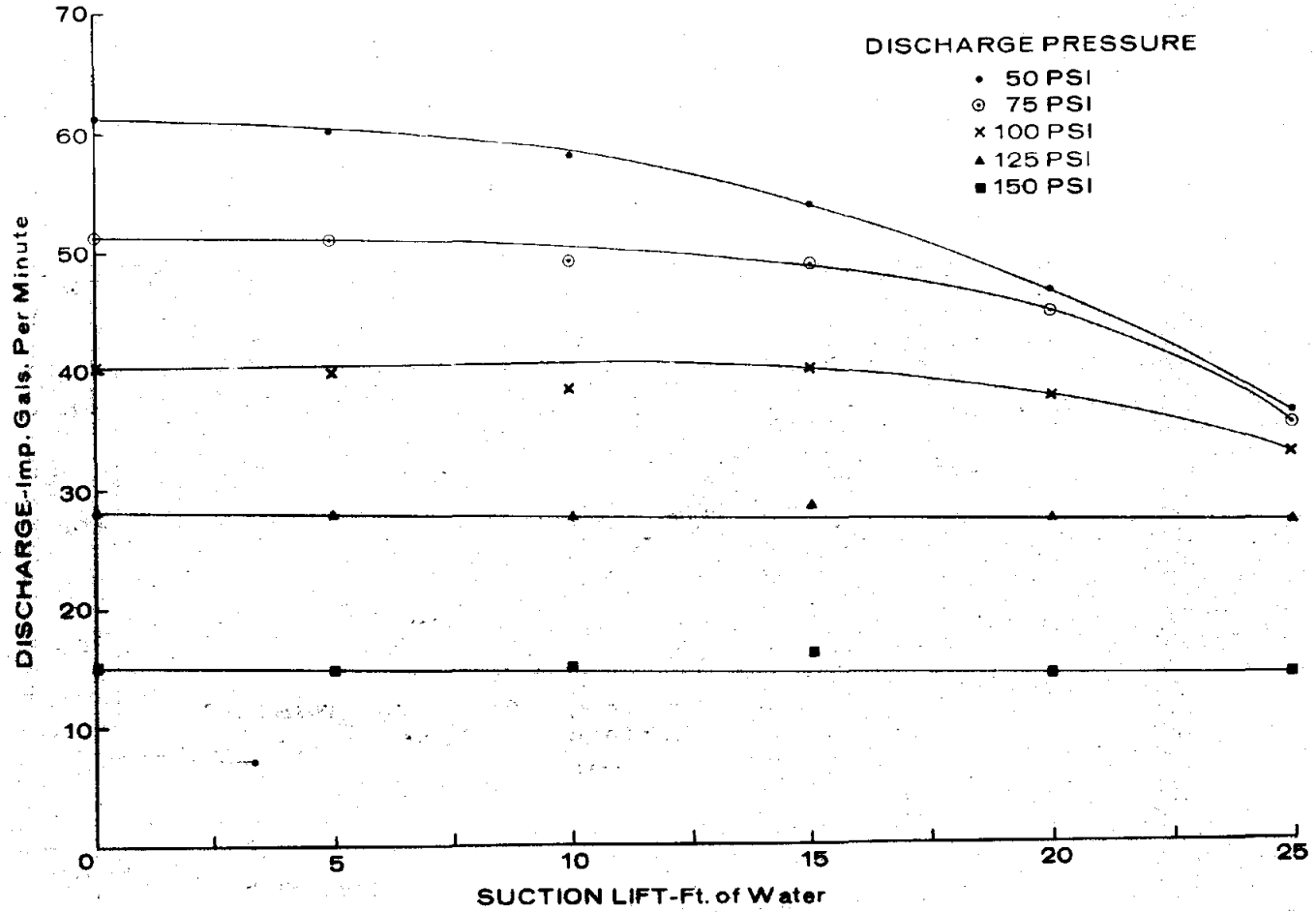
Note 2/ The ease of start is given as the number of pulls on the rewind starter needed to start the engine.

Figure No.1



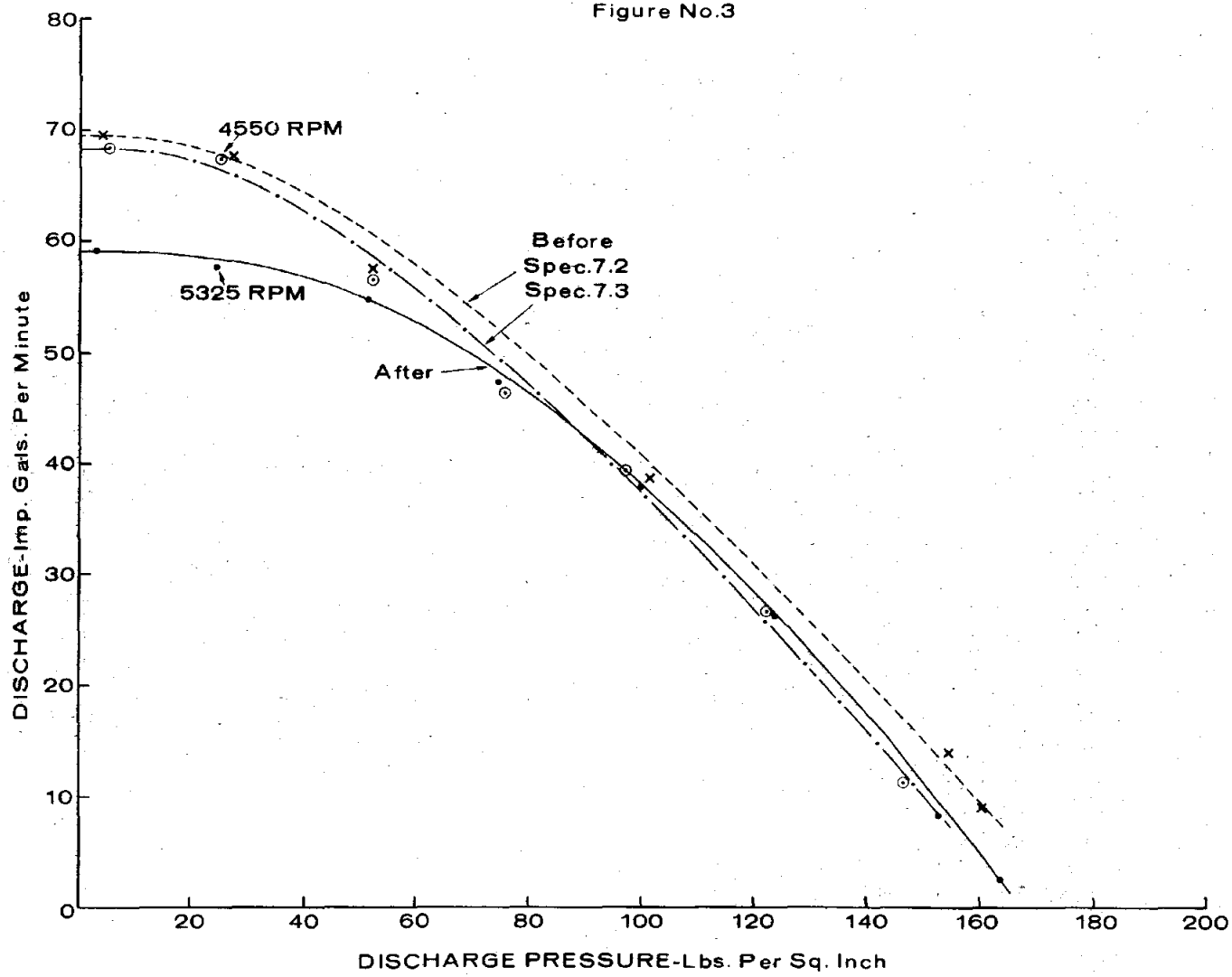
WAJAX MARK 26 CENTRIFUGAL PUMP
UNIT "A" PERFORMANCE AT MINIMUM SUCTION LIFT SPEC. 7.1

Figure No.2



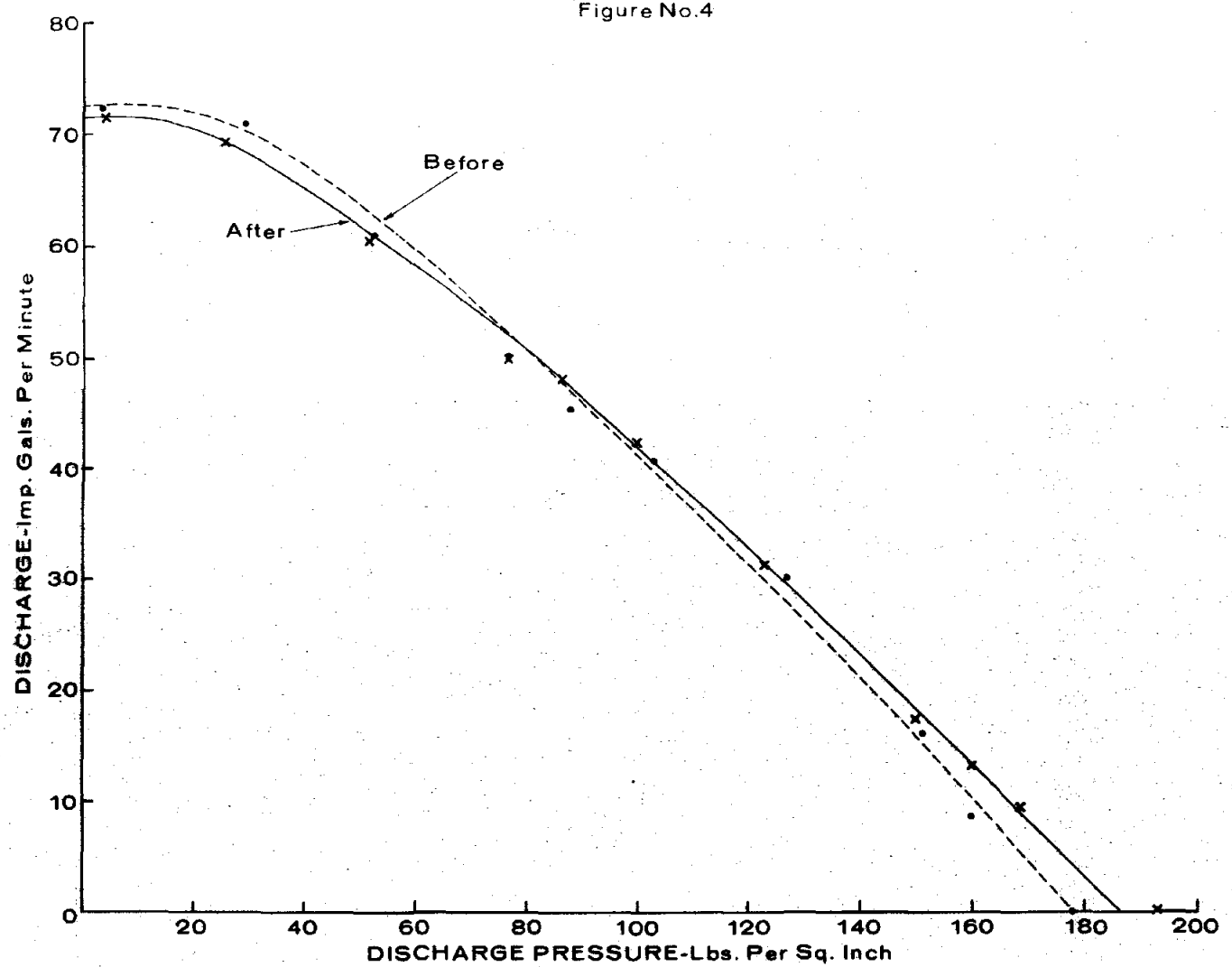
WAJAX MARK 26 CENTRIFUGAL PUMP
UNIT "A" PERFORMANCE AT VARIED SUCTION LIFT. SPEC. 7.2

Figure No.3



WAJAX MARK 26 CENTRIFUGAL PUMP
UNIT "A" PERFORMANCE AT 5FT. SUCTION LIFT
BEFORE AND AFTER MUDDY WATER TEST. SPEC. 7.3

Figure No.4



WAJAX MARK 26 CENTRIFUGAL PUMP
UNIT "B" PERFORMANCE AT 5 FT. SUCTION LIFT
BEFORE AND AFTER ENDURANCE TEST. SPEC. 7.3