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COMPLETION REPORT

U. S. ATOMIC ENERGY COMMISSION
CONTRACT NO. AT-(29-1)-507

Greenhouse #56

ENIWETOK
PROVING GROUND FACILITIES

VOL. XI
OPERATING MANUALS

HOLMES & NARVER, INC.
LOS ANGELES, CALIFORNIA

1 September 1951

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PREFACE

Written instructions for the proper operation and maintenance of utilities and operating equipment designed by the A-E-C-M, under Contract No. AT-(29-1)-507, were provided in several different forms. The intent of this Appendix is to discuss in general those which apply to normal operating and maintenance procedures and to present in detail those which might be considered as peculiar to this particular operation.

NORMAL PROCEDURES

VENDORS' MANUALS

Operating instruction manuals were provided by many manufacturers of equipment. These were furnished to the Jobsite. Following is a list of typical equipment for which such instructions were provided:

1. Distillation Units by Cleaver-Brooks Company
2. Diesel Generator Units by Fairbanks-Morse Company
3. Dehumidification Units by W. S. Kilpatrick & Co.

OTHER REFERENCES

Reference was made to published books, codes, and technical manuals. The following list of titles is typical of the War Department Technical Manuals which were used:

1. Electrical Facilities, General Engineering Data and Practices, Tools and Equipment and Safety Practices, Repairs and Utilities (TM5-680)
2. Overhead Distribution Systems, Repairs and Utilities, Electrical Facilities (TM-680C)

3. Electrical Facilities, Underground Distribution Systems, Repairs and Utilities (TM5-680D)
4. Electrical Facilities, Generating Plants, Repairs and Utilities (TM5-680G)
5. Common-battery Telephone Equipment (TM11-458)
6. Central Office Maintenance (TM11-473)
7. Electrical Communication Systems Engineering (TM11-486)

SPECIAL MAINTENANCE AND OPERATION INSTRUCTIONS

The following series of instructions were prepared by the A-E-C-M and are reproduced herewith because it is felt that they are peculiar to the type, nature, and location of this operation and that they might be of value in connection with future similar operations.

STANDARD OPERATING INSTRUCTIONS

NO. 1

MAINTENANCE AND OPERATION INSTRUCTIONS

HOIST AND ELEVATOR CONTROLS AT A TOWER

STANDARD OPERATING INSTRUCTIONS NO. 1

TABLE OF CONTENTS

STANDARD OPERATING INSTRUCTIONS NO. 1

MAINTENANCE AND OPERATION INSTRUCTIONS FOR
HOIST AND ELEVATOR CONTROLS AT A TOWER

GENERAL

1. This operating standard outlines the procedure to be followed in maintaining and operating the hoist and elevator controls and equipment at a tower.
2. The motor generator set is to be left running idle and the dc motor field coils energized at all times.
3. The group or facility charged with the responsibility for the operation and maintenance of the hoist and elevator controls and equipment should have qualified personnel on call who will be instructed in case of a power failure to go immediately to the tower and restart the motor generator set. The power house "watch" is charged with responsibility of notifying the proper personnel upon power failures.

DAILY OPERATION

4. The operator shall make the following checks and tests of the unit each day and report immediately to his supervisor any variation from normal, who in turn will notify the Engineering Division.

(a) Operate the elevator by means of the ground control station as follows:

OPERATION "A"

1. Push "up" button
2. Hold "Faster" button in for 12 seconds
3. Hold "Slower" button in for 12 seconds
4. Push "stop" button
5. Push "down" button
6. Hold "faster" button in for 12 seconds
7. Hold "slower" button in for 12 seconds
8. Push "Stop" button

(b) If the car operates correctly, turn the transfer switch to "HOIST" and, after untying the hand line securing the hoist sheave, operate the hoist from the ground control station as follows:

(REPEAT OPERATION "A")

(c) If the hoist operates correctly, turn the transfer switch to "ELEVATOR" and operate the elevator from the elevator controls.

(REPEAT OPERATION "A")

(d) If the elevator operates correctly, ride it to the top of the tower. Check the following:

1. Time the upward trip of the elevator; if it is not completed in 2 minutes 45 seconds, report this fact to the supervisor immediately, who in turn shall notify the Engineering Division.
2. That the elevator automatically slows dowr as it approaches the cab trap door.

3. That it stops within 3 inches of the floor level.

4. That when it stops, the brake immediately checks its movement with no lost motion.

(e) Proceed to the upper motor generator set control station and push the "stop" button. Allow approximately two minutes for the motor generator set to run down to zero speed; then push the "start" button, restarting motor generator set. Inspect the hoist cable and see that it hangs directly downward to the lower sheave with no twists or crossings.

(f) Transfer to "HOIST" control. Operate the hoist controls from the upper control station and;
(REPEAT OPERATION "A") except after instruction 4(a)2, while the hoist is rising at full speed trip the upper hoist limit switch by hand and ascertain that the hoist stops and remains in this standstill position.
After 15 seconds, continue Operation "A".

(g) Transfer to "ELEVATOR" control and ride the elevator to ground level.
Check the elevator operation as follows:

1. Time the trip downward at 2 minutes 45 seconds.

2. That the elevator automatically slows down as it approaches the ground level.

3. That it stops within 3 inches of the ground level.

4. That when it stops, the brake immediately checks its movement with no lost motion.

5. Remove the elevator safety gate and check that the elevator will not move when either the elevator or ground control station is tried.

6. With the elevator in motion either up or down trip the door safety switch.

7. Check that the elevator stops promptly and cannot be operated until the switch is restored to normal.

8. With the safety gate in position, from the ground control station, move the elevator upward to approximately the 70 feet level.

9. Stop the elevator at this point and secure the "stop" lockout button.

(h) Transfer to"HOIST" control and,

1. Bring the hoist sheave to ground level.

2. Secure the sheave and headache ball with a 3/4 inch hand line to the Eastward tower leg.

3. Secure the "stop" lockout button.

(i) Check the motor generator set bearings for temperature and ascertain that the heating lamps in the switch gear cubicles are all lighted. Close the hand doors to the control cabinets and lock the control house doors.

WEEKLY CHECK

5. The controls and equipment should be checked weekly as follows:

(a) Check voltage from Rectifier (208v dc-Terminals 17 & 25)

(b) Check exciter voltage (250v dc-Terminals 19 & 19A)

(c) Check generator voltage at no load (50v dc-Terminals G1 & G2)

(d) Check temperature of motor generator set and hoist and elevator motors for undue heating. Check temperature of control cabinet (110 deg. F.)

(e) Grease all sheaves and pulleys.

(f) Check motor generator set bearings, but do not grease.

(g) Check brushes on exciter, main generator, hoist and elevator motors.

REGULAR OPERATION

6. After hoist and elevator controls and equipment have been checked in accordance with the procedure outlined in paragraph (4) the units are ready for regular operation. Any variation or deviation from normal operating conditions is to be reported immediately to the Engineering Division.

MAINTENANCE

7. Electrical and mechanical equipment is to be maintained in accordance with Standard Instructions issued and approved by the Engineering Division.

MISCELLANEOUS

8. See the following Square D Company information:

(a) Drawing E.S. 2215 showing: Sequence of operation, variable voltage control; preparation for installation; and caution.

(b) Service Bulletin 19 AS

(c) Service Bulletin 31 AS

(d) Service Bulletin 48 AS

(e) Drawing D3719-1 showing motor control switchboard.

(f) Drawing D3719-3 showing control wiring schematic diagram

(g) Drawing D3719-4 showing load wiring schematic diagram.

(h) Drawing D3719-5 showing wiring diagram.

(i) Drawing D3719-6 showing exterior wiring diagram.

2 February 1951

STANDARD OPERATING INSTRUCTIONS

NO. 2

MAINTENANCE AND OPERATION INSTRUCTIONS

POL FACILITIES PARRY ISLAND

STANDARD OPERATING INSTRUCTIONS NO. 2

TABLE OF CONTENTS

STANDARD OPERATING INSTRUCTIONS NO. 2

MAINTENANCE AND OPERATION INSTRUCTIONS FOR
POL FACILITIES PARRY ISLAND

GENERAL

1. This operating standard outlines the procedure to be followed in maintaining and operating the POL facilities and the tank farm on Parry Island. The same general instructions cover the POL facilities at Eniwetok Island.

EQUIPMENT

2. Drawing FS 497 reproduced in this volume applies.

3. The equipment installed at the POL tank farm and pump house is as follows:

Pump House Equipment.

(a) Four electric motor driven centrifugal pumps (P-1, P-2, P-3 and P-4) with allied pipe, valves and fittings, and pressure gauges needed to complete the installation.

(b) Four dehydrators, (Dehydrators No. 1 and 2 for diesel oil dehydration, and Dehydrators No. 3 and 4 for gasoline dehydration) with the allied pipe, valves, fittings, gauges, meters, and pressure regulators needed to complete installation.

(c) Two deaerators with allied equipment needed to complete the installation. Deaerator No. 1 is for diesel oil and No. 2 is for gasoline.

STANDARD OPERATING INSTRUCTIONS NO. 2

MAINTENANCE AND OPERATION INSTRUCTIONS FOR
POL FACILITIES PARRY ISLAND

Yard Storage.

(a) Diesel Storage Equipment.

1. Five horizontal storage tanks (Nos. 1 through 5) of 10,000 gal. capacity with allied pipe, valves, controls, and fittings necessary to complete the installation.
2. Eight vertical storage tanks of 42,000 gal. capacity (Nos. 304, 305, and 153 through 158), with allied pipe, valves, and fittings necessary to complete the installation.

(b) Gasoline Storage.

1. Four horizontal storage tanks (Nos. 6 through 9) of 10,000 gallon capacity with allied pipe, valves, fittings, and controls necessary to complete the installation.
2. One vertical storage tank (No. 307) of 42,000 gallon capacity with allied pipe, valves, and fittings necessary to complete the installation.

Filling Station.

(a) One underground storage tank (No. 10) of 2000 gallon capacity with allied pipe, valves, and fittings.

(b) Two standard filling station gasoline pumps with allied equipment.

STANDARD OPERATING INSTRUCTIONS NO. 2

MAINTENANCE AND OPERATION INSTRUCTIONS FOR
POL FACILITIES PARRY ISLAND

DIESEL FUEL LOADING OPERATION

4. The diesel fuel oil is delivered to the POL tank farm by a tanker ship which anchors off shore and connects to a flexible line at the marker buoy. This flexible line, in turn, is connected to a steel submarine pipe which delivers the diesel fuel oil to dehydrators Nos. 1 and 2 through valve V-2, strainer S1, pressure regulator V3, and valves V4 and V5. Salt water in the submarine line is drained back into the lagoon through valve V-1. The entrained water is separated and drained off at the dehydrators Nos. 1 and 2 and the diesel oil then goes to deaerator No. 1 through valves V8 and V9 and pilot operated motor valves V6 and V7, where the entrained air is separated and vented to the atmosphere. The diesel fuel then leaves the deaerator and passes through Meter M-1, valves V13, V14 and V15 to the main diesel loading header, and is delivered to the tank loading header through valve V23 and liquid level control valve L-1 and thence through valves V27 through V28 into tanks 1 through 5 respectively. The diesel fuel is delivered to tanks No. 304 and 305 from the main diesel loading header through valves V38, V39 and V42, and to tanks 153 through 158 through valves V41, V34, V36. During the loading operation valve V1 is opened and valve V2 closed until the excess water has been drained from the submarine line; then valve V1 is

closed and valve V2 is opened allowing the diesel oil to pass into the unloading system. Valves V112, V113, V115, are closed during this operation.

A line is connected across the main unloading header and the vent on tank No. 3 through the float chamber of Liquid Lever Control valve L1 which is used to actuate the valve. This lever control can be set to operate on an individual horizontal tank, all five tanks, or can be isolated from the system by means of block valves V46 and V47.

DIESEL UNLOADING OPERATION

5. Diesel fuel oil is unloaded to the main unloading header from tanks Nos. 1 to 5 inclusive through valves Nos. V17, V18, V19, V20 and V21 from tanks Nos. 304 and 305 through valves V38, V42 and V40 and from tanks Nos. 153 to 158 inclusive through valves Nos. V35 and V36. The oil then passes to the diesel transfer pump suction manifold and to pumps P1 and P2 through valves V48 and V51 and is discharged from the pumps to dehydrators No. 1 and 2 through check valves V50, V52, valves V51, V53, V115, Strainer S-1, Pressure Regulator Valve V3 and Valves V4 and V5. Engrained water is separated at the dehydrator, and the diesel oil then leaves the dehydrators through valves V8 and V9, and pilot operated motor valves V6 and V7, deaerator No. 1, meter M-1, Pressure Regulator valve V11,

valves V13 and 14 thence to the loading rack through valve V112 and quick opening valve V111 into tank truck. A line also supplies the powerhouse and laundry through valve V113.

During the unloading operation, valves V2 to V15 are closed, and the required tank outlet valves, pump suction and discharge valves, and valve V115 are opened. After the truck has been filled and the pumps cut off, valve V15 should be opened to relieve the pressure on the system back into the tanks.

NOTE: Valve V15 must always be closed when a truck is being loaded to prevent the pump from circulating the liquid back through the tanks thus giving the wrong meter reading.

GASOLINE LOADING OPERATION

6. Gasoline is delivered to the POL tank farm by tanker ship which anchors off shore and connects to a flexible line at the marker buoy. This flexible line, in turn, is connected to a steel submarine pipe which delivers the gasoline to Gasoline Dehydrators Nos. 3 and 4 through valve V55, Strainer S-2, Pressure Regulator valve V56, and valves V57 and V58. (Salt water in the submarine line is drained back to the lagoon through valve V114). The entrained water is separated at the dehydrators; the gasoline then goes to deaerator No. 2 through valves V59 and V60, and Pilot operated motor valves V61 and V62,

where the entrained air is separated and vented to the atmosphere. The gasoline then leaves the deaerator and passes through meter M2, pressure regulator valve V64, valves V66, V68 and V69 to the main gasoline loading header, and is delivered to the tank loading header through valve V116 and liquid level control valve L2 and thence through valves V70, V71, V72 and V73 into tanks 6 through 9. The gasoline is delivered also to tank No. 307 through valves V84 and V85 from the main gasoline header.

During the loading operation, valve V114 is open and V55 closed until the excess salt water has been drained from the submarine line; then V114 is closed and valve V55 is opened allowing the gasoline to pass into the system. Valves V54 and V109 are closed during this operation.

A line is connected across the main unloading header and the vent on tank No. 7 through the float chamber of liquid level control valve L2. This line is provided with two block valves, V86 and V87, for cutting the float chamber off the system.

GASOLINE UNLOADING OPERATION

7. The gasoline is unloaded from tanks 6 through 9 to the main gasoline unloading header through vavles V78, V79, V80 and V81 and from tank 307 through valves V83 and V85. Thence it

is piped to the gasoline transfer pump suction manifold, and to pumps P3 and P4 through valves V105 and V108 then discharged from the pumps to dehydrators 3 and 4 through check valves V104 and V107, valves V103, V106, V54 Strainer S2, Pressure Regulator valve V56, valve V57 and V58. Entrained water is separated at the dehydrators; then the gasoline leaves the dehydrators and goes through valves V59 and V60, Pilot operated motor valves V61 and V62, Deaerator No. 2, Meter M2, Pressure regulator valve V64, valve V66 and V68 to the tank truck loading rack, and also through valve V67 underground tank No. 10 at the gasoline filling station. At the loading rack, the gasoline passes through valve V109 and quick opening valve V110 to tank truck.

During the unloading operation, valves V55 and V69 are closed and the required tank outlet valves, pump suction and discharge valves V54 are opened. After the truck has been loaded and the pumps cut off, valve V69 should be opened to relieve the pressure on the system back into the tanks.

Valve V69 must always be closed when a truck is being loaded to prevent the pump from circulating the liquid back through the tanks, thus giving the wrong meter reading.

DEHYDRATION OPERATION

8. The dehydrators are equipped with a water trap located in the sump. When the water level rises in the sump pilot operated motor valves No. V6 and V7 are closed, shutting the flow of the diesel oil. Pilot operated motor valves V91 and V92 open, and the water is drained from the sump through valves V90, V93, strainers S3 and S4, and motor valves V91 and V92 to a dry well. These motor valves are operated by a pilot attached to the water trap. When the excess water has been drained off, valves V6 and V7 open, the diesel oil resumes its flow, and the motor valves V14 and V15 close, shutting off the water drain. The sumps are equipped with an auxiliary drain and a gauge glass. Should the automatic equipment become inoperative, the water can be drained through this auxiliary drain by operating valves V94 and V95.

The gasolone dehydration operation is the same as described above. See FS 497 for valve numbers.

CLEANING OF DEHYDRATORS

9. The normal pressure drop through the dehydrators is 2 to 3 pounds, and filters should be changed if the drop exceeds 5 pounds. It is necessary to check the pressure drop at ten-day intervals. If new packing is required, a filter recommended or supplied by the manufacturer should be used.

STANDARD OPERATING INSTRUCTIONS NO. 2

MAINTENANCE AND OPERATION INSTRUCTIONS FOR
POL FACILITIES PARRY ISLAND

DO NOT USE WOOD EXCELSIOR.

To repack: Close inlet and outlet valves.

Drain water from sump.

Drain remaining fuel into tank or to dry well.

Remove head flange and grid assembly.

Remove old filter and inner grid.

Clean out sediment and wood fiber.

Insert new packing.

NOTE: The amount of packing supplied by the manufacturer is the correct amount for the unit. If there is any packing left over or if the space is not entirely filled, remove the packing and repack.

The packing should be installed or inserted in layers of 4 inches to 6 inches until all of it is in position. The packing must be placed evenly throughout the dehydrator; otherwise "channelling" will take place and the fuel will not be properly dehydrated. Under no circumstances should there be any open spaces after the packing has been placed.

Replace front grid assembly, head gasket, and head.

Use a suitable sealer on the gasket to assure a tight fit.

STANDARD OPERATING INSTRUCTIONS NO. 2

MAINTENANCE AND OPERATION INSTRUCTIONS FOR
POL FACILITIES PARRY ISLAND

Close all valves except "inlet" and "outlet".

Circulate clean dry fuel thru the dehydrator for at least one hour, allowing no water to come in contact with the packing during the "start-up" operation. Allow the unit to remain idle for at least one hour.

The unit is now ready for operation.

NOTE: Should water get in contact with the packing before it is properly saturated with fuel, it will be necessary to circulate clean dry oil through the unit for several hours before proper dehydration will take place. If water is allowed to stand in the filter, it will be necessary to change the packing. All automatic equipment must be checked at least once each month.

POL FACILITIES PARRY AND ENIWETOK

RECOMMENDATIONS FOR BETTER OPERATION AND SAFER OPFRATING CONDITIONS

1. By-Passes.

A by-pass should be installed around Meter M-1 and Pressure Regulator V-11, also around Meter M-2 and Pressure Regulator V-64. This will facilitate repairs without shutting down operations. See FS 497 in POL operating and maintenance manual. The present by-passes in these lines are of no value as installed and should be removed. Valves V-12-13-14-65-66 and 68 should be reused in the new by-pass as shown in FS 603. The gasoline line to tank No. 10 should be placed down stream from valve V-68 so that this tank could be filled when Meter M-2 is shut down.

2. Water Drain Controls.

Motor Valves V-6-7-61-62, 91, 92, 97 and 98 should be inspected, repaired and reinstalled to operate automatically. Motor valves V-6, 7, 61 and 62, which are normally open, should automatically close; and motor valves V-91, 92, 97 and 98, which are normally closed, should automatically open when the water level in the dehydrator sumps rises. As these valves are not operating correctly, it is necessary to drain the sumps manually through valves V-94, 95, 100 and 101. See FS 605 for correct control piping installation.

3. Cleaning Dehydrators.

Approximately 500 gallons of fuel is lost to a dry well each time the dehydrators are cleaned. An auxiliary tank and a

NOTE: [illegible]

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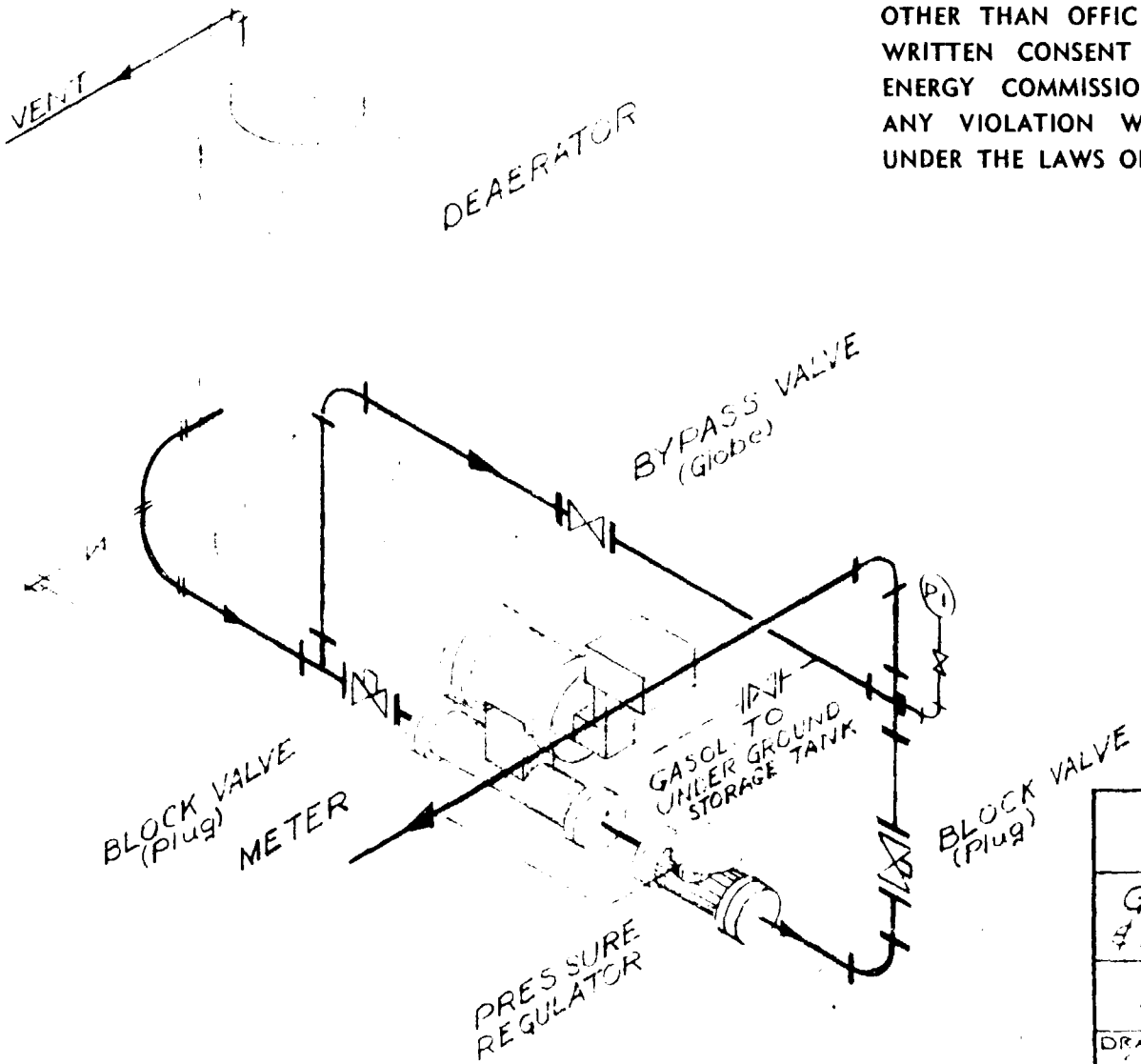

HOLMES & NARVER ENGINEERS	
GASOLINE & DIESEL OIL METER & MOTOR VALVE BYPASS PIPING	
POL FACILITIES SITE "B"	
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DATE 3-17-51	SHEET FS-[illegible]

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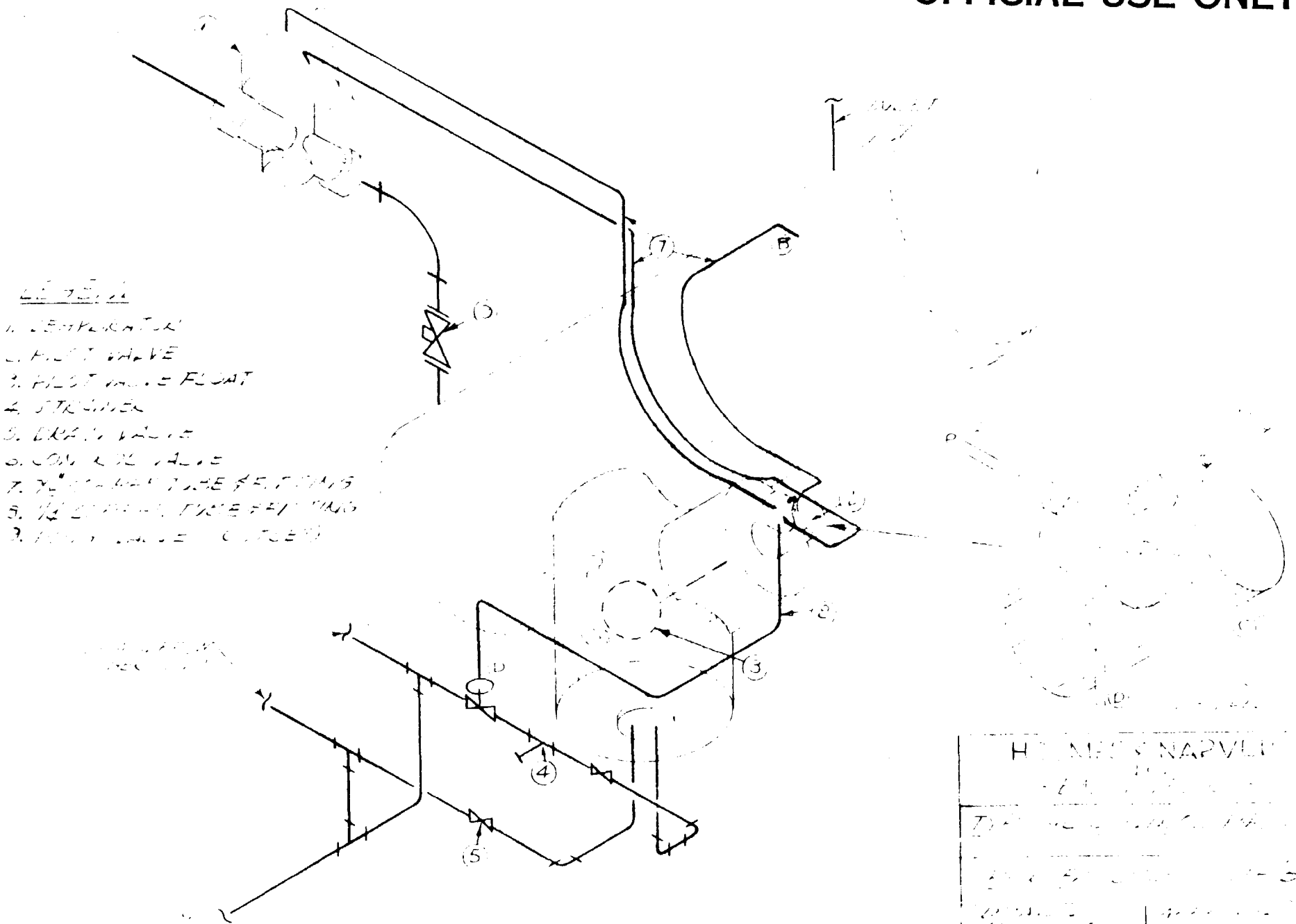


drain line should be installed to retain the liquid, which could be returned to the system when cleaning operations are finished. See FS 606.

4. Loading Rack.

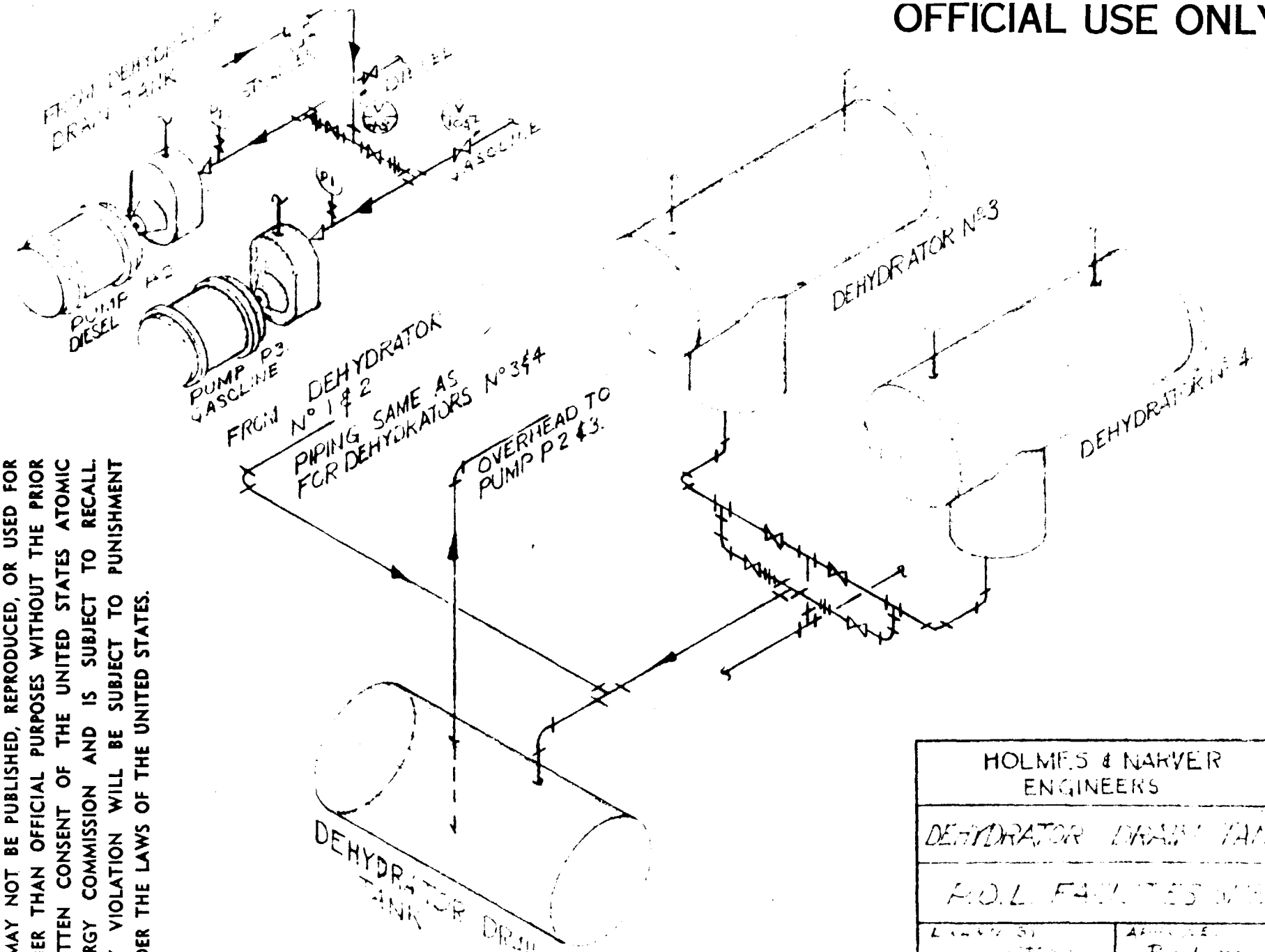
The fence section of the loading rack at both Eniwetok and Parry interferes with efficient and safe loading of the trucks. The pipe section of the loading nozzle should be lengthened at least 2 feet. The counter-balance weight should be increased also to offset the addition of the pipe.

The rack and assembly for tying the nozzle inside the fenced enclosure causes the employee to work over the barbed wire guard on the fence. The tying assembly could be installed at the outside of the fence to eliminate this hazard. See FS 607.

Gasoline and fuel oil are being spilled after each truck loading operation. The liquid forms a pool underneath the truck and creates a fire hazard which could be eliminated by better nozzle control and a concrete pad equipped with a suitable drain to remove the waste fluid from the area.

5. Tank Gauge.

A standard gauge should be provided to measure the oil, gasoline and water contents of each tank.



HOLMES & NARVER ENGINEERS	
DEHYDRATOR DRAIN TANK	
P.O.L. FACILITIES	

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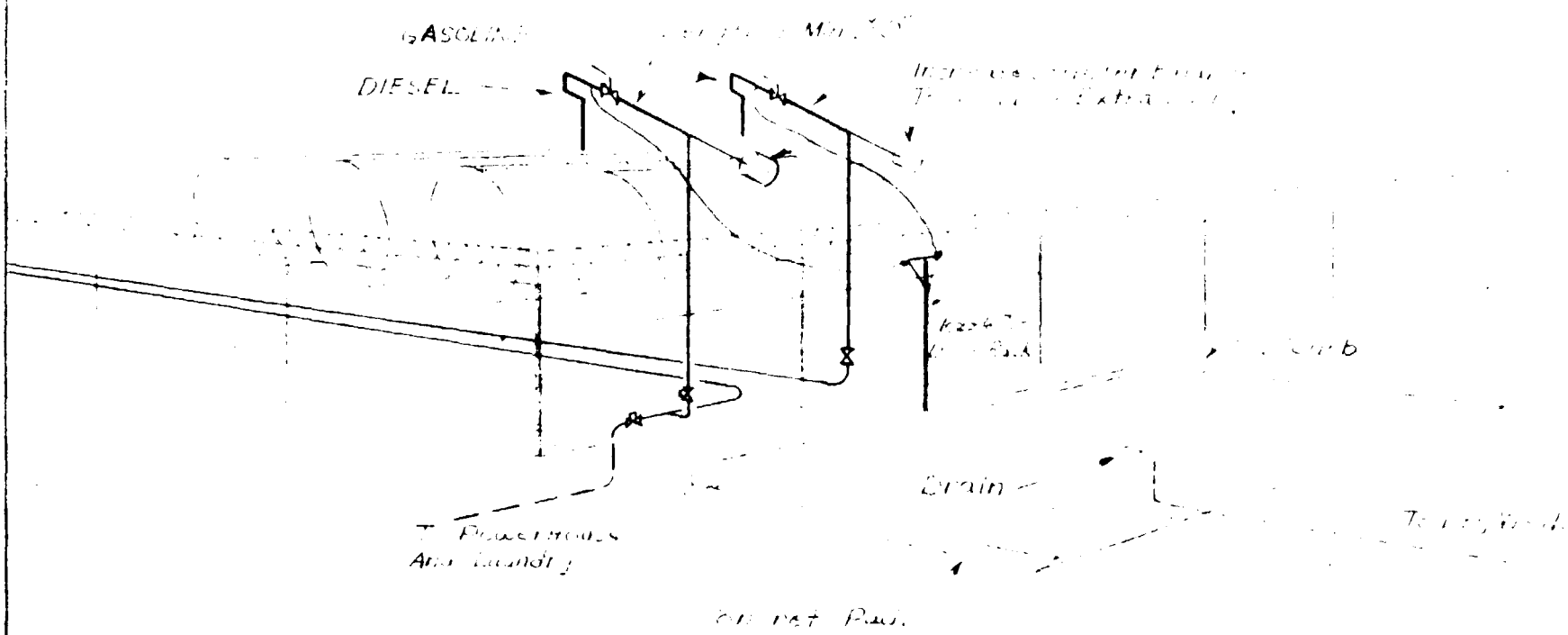

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HOLMES & NARVER ENGINEER	
LOADING RACK AREA	
P.O.L. FACILITY	
DRAWN BY	APPROVED
DATE 5-27-5	SHEET FS C-1

6. Guard Posts.

The piping above the ground near the service station should be protected by posts to prevent their being struck by passing vehicles. See FS 609.

7. Drainage from Tanks.

A drainage manifold should be installed at each set of tanks to facilitate the flow of drainage to the lagoon or into a dry well. The present method of individually draining each tank to the ground creates a fire hazard. The installation of a suitable drain manifold will eliminate this hazard. See FS 611.

8. Dikes.

Suitable stairs should be installed over the dikes at points where it is necessary for the workmen to use while performing his duties. This would prevent the dikes being damaged as is the case at present. See FS 610.

Also, the dikes have not been sufficiently stabilized, as natural erosion is destroying them. Additional bituminous oil should be sprayed on the dikes as required.

9. Pilot Operated Motor Valves.

At present it is necessary to shut down both dehydrators when repairs are required to the pilot operated motor valve in the fuel outlet lines. By moving the valves V8 and V9 down stream

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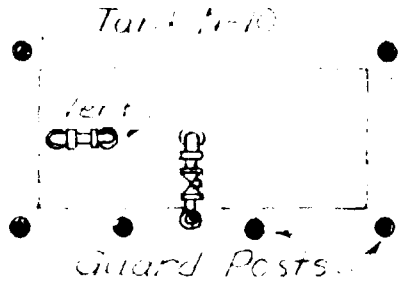

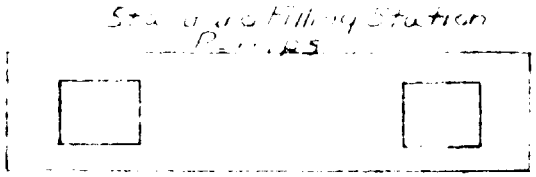

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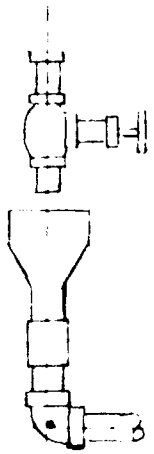
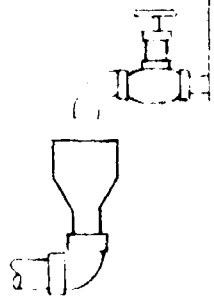
HOLMES & NARVER ENGINEERS	
GUARD POSTS	
P.O.L. FACILITIES	
DRAWN	APPROVED
DATE	



Typical Drain Manifold Arrangement
For Horizontal Storage Tanks



Typical Drain Manifold Arrangement
For Vertical Storage Tanks

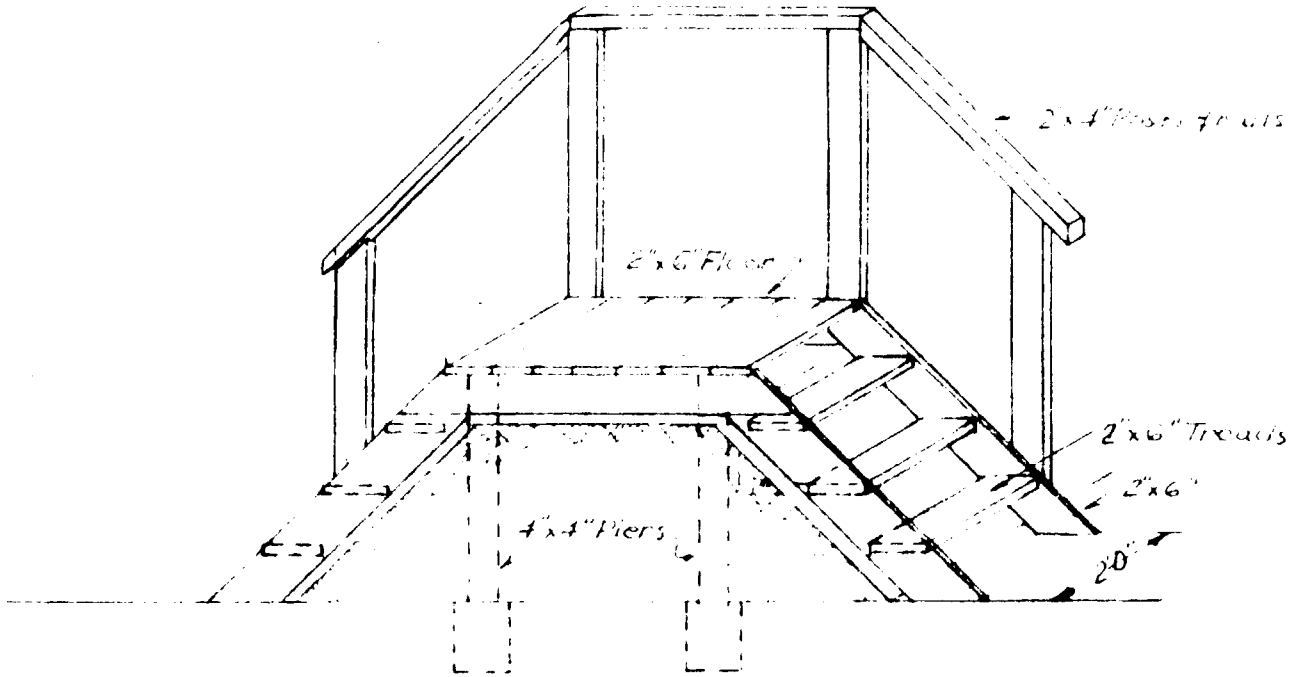
HOLMES & NARVER

DRAWING

FACILITIES SITE

DATE

SHEET



Extend Piers To Firm bearing Soil & Set In Concrete

Note: Change To Suit Conditions In The Field

HOLMES & NARVER ENGINEERS

DYKE CAR SHED

POL FACILITY

DRAWN BY	APPROVED
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DATE	
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from valves V6 and V7, and valves V59 and V60 down stream from V61 and V62 it would be possible to make repairs with only one unit at a time shut down. See FS 638.

10. Liquid Level Control.

    The liquid level control between the horizontal tanks is connected across the unloading header and a vent on one of the tanks thus making it necessary to leave all the tank outlet valves open in order to control the liquid level. A separate manifold should be installed for this liquid level control system. See FS 608.

11. Some of the tank ships are equipped with hydraulic or positive displacement pumps which build up excessive pressures when the liquid level control cuts off liquid flow or when flow to tanks is changed. Pressure relief valves should be installed up stream from the pressure reducing valves V3 and V56 to bleed off or reduce this excess pressure. A tank should be provided at each relief valve to save the liquid and a means of returning the fluid to the system installed. See FS 639.

12. A parts list should be made up covering all equipment.

13. Valve identification tags should be provided and installed. See FS 604.

14. A print of FS 497 should be displayed in the POL Pump House.

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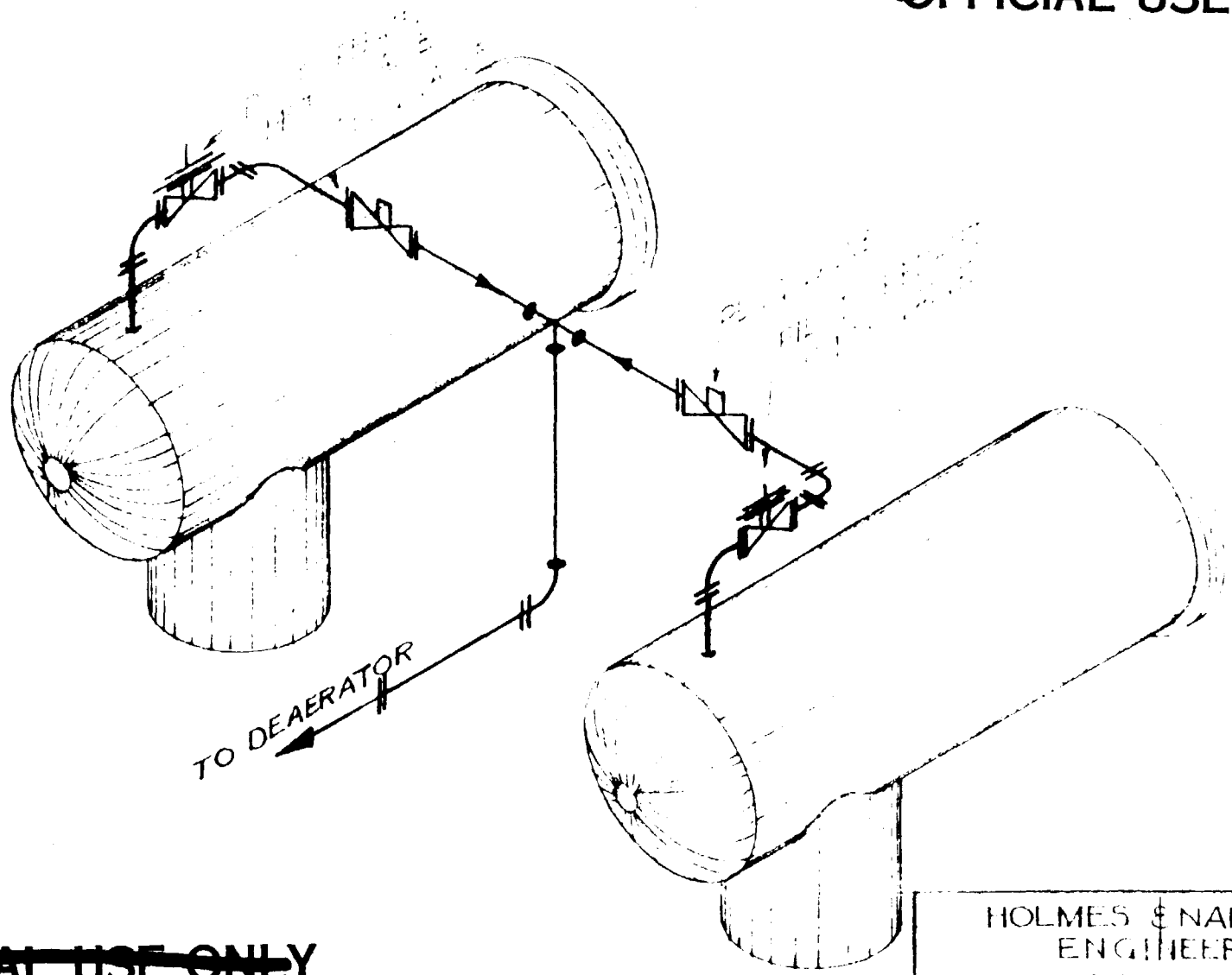

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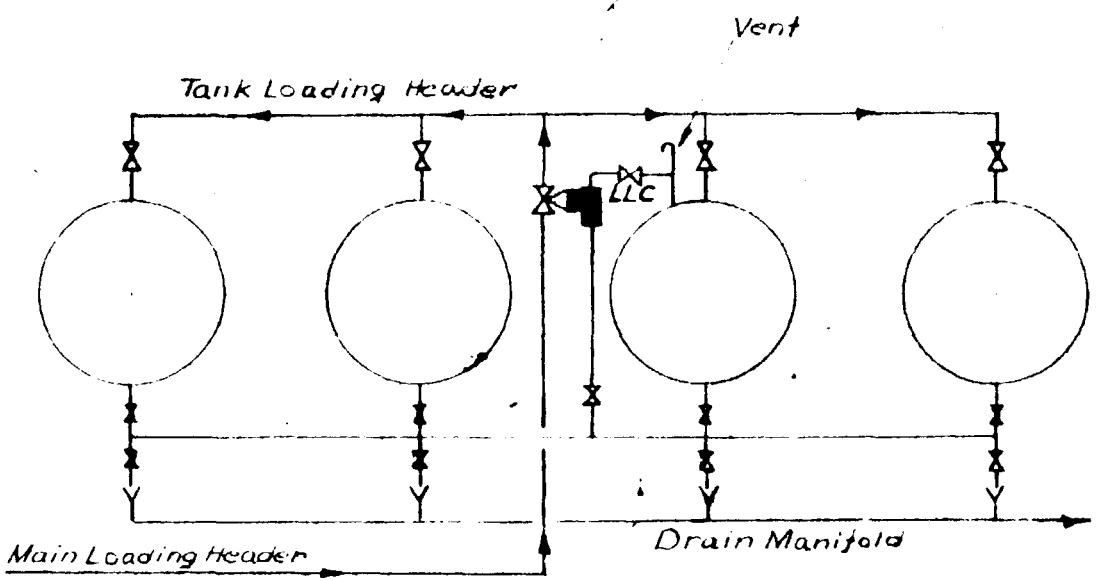
HOLMES & NARVER
ENGINEERS

DEHYDRATOR DISCHARGE PIPING

P.O.L. FACILITIES SITE "B"

DRAWN	APPROVED
DATE 3-31-51	SHEET FS . 35



HOLMES & NARVER ENGINEERS

LIQUID LEVEL CONTROL SYSTEM

P.O.L. FACILITIES SITE "B"

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[illegible]	[illegible]
DATE	SHEET
3-31-51	FS [illegible] 3

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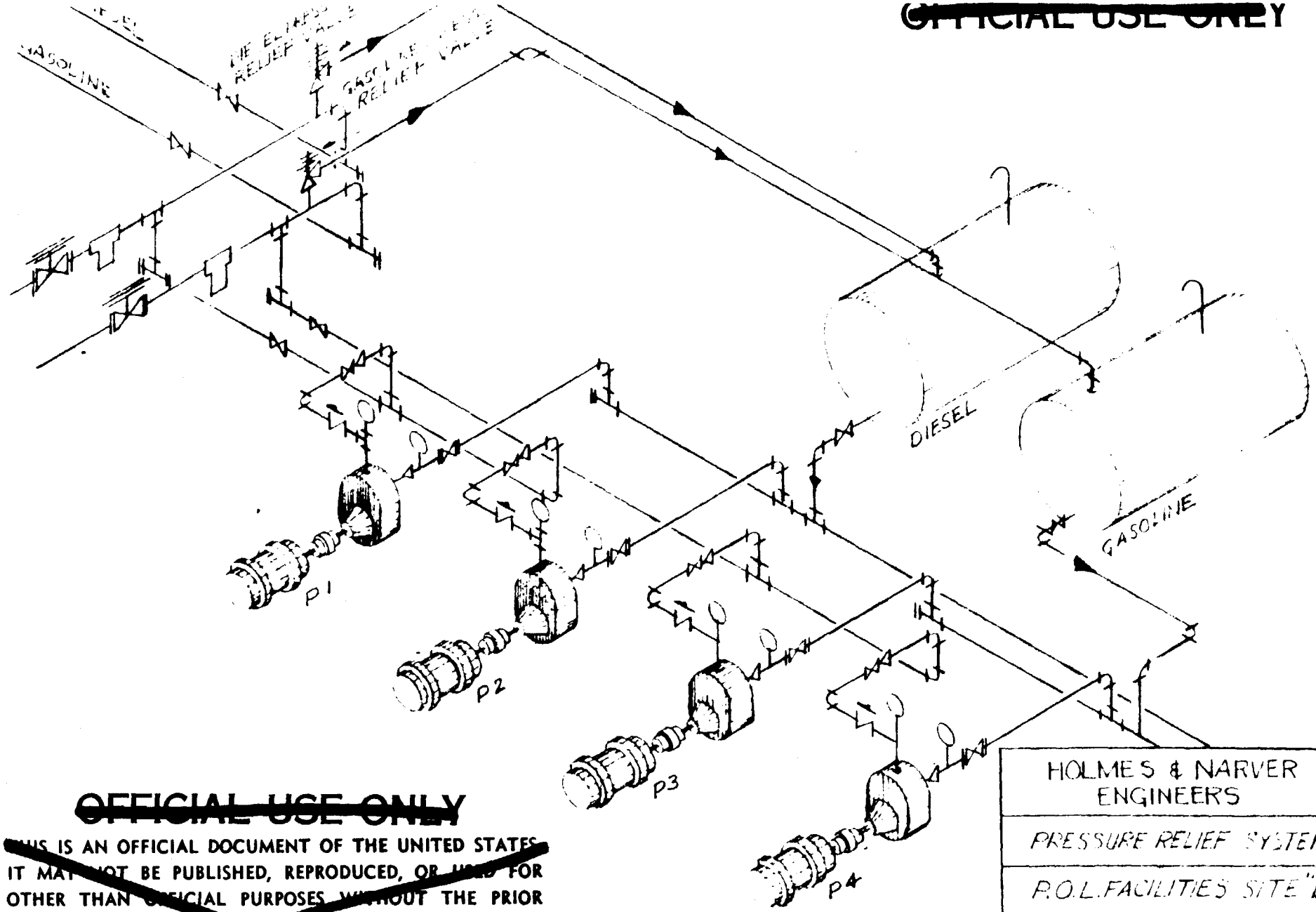

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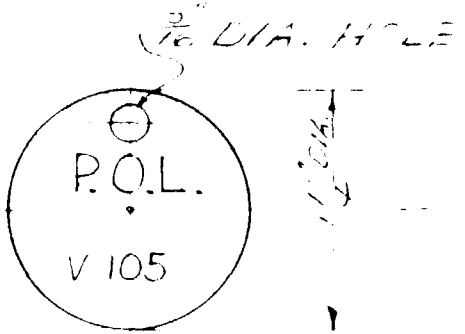
HOLMES & NARVER ENGINEERS	
PRESSURE RELIEF SYSTEM	
R.O.L. FACILITIES SITE "B"	
DRAWN BY	APPROVED
DATE 3-31-51	SHEET FS 1



2 STEEL
NAME OF EQUIPMENT
ISSUED TO
TAGS TO BE MANUFACTURED FROM
1 TO 150 - CONSECUTIVELY

HOLMES & NAEVER ENGINEERS	
VALVE IDENTIFICATION TAGS	
ARK. FACILITIES SITE "B"	
APPD.	APP.
DATE	DWG. NO. E. J. 604

STANDARD OPERATING INSTRUCTIONS

NO. 3

OPERATING AND MAINTENANCE INSTRUCTIONS

DIESEL ENGINE GENERATOR PLANTS - ALL SITES

STANDARD OPERATING INSTRUCTIONS NO. 3

TABLE OF CONTENTS

STANDARD OPERATING INSTRUCTIONS NO. 3

OPERATING AND MAINTENANCE INSTRUCTIONS FOR DIESEL ENGINE GENERATOR PLANTS - ALL SITES

These engines are provided with:

1. Woodward UG8, hydraulic relay, dial type governor, with speed droop adjustment, panel board and hand operated synchronizer, throttle limit adjustment and throttle position indicator (See section on Hydraulic Governors.)
2. Pressure gauges and thermometers
3. Intake air filter and silencers
4. Cylinder indicating cocks and relief valves
5. Thermocouple, pyrometer connection on each cylinder
6. Lube oil purifying system
7. Compressed Air starting system

The engine operation and maintenance are covered in the Fairbanks-Morse operating instruction manual No. 3100A6-1/4. The operators should familiarize themselves with this manual and follow it closely in the operation of the engine.

GENERAL MAINTENANCE INSTRUCTIONS

Inspect the engine and its equipment regularly. It is an excellent plan to have a regular inspection routine. Systematic care of the whole installation reduces cost of maintenance. After making a careful study of the requirements of the particular installation, an inspection and maintenance routine should be established and adhered to rigidly.

STANDARD OPERATING INSTRUCTIONS NO. 3

OPERATING AND MAINTENANCE INSTRUCTIONS FOR DIESEL ENGINE GENERATOR PLANTS - ALL SITES

Cleanliness is an important item in engine operation; a well kept engine room lessens the likelihood of trouble with machinery. Check the drive equipment for sufficient lubrication and tension on all V-belt drives; take readings of all gauges, thermometers, and instruments at regular intervals as determined by the Engineer-in-Charge. It is a good plan to chart curves showing the fuel and lubricating oil consumption and also the various pressures and temperatures. This data should prove very beneficial in detecting any irregularity in the engine operation.

Holding to a rigid inspection routine will insure more efficient operation, and cut maintenance to a minimum. See chart of Typical Inspection Maintenance Schedule, FS 475.

ENGINE AUXILIARY SYSTEMS

The function, operation, and maintenance of the engine auxiliary systems are discussed in the following pages. Applicable drawings are:

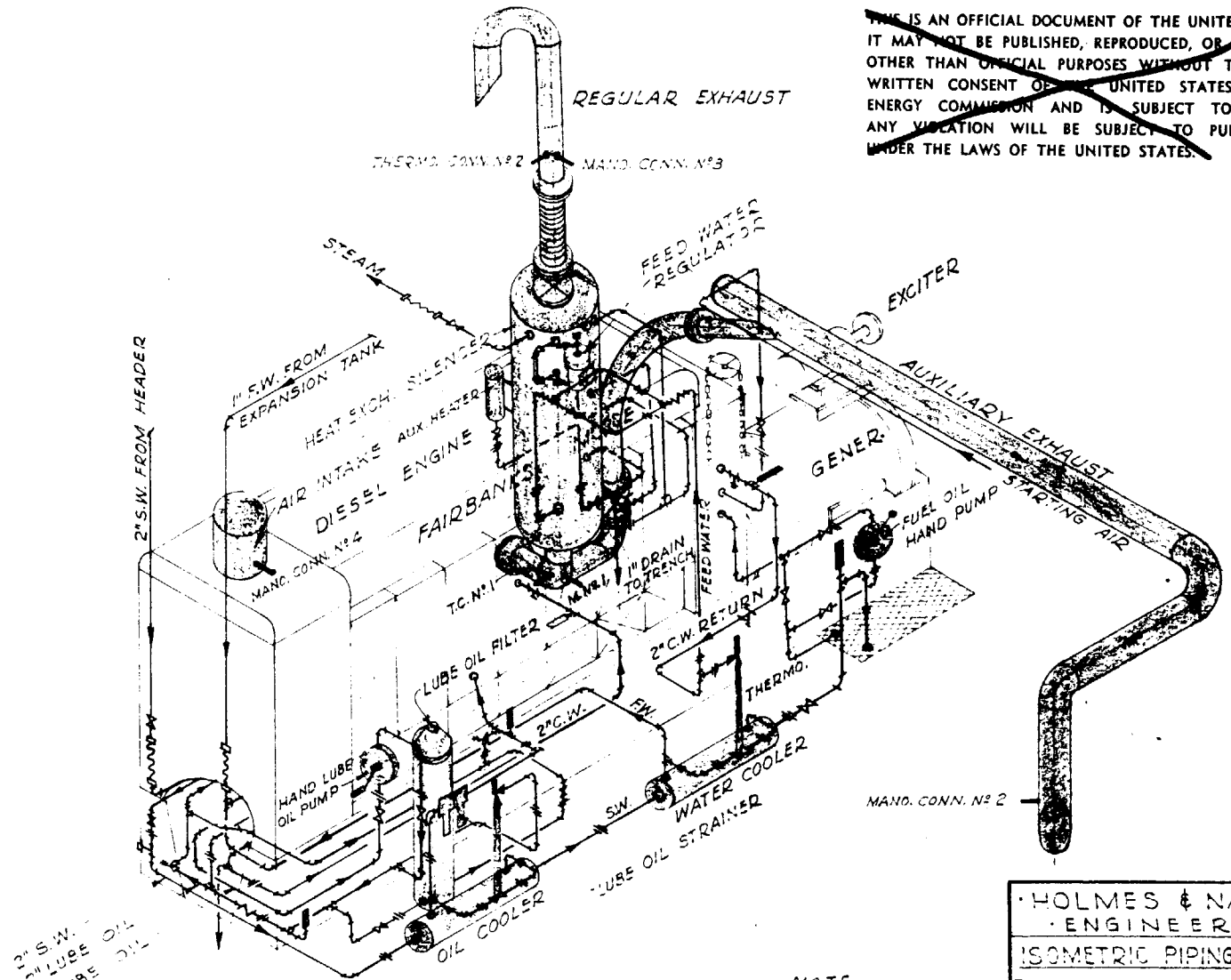
Drawing No.	Description
423	Isometric piping layout, typical Diesel Generator unit
430	Diesel fuel oil and lube oil systems
435	Diesel engine jacket water cooling system
459	Exhaust system
451-1	Diesel engine auxiliary piping
466	Starting air system
475	Typical maintenance schedule

~~OFFICIAL USE ONLY~~

TYPICAL INSPECTION AND MAINTENANCE SCHEDULE

FAIRBANKS-MORSE DIESEL ENGINE MODEL 31A6¼

PARTS	ROUTINE OPERATIONS	QUARTERLY OR EVERY 2000 HRS.	SEMI-ANNUALLY OR EVERY 4000 HRS.	ANNUALLY OR EVERY 8000 HRS.
SCAVENGING BLOWER	Check air pressure daily. Inspect blower monthly	Clean the air blower valves and valve guides	Remove and clean the crank case breather element.	Check blower bearings, grease rack outboard bearing. Check the blower vane and valves.
CAMSHAFT AND DRIVE			Check and adjust camshaft drive chain.	Inspect camshaft, check timing chain and idler.
SILENCER	Check exhaust silencer Feedwater system, daily.	Inspect silencer, hold down bolts and tighten, check for soot and scale	Inspect and clean exchanger silencer, more often if required.	Check and Overhaul, feedwater system valves, regulators, and guages. Clean scale and soot from silencer and outlet stack.
INJECTION SYSTEM	Check spray valve tightness each time engine shuts down. Indicate engine weekly.	Inspect and clean nozzles (oftener if required)	Clean and test nozzles. Clean and grind fuel pump valves, inspect plungers.	Clean & test nozzles. Check all moving parts for wear & adjustment. Check and recondition all pump and check valves.
STARTING SYSTEM	Check air start check valves, blow air tanks, check safety valves daily.	Drain air lines to remove trapped moisture	Clean & grind air valves, check press. gauges. Inspect piping for leaks.	Dismantle & recondition air valves. Overhaul air compresson. Check piping. Inspect & clean air tanks. Check pressure gauges
LUBRICATION SYSTEM	Check mechanical lubrication oil all hand lube parts hourly, clean strainers daily check Filters	Examine piping for loose joints and leaks.	Examine piping, clean heat exchangers, oil tanks. Flush crankcase, inspect Lube oil pumps.	Flush crankcase, recondition lube oil pumps renew packing, clean & repair relief or by-pass valves, clean oil piping & tanks.
PISTONS	Check condition of the piston rings thru exhaust port's monthly.		Pull pistons and clean. Inspect piston and rings.	Pull pistons, remove rings, renew, clean and inspect piston, oil cooling pipe. Check end and side clearance.
CYLINDERS & HEADS	Blow out indicator connections daily.		Examine and clean heads. Inspect and wash jackets.	Inspect and clean heads and jackets, Measure liner diameter, check gasket annealing.
WRISTPIN & CRANKPIN BEARINGS	Open handhales, look and smell for hot bearings, listen for knocks.		Check and adjust.	Remove & inspect piston pins, check piston & pin alignment. check boltelongation, inspect bolts & bearings. Replace & adjust bearings
MAIN BEARING CRANKSHAFT		Check main bearings and connecting rod bearings to be sure of no gap between shells	Check main-bearing alignment, and end bearing clearance	Remove caps, inspect lining & journals, remove and inspect lower shells, clean oil passages examine shaft for cracks, check journal level
GOVERNOR ALARMS & INSTRUMENTS	Check operation of alarms daily, check pres. ga. lines and clean temp. ind. elements monthly.		Calibrate instruments, check pressure gauges with dead-weight tester.	Calibrate instruments, check pressure gauges, overhaul governor, check all moving parts for wear and adjustment.
EXHAUST		Clean exhaust equipment and lines monthly or as required.		Inspect and clean carbon from exhaust ports, piping and mufflers.
COOLING SYSTEM	Check water level in surge tank, inspect cooling system & heat exchangers, daily.	Inspect piping and valves. Check water pump packing for leakage. Tighten all bolts.		Inspect and clean entire system, remove scale, overhaul valves and pumps
FUEL-OIL SYSTEM	Clean strainers daily. Check filters weekly.		Drain water and sediment.	Inspect and clean oil piping, tanks, etc. overhaul pumps, filters & strainers, check meters and gauging devices.
ELECTRICAL EQUIPMENT	Clean all brushes each port clean [illegible]	Clean, adjust and calibrate [illegible]	Clean & calibrate indicating instruments & relays. Inspect circuit breakers and clean.	Clean, adjust & calibrate all meters & relays and overhaul all rotating machinery and switchgear.



NOTE

FOR LUBE OIL & FUEL OIL SYSTEMS SEE E.S. Nº 430
FOR JACKET WATER COOLING SYSTEM SEE E.S. Nº 435

HOLMES & NARVER ENGINEERS
ISOMETRIC PIPING LAYOUT
TYPICAL DIESEL GENERATOR UNIT AT LOCATIONS C-D & E.
DRAWN BY: C.W.E. / APPR. BY: BLL
DATE / SHEET NO.

DIESEL LUBE OIL COOLING AND PURIFICATION SYSTEM

DRAWING FS 430

DESCRIPTION

The lubricating oil piping system is shown on FS 430. The arrangement shown is typical for diesel units at all stations.

The system consists of a built-in lubricating oil pump with a capacity of 60 GPM, oil filter, oil cooler, oil strainer, auxiliary hand oil pump, piping, fittings, thermostats, thermometers, gauges and drain.

The oil filling is by hand through an oil filler nozzle located at rear of engine, top of block.

The built-in lubricating oil pump draws oil from the oil pan through a coarse intake strainer and forces it through the cooler and fine strainer into the engine. A small part of the oil from the pump is by-passed through the filter, cooler, strainers and back into the engine. The temperature of the oil is regulated by means of an automatic regulator, V-9, which by-passes more or less oil around the cooler.

After leaving the cooler, the oil flows into the engine system; the inlet is provided with a regulating relief valve V-7 set at 30 psi for by-passing excess oil.

Should the built-in lubricating oil pump fail, a hand operated auxiliary lubricating pump is available by opening valves V-3 and V-8. Thus the pump may also be used as a pre-lubrication pump and can be operated for a short time after the engine stops for after-cooling purposes.

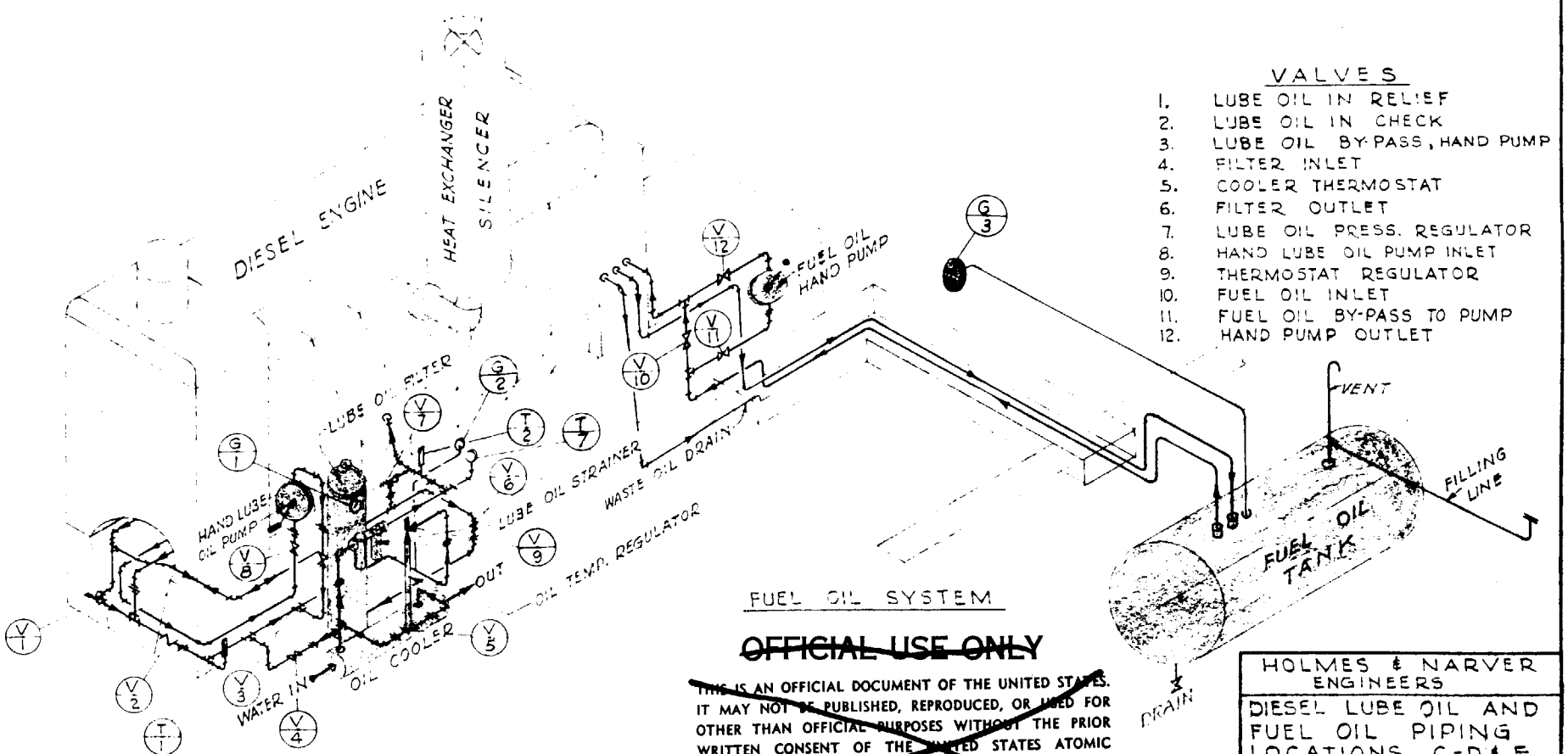
~~OFFICIAL USE ONLY~~

GAUGES
1. OIL FILTER
2. OIL OUTLET
3 FUEL OIL

LEGEND
(T) THERMOMETERS
(V) VALVES
(G) GAUGES

THERMOMETERS
1. LUBE OIL IN
2. LUBE OIL OUT

VALVES
1. LUBE OIL IN RELIEF
2. LUBE OIL IN CHECK
3. LUBE OIL BY-PASS, HAND PUMP
4. FILTER INLET
5. COOLER THERMOSTAT
6. FILTER OUTLET
7. LUBE OIL PRESS. REGULATOR
8. HAND LUBE OIL PUMP INLET
9. THERMOSTAT REGULATOR
10. FUEL OIL INLET
11. FUEL OIL BY-PASS TO PUMP
12. HAND PUMP OUTLET



LUBE OIL SYSTEM

FUEL OIL SYSTEM

~~OFFICIAL USE ONLY~~

HOLMES & NARVER ENGINEERS

DIESEL LUBE OIL AND FUEL OIL PIPING LOCATIONS C-D & E.

DRAWN BY: C.W.E	APP:
DATE	SHEET NO.

DIESEL LUBE OIL COOLING AND PURIFICATION SYSTEM

DRAWING FS 430

The normal operating pressure on the lubricating system is 20-30 psi as read on G-1 or G-2, and the normal operating temperature should be 190°F as read on T-1.

The strainer is normally cleaned by turning the handles located on the top side of the strainer. These handles should be turned three or four times a day; check the lubricating oil at the filter gauge. When the oil pressure reaches 30 or 40 pounds or when the oil flow is insufficient to keep the oil in desired condition, the filter cartridges should be replaced. However, once a week the strainer cartridge should be removed and cleaned. Remove drain plugs and allow lube oil remaining in strainer case to drain in bucket. Clean strainer, cartridge and case. Replace drain plugs and cartridge.

An oil level gauge dip stick is provided at the control side of the engine for measuring the oil level.

The lubricating oil in the system should be completely drained and renewed at regular intervals; the time period between oil changes depends upon engine operating conditions and the type of lubricating oil used.

For additional care and cleaning of lube oil system refer to Manufacturer's Instructions.

DIESEL FUEL OIL SYSTEM

DRAWING FS 430

DESCRIPTION

The fuel oil system consists of the supply, injection, and drain systems; the supply system includes the tank, built-in supply pump on the engine, built-in filter, hand fuel oil pump, and the necessary piping, fittings, thermometers and gauges as shown on FS 430. The fuel supply pump is driven from the governor drive.

The service supply system consists of one 3500 gallon horizontal storage tank equipped with inspection manhole, gauge hole and gauge stick, fuel gauge mounted in plant, filling line, vent line, and supply and overflow line back to tank from each diesel engine.

The fuel oil storage tank is located outside the power plant.

The filtered fuel oil is supplied to the diesels by a positive displacement engine-mounted fuel pump.

Leakage from injectors and pumps is drained to pipe trench drain.

PRELIMINARY OPERATION

Fuel oil service tank is filled from tank truck; prior to filling, check vent valve for proper operation and connections for tightness.

In the event the fuel pump on engines ceases to function properly, the engine may be run on the hand-operated fuel pump by closing valve V-10 and opening valves V-11 and V-12.

JACKET WATER COOLING SYSTEM

DRAWING FS 435

DESCRIPTION

The jacket water cooling system is of the Closed Circuit Type employing soft water circulated at a high rate through the engine block, then through tubular type heat exchangers, where it is cooled and then returned to the engine.

1. The jacket water cooling system consists of built-in soft and raw water pumps, surge tank, heat exchangers, regulators, thermometers, gauges, valves and piping.

   Having performed its engine cooling functions, the soft water leaves the engine and is circulated through the cooling water heat exchanger where its heat is absorbed by the cool raw water. A bypass with an automatic temperature regulator (V-16) is provided with the heat exchanger, so that the temperature of the soft water may be regulated.

   The raw water pump draws water from the salt water system and discharges it through the lubricating oil cooler and the soft water heat exchanger and discharges to the drain trench.

2. The cooling water return from the engine to cooler goes through a thermostatic regulator valve V-16 and part is diverted as feed water to the heat exchanger silencer system which consists of a Maxim silencer heat exchanger, feed water regulator, gauges, auxiliary electric heater,

log. After the engine has been shut down, continued operating the circulating pump to remove heat in the engine mass. Continue operating circulating pump until temperature drops to 100°F.

7. The following list of degreasing and cleaning solutions are suggested for cleaning the jacket water cooling system. This operation should be done on an annual basis or more often, depending on the care taken in supplying the cooling system with soft water.

Two types of cleaners are suggested to flush the cooling system. The "A" cleaners are for removing scale. The "B" cleaners are for removing oils and greases and to neutralize acidity after using the "A" cleaners.

"A" cleaners	Mixing ratios
Okite #32	1 part to 10 parts water
Turco Descaler	1 " " " " "
Magnus D-Rust-R	1 " " " " "
Kelite E-15	1 " " " " "

"B" cleaners	Mixing ratios
Okite penetrant	3 oz. per gallon water
Turco prosolv	2 oz. " " "
Magnus #240X	3 oz. " " "
Kelite E-10	5 oz. " " "

JACKET WATER COOLING SYSTEM

DRAWING FS 435

To clean jacket water cooling system of oil, follow steps (a) and (b). For removal of scale, follow steps (a) to (f), inclusive.

(a) Run engine at reduced speed with water temperature between 140°F - 160°F. Circulate "B" cleaner through system for at least 30 minutes.

(b) Drain and flush with clean water.

(c) Run engine at reduced speed with water temperature approximately 140°F. Circulate "A" cleaner solution through engine for not more than 30 minutes.

(d) Drain and flush with clean water.

(e) Circulate a "B" cleaner solution to neutralize acidity.

(f) Drain and fill system with soft water and test for acidity.

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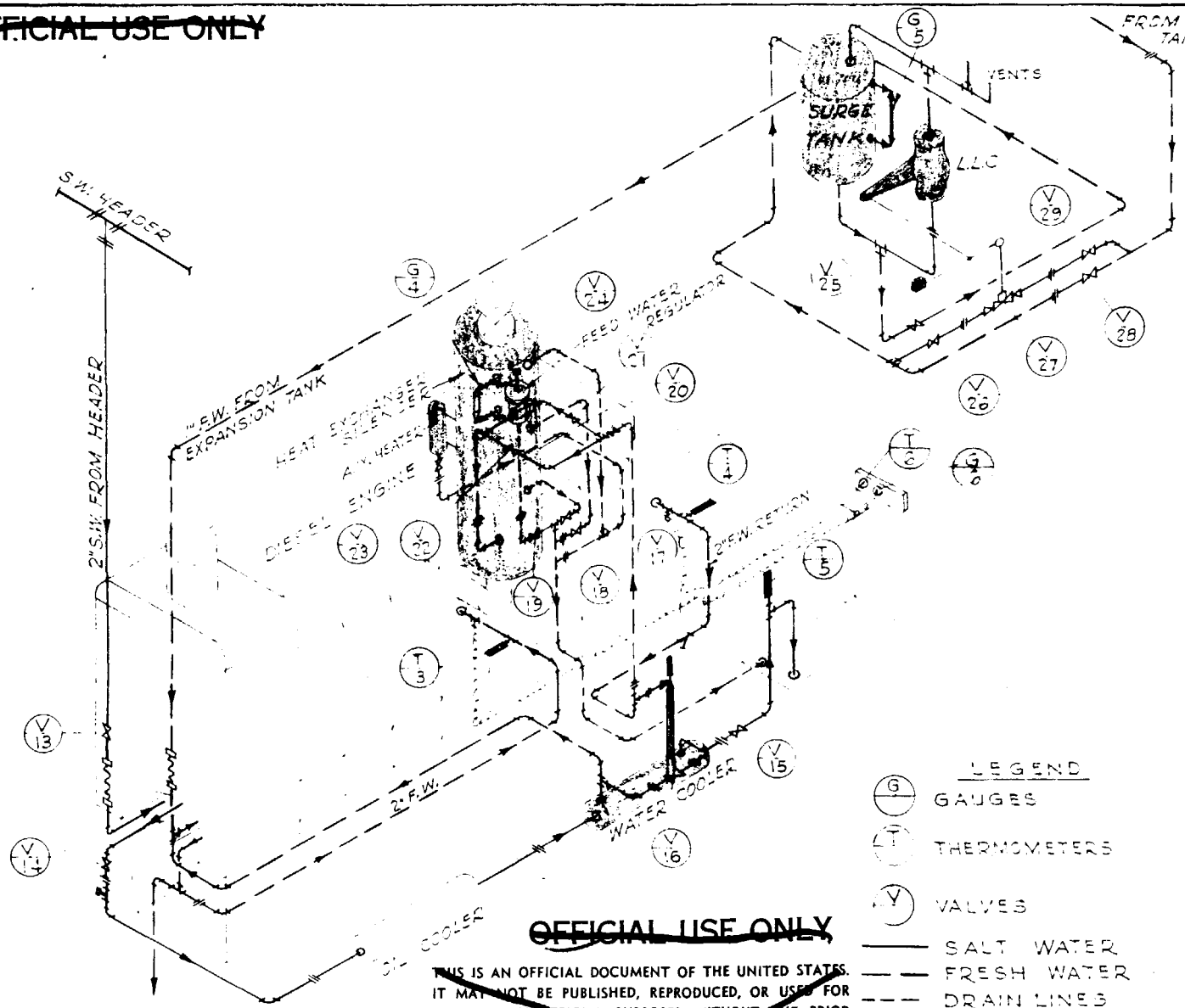

GAUGES
4. FEED WATER REG.
5. SURGE TANK
6. F.W. RETURN

VALVES
13. SALT WATER INLET
14. SALT WATER OUT
15. SALT WATER TO DRAIN
16. F.W. THERMO. REGULATOR
17. SILENCER DRAIN
18. SILENCER DRAIN
19. REGULATOR DRAIN
20. FEED WATER
21. F.W. IN TO REG.
22. REG. BY-PASS
23. AUX. HEATER OUT
24. SILENCER SAFETY
25. F.W. OUT
26. REG. BLOCK
27. L.L.C. REG. F.W. IN
28. F.W. BY-PASS
29. REG. BLOCK

THERMOMETERS
3. FRESH WATER IN
4. FRESH WATER RETURN
5. SALT WATER OUT
6. COOLING WATER INLET

LEGEND
G — GAUGES
T — THERMOMETERS
V — VALVES
——— SALT WATER
— — — FRESH WATER
– – – DRAIN LINES

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HOLMES & NARVER ENGINEERS	
DIESEL ENGINE JACKET WATER COOLING SYSTEM LOCATIONS C-D & E	
DRAWN BY: C.W.E	APP:
DATE	SHEET NO.

DIESEL ENGINE EXHAUST SYSTEM

DRAWING FS 459

The exhaust systems for the diesel engines consist of vertically mounted spark-proof heat exchanger silencers to reduce objectionable noises and to act as a steam supply to the distillation units, equipped with gauges, feed water regulator, auxiliary electric heater, necessary valves, fittings and pipe. The gases are exhausted out of silencer through a butterfly valve V-31, and flexible pipe through the roof, to isolate the system from engine vibration and eliminate any stresses caused by thermic expansion and differential settlement.

The exhaust system will require periodic (once a month) inspection and removal of carbon accumulations. In some instances it may be necessary to clean the system oftener than once a month, should the exhaust temperatures exceed 550°F. Observe the exhaust; smoky exhaust indicates poor operation and incorrect adjustments. The importance of keeping the carbon formations to a minimum cannot be over-emphasized.

A periodic check should be made of all silencer piping support nuts. Make sure these nuts are drawn up tight.

AUXILIARY EXHAUST SYSTEM

In addition to the regular exhaust system there is at Runit, the Aomon Group, and Engebi, an exhaust system consisting of an outlet on the main exhaust tee below the silencer, through a butterfly valve V-30 and flexible pipe to a 12 inch header inside of the plant that exhausts from a 24 inch electrically operated valve V-32 through the wall located just above floor and to right of plant entrance.

DIESEL ENGINE EXHAUST SYSTEM

DRAWING FS 459

The exhaust temperatures will vary from engine to engine depending on installation and climatic conditions. More important than actual temperature is the change in temperature which may be observed from that obtained from the engine in good operating condition.

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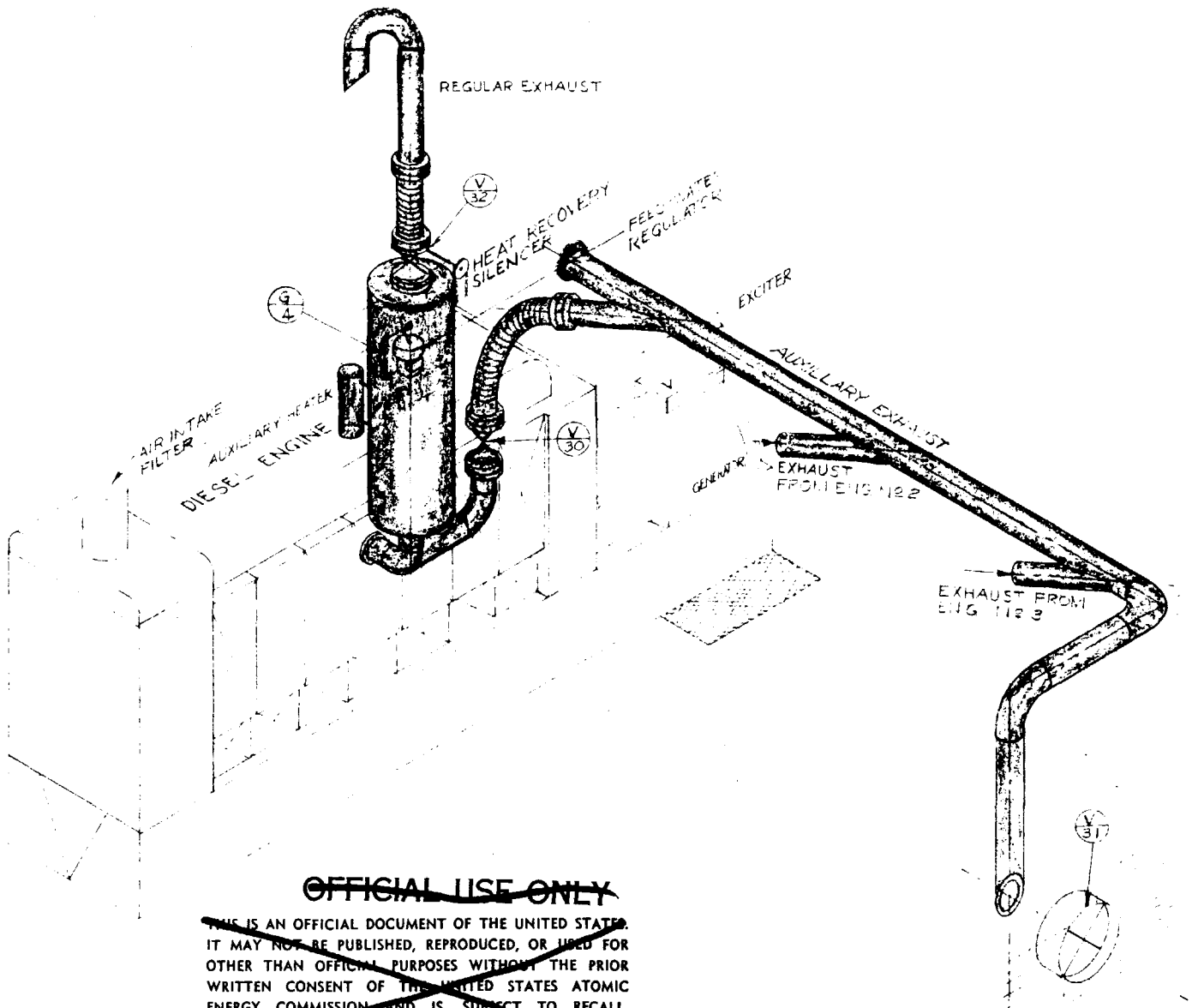

LEGEND

V 4 Valves

G Gauges

VALVES

30 - Auxiliary Exhaust

31 - Auxiliary Exhaust to Atmosphere

32 - Engines 1&2 Exhaust

GAUGES

4. Feed Water Reg.

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HOLMES & NARVER ENGINEERS	
DIESEL ENGINE EXHAUST SYSTEM LOCATIONS C-D & E	
DRAWN BY: B.G.R.	APP: B.L.
DATE 2-8-51	SHEET NO. FS 459

STARTING AIR SYSTEM

DRAWING FS 466

DESCRIPTION

A complete 250 psi compressed air system has been provided to supply the diesel engines and their turning jacks with starting and operating air.

The system consists of one motor driven and one gas engine driven air compressor, two air receivers, and the necessary safety valves, pressure gauges, controls, valves, fittings and piping.

All compressors are Fairbanks-Morse Type "E" with water cooled cylinders, cooling water being supplied from a hopper.

The motor driven compressor is provided with start, stop, and unloading controls; the engine driven compressor is provided with a stop and unloader only; starting is by means of a hand crank. The motor driven unit normally supplies the required air for plant operation; the engine driven unit is provided for emergency or standby use.

The two starting air receivers are equipped with safety valves, pressure gauges and drain valves, the air supply header is equipped with a by-pass and pressure reducing valve, V-46, to reduce air pressure to 20 lbs. to supply instrument air.

Blow down all compressed air receivers and piping once a week, open each of the receiver drain valves V-43 and V-44 for not more than 30 seconds or until sound of escaping air becomes uniform, indicating no slugs of condensate are passing through pipe. Also open high and low pressure blow down valves V-45 and V-50 to clean condensate out of lines.

STARTING AIR SYSTEM

DRAWING FS 466

PRELIMINARY OPERATIONS

Close air receiver drain valves V-43, V-44, blow down high pressure line valve V-45, by-pass valve V-36 and blow down low pressure valve V-50. Close equipment stop valve V-34.

Open header valves V-38, V-40 and air receiver stop valves V-41 and V-42, open pressure regular (V-46) block valves V-35 and 49.

Fill compressors and engine with proper amount and grade of lubricating oil, check V-belt drives for proper tension, start engine driven compressor by hand crank after tank has been filled with gasoline. Start motor driven compressor by turning switch located in electrical panel.

Adjust controls on motor driven compressor to stop when pressure reaches 250 psi and start when pressure drops to 245 psi as indicated by G-8 and G-9.

TO START DIESEL ENGINE

Engine starting is accomplished by the action of compressed air; open valve V-34 and admit air to the pistons in their proper firing order.

Instant turnover is assured with the elimination of dead centers by admitting air to the cylinders until the engine begins to fire.

Check starting air pressure on engine gauge G-10. G-10 should indicate same pressure as G-8 and G-9 before engine is started. See that all other operations are complied with before and after engine is started. For instructions to start and run engine see

STARTING AIR SYSTEM

DRAWING FS 466

Fairbanks-Morse Instruction Manual No. 3100A6-1/4. After engine is running, close valve V-34.

The engine driven compressor should be run a minimum of 20 minutes each twenty-four hours.

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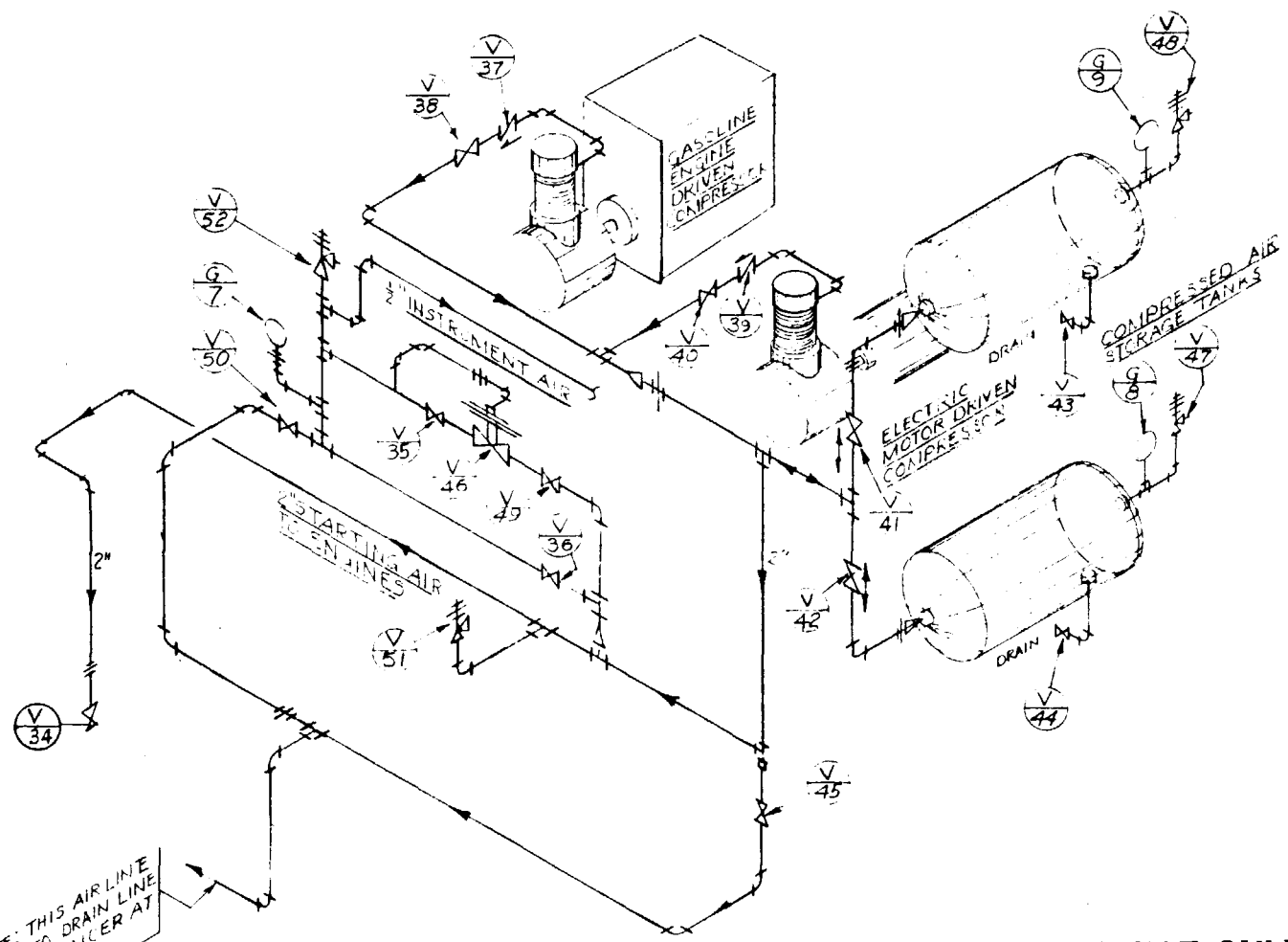


LEGEND

(V) Valve

(G) Pressure Gage

VALVES

35	Block Valve Instrument Air
36	By Pass Valve High Press Air
37	Check Valve Gas.Eng.Comp.Disch.
38	Comp Cut-Let Valve
39	Check Valve Elect Motor Comp. Disc.
40	Comp. Outlet Valve
41	Air Storage Tank Block Valve
42	Air Storage Tank Block Valve
43	Drain Valve Air Storage Tank
44	Drain Valve Air Storage Tank
45	Blow-Down High Press. System
46	Pressure Reducing Valve
47	Relief Valve, Storage Tank
48	Relief Valve, Storage Tank
49	Block Valve High Press. System
50	Blow-Down Low Press. System
51	Relief Valve-Starting Air.
52	Relief Valve-Instrument Air

GAGES

7	Instrument Air Gage
8	Storage Tank Air Gage
9	Storage Tank Air Gage

HOLMES & NARVER
ENGINEERS

DIESEL ENGINE STARTING AIR SYSTEM
TYPICAL FOR SITES C-D&E

DRAWN BY	APP.
DATE 2-12-51	SHEET NO. FS 466

HYDRAULIC GOVERNORS

The governors are remote controlled by slow-speed motors mounted on the governor and with the control switch in a remote location. The following instructions apply specifically to Woodward's UG-8 dial-control governor:

The UG-8 dial type governor is of the hydraulic type and is normally isochronous (will maintain same engine speed regardless of engine load). Speed adjustment (synchronizer), speed droop and load limit controls are standard features.

THE SYNCHRONIZER

The synchronizer, or speed adjusting control, is used to change the engine speed when running alone or to change the engine load when the engine has been paralleled with other units. The synchronizer indicator located directly below the synchronizer merely indicates the number of revolutions of the synchronizer knob.

THE SPEED DROOP

The speed droop control can be set to automatically divide and balance load between engines driving the same shaft, or paralleled in an electrical system.

Droop is incorporated in the governor through a linkage which varies the compression of the speeder (speed adjusting) spring as the terminal shaft rotates. Increased fuel reduces spring compression, reduces the governor speed setting accordingly, and the unit will gradually reduce its speed as load is applied. This relationship between load and speed acts as resistance to load changes when the unit is interconnected with other units either mechanically or electrically.

As droop is reduced toward zero the unit becomes able to change load without changing speed. As a general rule, units running alone should be set on zero droop, interconnected units should be run at the lowest droop setting that will give satisfactory load division.

A.C. generating units tied in with other units should have droop set sufficiently high (30 to 50 on the dial) to prevent interchange of load between units. If one unit in the plant, or system, has enough capacity, its governor may be set on zero droop and it will regulate the frequency of the entire system. This unit will take all the load changes within the limits of its capacity and will control frequency if its capacity is not exceeded.

The system frequency is adjusted by operating the synchronizer of the governor having zero droop. The distribution of load between units is accomplished by operating the synchronizers of the governors having speed droop. THE LOAD LIMIT control hydraulically limits the load that can be put on the engine by restricting the angular terminal shaft rotation of the governor, and consequently, the quantity of fuel supplied to the engine. The control may also be used for shutting down the engine by turning it to zero.

CAUTION: DO NOT MANUALLY FORCE ENGINE LINKAGE TO INCREASE FUEL WITHOUT FIRST TURNING LOAD LIMIT KNOB TO 10.

INSTALLATION

When the governor is installed on the engine, particular care should be exercised to see that it is mounted squarely and that the drive connection to the engine is aligned properly. A gasket should

be placed between the base of the governor and the mounting pad on the engine. If the governor is equipped with a serrated drive shaft, it should slip into the internal serrations of the drive freely enough to drop into place of its own weight.

CAUTION: DO NOT DROP OR REST THE GOVERNOR ON ITS DRIVE SHAFT.

If a keyed type governor drive shaft is used, the gear placed on this shaft should be checked to insure that it is meshing properly. There should be neither excessive backlash nor binding. Irregularities caused by uneven gear teeth, shaft runout, etc., will be picked up by the governor, transmitted to the fuel control system, and will result in erratic governing.

Since the load limit device operates hydraulically rather than mechanically the load indicating pointer position cannot be changed by turning the load limit control unless the governor is running (or has oil pressure in its accumulators). When installing governor the terminal shaft must be rotated by a lever in order to obtain no fuel (zero load) position.

CAUTION: DO NOT MANUALLY FORCE ENGINE LINKAGE TO INCREASE FUEL WITHOUT FIRST TURNING LOAD LIMIT KNOB TO 10.

The linkage from the governor terminal shaft to the fuel control system should be free from lost motion or excessive friction. It is often desirable to install a light spring acting to decrease fuel for the purpose of taking up lost motion due to wear. Avoid exceeding the working capacity of the governor by using too strong a spring.

OIL SPECIFICATIONS

Use SAE 20 or SAE 30 oil for ordinary temperature conditions. If governor operating conditions are extremely hot, use SAE 40 or SAE 50; if extremely cold, use SAE 10. The oil must not contain additives which are used to free up rings, remove carbon, etc., unless a non-foaming additive is also present. The oil should not foam or sludge excessively when agitated, or form gummy deposits when heated.

DIRTY OIL CAUSES MOST GOVERNOR TROUBLES. Use clean, new oil or filtered oil. All containers must be clean and should be rinsed with light grade fuel oil before using.

Keep governor oil at correct level in oil gauge.

STARTING ENGINE

When starting the engine, set the load limit (fuel limit) at 5 on the dial. This prevents the engine from getting excessive fuel and accelerating too rapidly. After the engine has warmed up, turn the load limit to 10. By means of the synchronizer adjust engine to its normal speed. Experience will determine if it is necessary to further limit the fuel on future starts.

COMPENSATING ADJUSTMENTS

Although the governor may appear to be operating satisfactorily because the engine runs at constant speed (without load) the governor still may not be adjusted correctly. High overspeeds and underspeeds after load changes and slow return to normal speed are results of incorrect compensation adjustments.

Make the following adjustments to be certain that the governor will give optimum control.

After the temperature of the engine and the oil in the governor have reached their normal operating values, the compensation should be adjusted without load on the engine as follows:

1. Loosen the nut holding the compensation adjusting pointer and set the pointer at its extreme downward position.
2. Remove the plug, open compensating needle valve two or three turns with a screwdriver, and allow the engine to hunt or surge for about one half minute to bleed trapped air from governor oil passages.
3. Gradually close needle valve until hunting just stops. Do. not go beyond this position. Check the amount of needle valve opening by closing the valve completely, noting the amount of a full turn required to close. Open the valve to the previously determined opening at which hunting stopped. Test action by manually disturbing engine speed. If the needle valve is now less than 1/2 turn open and more than 1/8 turn open, the adjustment is satisfactory and (4), (5), (6), and (7) instructions should be ignored.
4. If hunting did not stop with the needle valve at least 1/8 turn open, raise the compensation pointer two divisions of the scale and continue with the following instructions.
5. Open needle valve approximately one turn to allow engine to hunt.

6. Proceed with instruction (3).
7. If necessary repeat (4), (5), and (3) until adjustment is satisfactory. Desirable needle valve opening is from 1/8 to 1/4 turn open.
8. It is desirable to have as little compensation as possible. Closing the needle valve farther than necessary will make the governor slow to return to normal speed after a load change. Excessive dashpot plunger travel caused by adjustment of the compensation adjusting pointer too far toward maximum position will cause excessive speed change upon load change.

HYDRAULIC CONTROL LINK ASSEMBLY

UG 8 GOVERNORS

1. Assemble the bracket control lever, with the lever arms down, to the bracket with the pin and secure with a castellated nut and cotter pin. Check to see that the lever turns freely on the pin.
2. Secure the bracket to the engine block with three cap screws and lock washers.
3. Assemble the control rod link between the bracket control lever and the fuel pump control rod ball pin. Clamp the fuel pump control rod end of the link, with the cap screw and lock washer flush with the top end of the control rod ball pin.
4. Secure the opposite end of the link to the bracket control lever with the link pin and cotter pin.

5. Assemble one end of the adjustable control link to the bracket control lever.
6. Assemble the opposite end of the adjustable control link to the governor lever in the third tapped hole from the serrated end. (Do not assemble the governor lever to the serrated shaft at this time.)
7. Set the adjustable control link to 4¼" between the lock nuts by turning the link rod. The link has right and left hand threads.
8. Set the hand control at full throttle or against the adjusting screw stop. Set the throttle arm so the rod measures 6¼" to 6-3/8" from the distributor disc cover on top of the fuel pump to the bottom of the screw head which secures the rod to the arm and lock in place. NOTE: This is a preliminary setting that may have to be altered slightly after the following adjustments are completed and the engine started. Any change in adjustment made here must have a corresponding adjustment made on the adjustable control link.
9. Set the throttle lever in "OFF" position.
10. Turn the "load limit" knob to 10. Turn the governor control shaft until the arrow of the knob on the dial marked "load limit" is at 10.
11. Pull the governor control shaft from the housing until the sharp edge of the small notch on the shaft is even with the boss on the fuel pump housing.

12. While holding the governor control shaft in this position, assemble the serrated governor lever to the serrated shaft of the governor and secure in place with the clamp screw.
13. Check to see that the governor oil sump is filled to the full mark with lubricating oil of the same grade as used in the engine.
14. Start the engine as instructed.
15. While the engine is running at maximum speed, with no load, the moving arrow on the "load limit" dial should stand at "1." If the arrow does not point to "1," set the adjustable control link until it does.

CAUTION: DO NOT USE THE LOAD LIMIT DIAL TO SHUT DOWN THE ENGINE.

16. With the throttle at full speed position, throw full load on the engine. The moving arrow on the "load limit" dial should advance to "9." NOTE: The position of the governor lever on the serrated shaft will determine the center of travel. The range from idling to full speed, as shown on the dial, is determined by the threaded hole used in the governor lever. About 10% below and at least 10% above the normal range of the governor is desirable for over-travel.

ELECTRICAL EQUIPMENT

GENERATORS, EXCITERS, AND SWITCHBOARDS

OPERATING INSTRUCTIONS - ELECTRICAL

GENERATORS AND EXCITERS

Each plant is equipped with 3 Fairbanks-Morse generators. The generators at Runit are all type TGZJM and the generators at the Aomon group and Engebi consist of 2 type TGZJM and 1 type PGZJ. These generators are rated as follows:

TYPE TGZJM		TYPE PGZJ
111	FRAME	111
147	KVA	244
118	KW AT 0 ELEV.	193
15.4	FIELD AMPS AT -80% P.F.	20.2
97	FIELD VOLTS	103
35.4	AMPS/TERM.	58.7
720	RPM	720
2400	VOLT	2400
3	PHASE	3
60	CYCLE	60

The exciters are all Fairbanks-Morse type DGZD, Frame RX 254, 3 KW, 24 amp 1750 RPM with Vee belt drive.

The generator and exciter electrical connections are shown on Drawing FS-625. Instructions for the operation and maintenance of the generating equipment are covered in the enclosed Fairbanks-Morse instruction books numbers 1800B and 2862.

ELECTRICAL EQUIPMENT

GENERATORS, EXCITERS, AND SWITCHBOARDS

OPERATING INSTRUCTIONS - ELECTRICAL

SWITCHBOARD

The switchboard is made up of 3 single panel Benjamin 2.4 KV metal clad cubicles. Information concerning these panels can be found on the following drawings:

AC Generator Panel - Benjamin Drawing No. 111-A-49

Wiring Diagram - AC Generator Panel - Benjamin Drawing 112-49

Power & Water Distillation Plant - Holmes & Narver Drawing FS-490

Diesel Engine Electrical Power System " " " " FS-625

The components on the panels are General Electric and information concerning them can be found in the following publications:

Power-Factor Meters - GEH-867E

Frequency Meters - GEH-868D

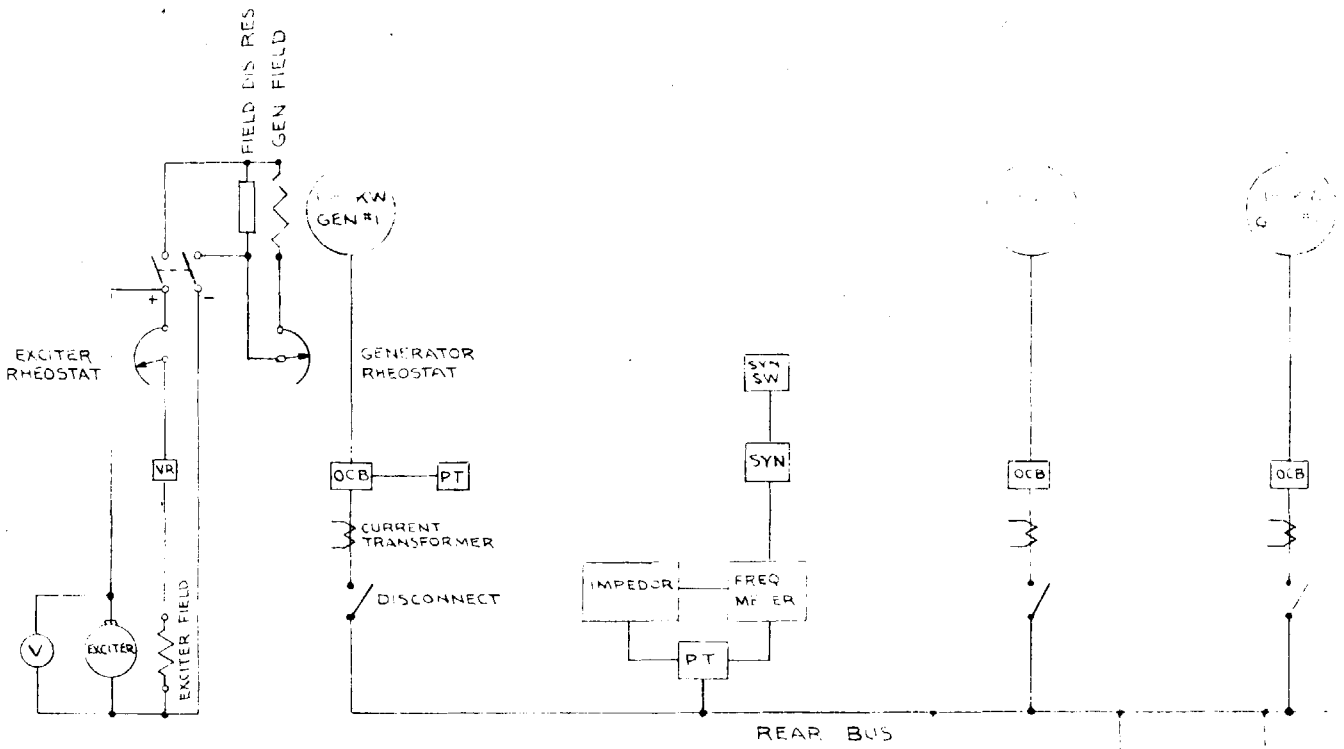
Synchroscopes - GEH-1526

Ammeters & Voltmeters GEH-1540

Watthour Meters - GEH-764Z

Voltage Regulator - GEH-1095C

~~OFFICIAL USE ONLY~~



VR VOLTAGE REGULATOR

PT POTENTIAL TRANSFORMER

OCB OIL CIRCUIT BREAKER

SYN SYNCROSCOPE

TYPICAL FOR SITE C, D, E

~~OFFICIAL USE ONLY~~

HOLMES & NARVER
ENGINEERS

DIESEL ENGINE
ELECTRICAL POWER SYSTEM
ONE LINE DIAGRAM.

DRAWN BY JLM	APP
DATE 21 APRIL 1951	SHEET NO FS 625

DRAWINGS AND PUBLICATIONS ON ELECTRICAL SYSTEM OF

POWER PLANTS AT RUNIT, THE AOMON GROUP, AND ENGEBI

FAIRBANKS-MORSE MOTORS AND GENERATORS INSTRUCTION BOOK NO. 1800B

FAIRBANKS-MORSE ALTERNATORS & SYNCHRONOUS MOTORS, INSTRUCTION BOOK NO. 2862

AC GENERATOR PANEL 118 & 147 KVA, 2400 VOLT, 60 CYCLE, W. A. BENJAMIN CO. DWG. 111-A-49

WIRING DIAGRAM, AC GENERATOR PANEL, 118 & 142 KW, 2400 VOLT 60 CYCLE, BENJAMIN DWG. 112-49

THE FOLLOWING GENERAL ELECTRIC PUBLICATIONS:

GEH-867E - Power Factor Meters

GEH-868D - Frequency Meters

GEH-1526 - Synchroscopes

GEH-1540 - Ammeters & Voltmeters

GEH-764Z - Polyphase Switchboard Watthour Meters

GEH-1095C - Wattmeters

INSTRUCTIONS
FOR THE
INSTALLATION, OPERATION, AND MAINTENANCE
OF
ALTERNATING-CURRENT MACHINERY

These instructions are intended to cover the major points in the installation, operation, and maintenance of alternating-current machinery. Wherever there are special conditions or variations in equipment, additional information or assistance may be secured upon request from the Engineering Department.

1. KEEP THE MACHINE CLEAR of all rags, boxes, and accumulation that might hamper ventilation. Any rubbish spread about a machine represents a fire hazard and breeding place for rodents which are a constant menace to all electrical equipment.
2. KEEP THE MACHINE CLEAN. Successful operation of a machine depends wholly upon the maintenance and service given it. A heavy layer of dirt, sand, or any foreign material allowed to accumulate on a machine can cause excessive overheating of the windings. If the winding is not cleaned periodically, dirt and grit will become imbedded in the coils and the danger of a serious injury increases at an accelerating rate. Dirt lodged in the windings can cause short circuits and result in expensive shutdowns for costly repairs, therefore, it is easy to realize how important and necessary a thorough cleaning at regular intervals by suction or mild blowing will save much time and expense.
3. KEEP THE MACHINE SERVICED. It is best to completely disassemble and overhaul a machine once a year unless adverse conditions

warrant more frequent attention. All parts should be completely cleaned and kept covered till assembly, and worn part replaced with spares kept in stock for such emergencies. All parts should be kept clean, connections made secure, and the lubricant checked after assembly before the machine is again put in operation. If all these precautions are taken and your machine gets the attention it requires for smooth uninterrupted service, the time and effort spent will be well worth the reward in top performance.

OPERATION

BEFORE STARTING

1. Machines that have been subjected to dampness in shipment or storage should be thoroughly dried out before being placed in service. Instructions for drying out and for insulation resistance tests are given further on under "Maintenance."
2. Check the voltage stamped on the nameplate to see that it agrees with that of the power supply or supply system.
3. See that all connections to the machine and the control apparatus correspond with the wiring diagrams.
4. Make sure that the bearings are properly lubricated. Grease lubricated, ball bearing, machines are shipped with the proper amount of high grade grease in the bearings. Refer to "Maintenance" for further information on lubrication of bearings.
5. Inspect the air gap to be sure that no foreign material is present.

6. When applicable, check the brushes to make sure they ride freely in the brushholders. The brushes were correctly positioned and springs adjusted to the right pressure at the factory.

HEATING

The rated temperature rise of the machine is stamped on the nameplate. The actual operating temperature of the machine will be the temperature rise of the machine plus the temperature of the surrounding air. Standard Class A insulated machines will withstand an occasional maximum observable temperature of 90°C (194°F) for open machines and 95°C (203°F) for enclosed machines.

MAINTENANCE

GENERAL

Proper maintenance must be given careful considerations if the best performance and longest life are to be expected from the machine. The major features are those of lubrication, care of the insulation, and commutation. A regular inspection schedule will practically assure continuous operation. Preventive maintenance will avoid costly repairs. How often various inspections should be made will depend a great deal upon the type of machine and the conditions under which it is installed and operated.

Keep the machine clean. Do not permit rubbish to accumulate about the machine. It may seriously restrict the ventilation of the machine or get into moving parts, and cause a breakdown. With the machine at rest and disconnected from the line, wipe off any accumulation of dust with a dry cloth. The inside of the machine may be cleaned by suction or mild blowing, if necessary. Remove any accumulations of oil or

grease with carbon tetrachloride in a well-ventilated room. Make sure there are no foreign materials in the air gap or other air passageways. If the machine is installed in a dirty place, it should be disassembled and thoroughly cleaned as frequently as the conditions warrant.

Listen for any mechanical noises which indicate metal-to-metal contact. If present, shut down the machine as soon as possible and check for misalignment or bearing failure.

Overheating, scorching odors and smoke are signs of shorts or serious overload. Stop machine and check load conditions against the rating. Check the drive and driven machine to see that they do not impose an excessive friction load on the machine. Test for short in field coils, and see that brushes and brush spring pressure are properly adjusted. See that there is a free circulation of air around the machine so that ventilation is not restricted. Check control for proper operation of overload protection devices.

Make a periodic examination of all field windings, and all cable connections for tightness. Where applicable, tighten all brush studs that may have developed slack due to drying out of washers, and make certain the studs are not displaced.

Inspect the mechanical drive to see that it is properly adjusted and in alignment.

LUBRICATION OF BALL BEARINGS

When the machine is shipped, the bearings are packed with the proper amount of high grade grease.

Double sealed, prelubricated bearings are packed with a special grease by the bearing manufacturer. Machines with such bearings can be

identified by the absence of grease fittings. The grease used will ordinarily maintain its lubricating qualities for the life of the bearing under normal operating conditions. Where high operating temperatures are encountered, the life of the bearing may be limited to the time the lubricant will last.

Ball bearings consume only a very small amount of lubricant, but enough must be present at all times to avoid injuries. The length of time a bearing can run without having grease added or replaced will depend upon the operating conditions.

Use a high grade neutral mineral grease composed of a soda soap base and a clean refined mineral oil. Do not mix greases of different types or specifications. A satisfactory grease should have the following qualities:

1. Freedom from abrasive matter such as grit, talc, mica, clay or fillers of any kind.
2. Freedom from corrosive substances such as free lime, iron oxide, etc.
3. Freedom from acid, alkali, and moisture.
4. At operating temperature, a consistency low enough to prevent excessive channeling yet high enough to avoid fluidity which would create churning or leakage.
5. The least possible tendency to change consistency such as hardening, thickening, or separation into oil and soapy matter.
6. A melting point considerably higher than the operating temperature.

Use only clean lubricant from clean, closed containers and keep it from becoming contaminated during regreasing operations. Do not over-lubricate. The housing should be no more than about one-third full of grease. Too much grease will cause churning, resulting in grease separation, overheating, and grease leakage.

Add grease sparingly observing precautions as to over-greasing. Complete regreasing is best left until the time of overhaul.

More complete renewal of the grease can, when necessary, be accomplished by forcing out the old grease with the new. Thoroughly wipe clean those portions of the housing around the filler and drain plugs. Remove the drain plug and free the drain hole of any hardened grease which may have accumulated. With the machine running, add new grease through the filler hole until it starts to come out of the drain. Before replacing the drain plug, let the machine run for ten to twenty minutes to expel any excess grease. The filler and drain plugs should be thoroughly cleaned before they are replaced.

CLEANING BALL BEARINGS

At such times as the machine is disassembled for general overhauling, the housing may be cleaned of old oil or grease by washing with carbon tetrachloride.

Open type bearings may be cleaned by placing them in wire basket suspended in a container of clean, cold petroleum solvent, or kerosene, and permitting them to soak for several hours. In stubborn cases, agitation in a hot oil bath may prove more expedient. Use a light transformer, spindle, automotive flushing, or motor oil not heavier than SAE-10 heated to about 220°F. In very bad cases, the bearings

may be boiled in an emulsifying solution of grinding or cutting compounds diluted with water. In such cases, the bearings must be thoroughly drained and spun until all moisture has evaporated, then immediately washed in clean petroleum solvent or kerosene by revolving them slowly by hand and gradually working up to spinning speed. Care should be taken that all solid particles are removed, by a brush if necessary, before turning or spinning the bearing. After the bearings have been thoroughly cleaned, spin them in clean, new light oil until the solvent has been completely removed. Relubricate the bearings immediately after they have been cleaned and washed. If they are to be stored before remounting, coat them with clean high grade oil or petrolatum and wrap in clean, oil-proof paper.

Petroleum solvents are inflammable and must be used with caution because of the fire hazard involved. Carbon tetrachloride or similar solvents are sometimes used because they are non-inflammable, but their use is discouraged in cleaning bearings because they leave the bearing surfaces bone dry and subject to rust. Compressed air is sometimes used to blow out bearings, but it is not recommended unless the air is free from dirt and moisture. If used, the bearing must be held so as to prevent spinning which may cause scoring of the bearing surfaces by dirt.

The ball bearings of horizontal machines only may, if desired, be cleaned without disassembling the motor by the following method: Remove the filler and drain plugs and free the holes of any hardened grease. Flush a light oil heated to about 190°F through the housing while slowly rotating the shaft. Repeat until the oil comes out clean indicating that most of the old grease has been removed. In cases where the grease

has become body oxidized, a preliminary flushing with a hot aqueous emulsion may be required, followed, if necessary, by flushing with a mixture of alcohol and light mineral solvent. The final flushing should always be with hot light oil. Relubricate in accordance with the recommendation given in the instructions for lubrication of ball bearings.

BEARING WEAR

A ball bearing is subject to negligible friction wear unless the lubricant becomes contaminated with abrasive material. Thus, if properly lubricated, a ball bearing will not wear gradually, and air-gap measurements are unnecessary. If ball bearings fail, they will do so in a relatively short space of time, generally as a result of excessive abuse. A bad bearing can usually be detected by the presence of vibration and noise long before complete failure can cause damage to the machine.

REMOVAL OF BEARINGS

In removing ball bearings from the shaft, pressure should be applied against the inner race, otherwise the bearing may be seriously damaged. Bearings may be removed by pressing out the shaft in an arbor press, or by means of bearing pullers. Always press or pull straight and square to avoid scoring the shaft or damaging the bearing.

CARE OF WINDINGS

Machines and spare coils should be stored in a clean, dry place until they are installed. Heat should be supplied to prevent "sweating" due to sudden temperature changes. Machines that have been subjected to moist atmosphere in transit, have been idle for some time without heat, or have become wet by accident, should be thoroughly dried out before being placed in service. Heating may be accomplished by passing current

at low voltage through the windings, or by the use of electric heaters or steam pipes. Proper temperature can be maintained during long period of idleness by placing a small heater inside the machine and covering the machine with a tarpaulin.

DRYING OF WINDINGS

Drying out can be most effectively accomplished by passing current through the windings. The current should be a mere fraction of full-load current,and the voltage should be low enough to be safe for the winding in its moist condition. The drying out heat may also be applied externally by the use of heating units placed around or in the machine. This method is most effective under a temporary housing of sheet metal or canvas, with a vent provided in the top for the escape of the moisture-laden air. The warm air must be adequately circulated over all surfaces to be dried, and if natural draft is not sufficient to accomplish this, small fans should be used to force circulation. Small machines may be conveniently dried out by heating in an oven. Regardless of method used, the temperature should not be permitted to exceed 90°C.

The time required for thorough drying out will depend to a considerable extent on the size and voltage of the machine, and on the method of heating. Insulation resistance measurements should be taken at intervals of several hours, until the readings become fairly constant. The normal insulation resistance value as established by AIEE Standards is as follows:

$$\text{Megohms} = \frac{\text{Rated Voltage of Motor}}{\frac{\text{Rating in KVA}}{100} + 1000}$$

In event the KVA rating is not known, the HP rating may be used to arrive at a sufficiently accurate value for practical purposes. Dry machines in good condition will have an insulation resistance value considerably higher than that obtained from the formula. A megohmmeter offers the simplest method of measuring this resistance as it gives a direct reading, but the voltmeter method can be used providing a proper direct-current source is available.

DIELECTRIC TESTS

After the windings have been thoroughly dried out, and insulation resistance readings are satisfactory, a high potential test may be applied to determine the dielectric strength of the insulation. New windings should successfully withstand a high potential test of twice normal voltage plus 1000. Old windings, of course, will not stand such a test: but it may reasonably be assumed that they might withstand 1-1/2 times normal voltage for one minute. High potential tests should not be applied repeatedly, as frequent application of high potential tends to weaken the insulation. After a dielectric test, insulation resistance readings should again be taken to ascertain whether or not the insulation has been damaged by the high potential.

A periodic insulation resistance check is advisable, especially on large machinery. A record of such readings should be kept. Consistent readings will indicate continuing satisfactory condition of the insulation. Declining reading will provide advance warning of troubles which may be corrected before breakdown occurs.

PERIODIC CLEANING

If top performance is to be expected from the machine, it must be kept clean. The frequency and extent of the cleanings will, of course,

depend upon the conditions under which the machine is required to operate. It most cases, the machine should be given a complete overhauling and thorough cleaning at least once a year.

Suction is the most desirable method of cleaning, and is especially recommended where metallic and abrasive dusts are encountered. If compressed air is used to blow out the machine, it must be dry and of moderate pressure (about 25 to 30 lb. psi). Even lower pressure is advisable if conducting and abrasive dusts are present, as such dusts are extremely harmful if driven into the insulation. Wherever possible, the air should be so directed as to prevent the least possibility of such damage.

GENERAL OVERHAULING

Machines should be given a complete overhauling and thorough cleaning at least once a year or oftener if conditions warrant. Smaller machines, whose windings are not sufficiently accessible, should be taken apart for cleaning.

Loose dust and dirt can be removed by suction or compressed air as outlined previously. Heavy dirt and grease may be removed by cloths, brushes, or scrapers, using caution not to damage vulnerable parts of the machine.

Carbon tetrachloride is the most efficient and the safest cleaning agent for the removal of grease, oil, and sticky dirt. It is non-inflammable, but sufficient ventilation should be provided to avoid toxic effects. Inflammable liquids such as gasoline are not recommended because of the fire and explosion hazard involved. The most effective method of applying the cleaning liquids is to spray it on with an atomizer. The pressure may be about 80 lb. for insulation in good

condition, but should be no more than about 40 lb. for old insulation. If an atomizer is not available, the liquid may be applied by a cloth or paint brush, a brush being handier for getting into corners and between small coils. Regardless of the method of application, care should be taken not to soak the insulation with the cleaning liquid.

While the cleaning methods described permit the insulation to dry quickly at ordinary room temperatures, it is advisable to make certain that all moisture has been driven off by heating it as previously discussed under "Drying of Windings" especially if varnish is to be applied.

The application of a high-grade insulating varnish will renew the insulation and greatly prolong its life. The windings should be thoroughly dried out, and the varnish applied while they are still warm. For oil or excessive dust conditions, a clear varnish should be used; but where excessive amounts of acid, alkali, or moisture are encountered, a plastic baking varnish is recommended. The varnish may be sprayed or brushed on. In the case of small rotors and stators, the most effective method is to dip the windings into the varnish. After varnishing, all metal parts adjacent to the insulation should be cleaned off with a varnish solvent. The windings should then be baked for 6 or 7 hours at a temperature not exceeding 90°C. The condition of the insulation, or the conditions under which the machine is to operate, may indicate a repetition of the foregoing varnishing and baking operations to be desirable. If time is at a premium and the machine cannot be spared from service long enough for adequate baking, or if facilities are not available for baking, fair results can be obtained by applying a quick air-drying varnish which will dry in a few hours at ordinary room temperatures.

COMMUTATION-SLIP RING MACHINES ONLY

Satisfactory commutation can be maintained by periodic examination of the slip rings and brush rigging. Faults detected in the early stages of formation can usually be corrected at little loss of time or expense.

The machine has been properly adjusted at the factory for successful operation. The brushholders have been properly aligned and the correct brush spacing established on the slip rings.

If during the course of service or repairs, the commutation appears unsatisfactory and warrants immediate attention, the source of poor operation may be attributed to several causes. The connections should be checked to insure good electrical contact and the brushes replaced if they are worn dangerously short. Care should be exercised to use the same grade and size of carbon brush, as these characteristics were determined when the machine was designed and are important contributing factors for satisfactory operation.

Rough or dirty slip rings represent the chief causes producing chattering and noise. It may be necessary to clean the rings with fine grain sandpaper applied to the surface with moderate pressure. The brushes must first be lifted from the ring surface, and if possible, the machine should be driven without load to provide a constant rotation of the motor at normal speed. Emery paper and emery cloth should never be used on a slip ring because emery is an electrical conductor and particles are likely to become imbedded in the mica insulation and cause short circuits.

While sandpapering offers the most satisfactory method for removing dirt and small surface irregularities, it may become necessary to resurface slip rings which are badly out of true by grinding or turning with

a tool having a rigid support. The ring connections should first be checked and resoldered if necessary, and the ring examined carefully to make sure that it is tight on the shaft.

It is generally preferred to remove the rotor from the machine and place it in a lathe, as this offers the best accessibility and more rigid support for turning, although the rings may be turned with the rotor left intact within the machine. The choice between the two methods depends largely on the size of the machine.

Before starting to turn or grind the rings, the windings of the rotor should be carefully protected from metal chips by wrapping them with canvas or some other closely woven material. This serves to shield the windings from any chips or metal dust which are certain to result in short circuits.

When turning or grinding the rings extreme caution must be taken to give the cutting tool a rigid support. It is best to take a light cut, taking several if necessary, to remove all bad spots on the rings. A fine grain sandpaper or commutator stone may be used for final surfacing, with care taken to eliminate all scratches; especially those running diagonal on the ring surface, until the rings have a highly polished surface.

After the rings have been carefully inspected the surface should be lightly polished with fine sandpaper or commutator stone. Windings should be thoroughly blown out, and all copper dust wiped from the slip ring surface and adjacent parts.

A close watch on all electrical equipment with periodic servicing will give years of dependable and uninterrupted performance. A little

time spent at regular intervals to keep the machine in first class condition will avoid costly repairs and shutdowns.

DISASSEMBLY

Refer to the assembly drawing of the machine and the parts list.

Uncouple the machine and remove the foot bolts holding it to the foundation, and transport the complete unit to some area permitting easy accessibility.

On the slip ring machines remove the dripproof covers and raise the brushes away from the rings. Place a piece of cardboard or heavy canvas between the brushholders and the rings to prevent marring or scratching of the rings when the rotor is removed. Disconnect the rotor leads from the brushholders.

Loosen the inner bearing caps by removing the holding-on screws and back off the brackets. Take off the ball bearing lock nuts and lock washers, and press off the ball bearings with a bearing puller. Replace the bearing lock nuts on the rotor shaft to prevent any damage to the threads. Slide the rotor out of the machine taking care not to damage any coils or coil connections. Remove the screws holding any fans to the rotor, and take off the fans.

See the section on "Maintenance" for complete details on cleaning, servicing, and replacement of parts for the machine.

ASSEMBLY

Reverse the preceding procedure, taking care not to damage the windings or the slip rings, and being sure that all machined surfaces are clean so that all the parts will fit together properly. All

electrical connections should be checked for good contact, and proper clearance established between live parts and ground, and between terminals of opposite polarity.

INSTRUCTIONS
FOR THE
INSTALLATION, OPERATION, AND MAINTENANCE
OF
DIRECT-CURRENT MACHINERY

These instructions are intended to cover the major points in the installation, operating and maintenance of direct-current machinery. Wherever there are special conditions or variations in equipment, additional information or assistance may be secured upon request from the Engineering Department.

1. KEEP THE MACHINE CLEAR of all rags, boxes, and accumulation that might hamper ventilation. Any rubbish spread about a machine represents a fire hazard and breeding place for rodents which are a constant menace to all electrical equipment.
2. KEEP THE MACHINE CLEAN. Successful operation of a machine depends wholly upon the maintenance and service given it. A heavy layer of dirt, sand, or any foreign material allowed to accumulate in or on a machine can cause excessive overheating of the windings. If the commutator is not cleaned periodically, dirt and grit will become imbedded in the bars and mica segments, and the danger of a serious injury increases at an accelerating rate. Dirt lodged in the brush rigging can cause short circuits and result in expensive shutdowns for costly repairs; therefore, it is easy to realize how important and necessary a thorough cleaning at regular intervals by suction or mild blowing will save much time and expense.
3. KEEP THE MACHINE PROPERLY LUBRICATED. If the machine is correctly lubricated at regular intervals and immediately

serviced when necessary, the bearing life can be prolonged indefinitely. It is not necessary to replace the lubricant on sealed ball bearing machines as they are permanently lubricated for the life of the bearing. These machines can be recognized by the absence of grease openings in the bearing housings.

4. KEEP THE MACHINE SERVICED. It is best to completely disassemble and overhaul a machine once a year unless adverse conditions warrant more frequent attention. All parts should be thoroughly cleaned and kept covered till assembly, and worn parts replaced with spares kept in stock for such emergencies. All parts should be kept clean, connections made secure, and the lubricant checked after assembly before the machine is again put in operation. If all these precautions are taken and your machine gets the attention it requires for smooth uninterrupted service, the time and effort spent will be well worth the reward in top performance.

OPERATION

BEFORE STARTING

1. Machines that have been subjected to dampness in shipment or storage should be thoroughly dried out before being placed in service. Instructions for dyring out and for insulation resistance tests are given further on under "Maintenance".
2. Check the voltage stamped on the nameplate to see that it agrees with that of the power supply or the supply system.

3. See that all connections to the machine and the control apparatus correspond with the wiring diagrams.

4. Make sure that the bearings are properly lubricated. Grease lubricated, ball bearing machines are shipped with the proper amount of high grade grease in the bearings. Refer to "Maintenance" for further information on lubrication of bearings.

5. Check the brushes to make sure they ride freely in the brushholders. The brushes were correctly positioned and springs adjusted to the right pressure at the factory. If any displacement has occurred in transit or installation, refer to the section on "Maintenance".

INITIAL RUN

Run the machine without load for about one hour. Check for unusual localized heating in bearings and windings. Check for proper direction of rotation. Observe action at the commutator to see that the brushes are riding smoothly so that there is no brush chatter. When these and all previously enumerated precautions are taken, the machine is ready for operation.

DIRECTION OF ROTATION

The machine has been connected for the correct rotation at the factory. To obtain opposite rotation, the armature or main field leads must be reversed. All leads are tagged as shown on the connection diagram and connections for opposite direction are indicated.

HEATING

The rated temperature rise of the machine is stamped on the nameplate. The actual operating temperature of the machine will be the temperature rise of the machine plus the temperature of the surrounding

air. Standard Class A insulated machines will withstand an occasional maximum observable temperature of 90°C (194°F) for open machines and 95°C (203°F) for enclosed machines.

MAINTENANCE

GENERAL

Proper maintenance must be given careful consideration if the best performance and longest life are to be expected from the machine. The major features are those of lubrication, care of the insulation, and commutation. A regular inspection schedule will practically assure continuous operation. Preventive maintenance will avoid costly repairs. How often various inspections should be made will depend a great deal upon the type of machine and the conditions under which it is installed and operated.

Keep the machine clean. Do not permit rubbish to accumulate about the machine. It may seriously restrict the ventilation of the machine or get into moving parts, and cause a breakdown. With the machine at rest and disconnected from the line, wipe off any accumulation of dust with a dry cloth. The inside of the machine may be cleaned by suction or mild blowing, if necessary. Remove any accumulations of oil or grease with carbon tetrachloride in a well-ventilated room. Make sure there are no foreign materials in the air gap or other air passageways. If the machine is installed in a dirty place, it should be disassembled and thoroughly cleaned as frequently as the conditions warrant.

Listen for any mechanical noises which indicate metal-to-metal contact. If present, shut down the machine as soon as possible and check for misalignment or bearing failure.

Overheating, scorching odors and smoke are signs of shorts or serious overload. Stop machine and check load conditions against the rating. Check the drive and driven machine to see that they do not impose an excessive friction load on the machine. Test for short in field coils or armature. See that brushes and brush-spring pressure are properly adjusted. See that there is a free circulation of air around the machine so that ventilation is not restricted.

Make a periodic examination of all field windings, field poles, and all cable connections for tightness. Tighten all brush studs that may have developed slack due to drying out of washers, and make certain the studs are not displaced.

Inspect the mechanical drive to see that it is properly adjusted and in alignment.

LUBRICATION OF BALL BEARINGS

When the machine is shipped, the bearings are packed with the proper amount of high grade grease.

Double sealed, prelubricated bearings are packed with a special grease by the bearing manufacturer. Machines with such bearings can be identified by the absence of grease fittings. The grease used will ordinarily maintain its lubricating qualities for the life of the bearing under normal operating conditions. Where high operating temperatures are encountered, the life of the bearing may be limited to the time the lubricant will last.

Ball bearings consume only a very small amount of lubricant but enough must be present at all times to avoid injuries. The length of time a bearing can run without having grease added or replaced will depend upon the operating conditions.

Use a high grade neutral mineral grease composed of a soda soap base and a clean refined mineral oil. Do not mix greases of different types or specifications. A satisfactory grease should have the following qualities:

1. Freedom from abrasive matter such as grit, talc, mica, clay, or fillers of any kind.
2. Freedom from corrosive substances such as free lime, iron oxide, etc.
3. Freedom from acid, alkali and moisture.
4. At operating temperatures, a consistency low enough to prevent excessive channeling yet high enough to avoid fluidity which would create churning or leakage.
5. The least possible tendency to change consistency such as hardening, thickening, or separation into oil and soapy matter.
6. A melting point considerably higher than the operating temperature.

Use only clean lubricant from clean, closed containers and keep it from becoming contaminated during regreasing operations. Do not overlubricate. The housing should be no more than about one-third full of grease. Too much grease will cause churning, resulting in grease separation, overheating, and grease leakage.

Add grease sparingly observing precautions as to overgreasing. Complete regreasing is best left until the time of overhaul.

More complete renewal of the grease can, when necessary, be accomplished by forcing out the old grease with the new. Thoroughly

wipe clean those portions of the housing around the filler and drain plugs. Remove the drain plug and free the drain hole of any hardened grease which may have accumulated. With the machine running, add new grease through the filler hole until it starts to come out of the drain. Before replacing the drain plug, let the machine run for ten to twenty minutes to expel any excess grease. The filler and drain plugs should be thoroughly cleaned before they are replaced.

CLEANING BALL BEARINGS

At such times as the machine is disassembled for general overhauling, the housing may be cleaned of old oil or grease by washing with carbon tetrachloride.

Open-type bearings may be cleaned by placing them in wire basket suspended in a container of clean, cold petroleum solvent or kerosene and permitting them to soak for several hours. In stubborn cases, agitation in a hot oil bath may prove more expedient. Use a light transformer, spindle, automotive flushing, or motor oil not heavier than SAE-10 heated to about 220°F. In very bad cases, the bearings may be boiled in an emulsifying solution of grinding or cutting compounds diluted with water. In such cases, the bearings must be thoroughly drained and spun until all moisture has evaporated, then immediately washed in clean petroleum solvent or kerosene by revolving them slowly by hand and gradually working up to spinning speed. Care should be taken that all solid particles are removed, by a brush if necessary, before turning or spinning the bearing. After the bearings have been thoroughly cleaned, spin them in clean, new light oil until the solvent has been completely removed. Relubricate the bearings

immediately after they have been cleaned and washed. If they are to be stored before remounting, coat them with clean high grade oil or petroleum and wrap in clean, oil-proof paper.

Petroleum solvents are inflammable and must be used with caution because of the fire hazard involved. Carbon tetrachloride or similar solvents are sometimes used because they are non-inflammable, but their use is discouraged in cleaning bearings because they leave the bearing surfaces bone dry and subject to rust. Compressed air is sometimes used to blow out bearings, but it is not recommended unless the air is free from dirt and moisture. If used, the bearings must be held so as to prevent spinning which may cause scoring of the bearing surfaces by dirt.

The ball bearings of horizontal machines only may, if desired, be cleaned without disassembling the motor, by the following method: Remove the filler and drain plugs and free the holes of any hardened grease. Flush a light oil heated to about 190°F through the housing while slowly rotating the shaft. Repeat until the oil comes out clean indicating that most of the old grease has been removed. In cases where the grease has become body oxidized, a preliminary flushing with a hot aqueous emulsion may be required, followed, if necessary, by flushing with a mixture of alcohol and light mineral solvent. The final flushing should always be with hot light oil. Relubricate in accordance with the recommendation given in the instructions for lubrication of ball bearings.

BEARING WEAR

A ball bearing is subject to negligible friction wear unless the lubricant becomes contaminated with abrasive material. Thus, if properly lubricated, a ball bearing will not wear gradually, and air-gap measurements are unnecessary. If ball bearings fail, they will do so in a

relatively short space of time, generally as a result of excessive abuse. A bad bearing can usually be detected by the presence of vibration and noise long before complete failure can cause damage to the machine.

REMOVAL OF BEARINGS

In removing ball bearings from the shaft, pressure should be applied against the inner race, otherwise the bearing may be seriously damaged. Bearings may be removed by pressing out the shaft in an arbor press, or by means of bearing pullers. Always press or pull straight and square to avoid scoring the shaft or damaging the bearings.

CARE OF WINDINGS

Machines and spare coils should be stored in a clean, dry place until they are installed. Heat should be supplied to prevent "sweating" due to sudden temperature changes. Machines that have been subjected to moist atmosphere in transit, have been idle for some time without heat, or have become wet by accident, should be thoroughly dried out before being placed in service. Heating may be accomplished by passing current at low voltage through the windings, or by the use of electric heaters or steam pipes. Proper temperature can be maintained during long periods of idleness by placing a small heater inside the machine and covering the machine with a tarpaulin.

DRYING OF WINDINGS

Drying out can be most effectively accomplished by passing current through the windings. The current should be a mere fraction of full-load current, and the voltage should be low enough to be safe for the winding in its moist condition. The drying out heat may also be applied externally by the use of heating units placed around or in the machine. This method is most effective under a temporary housing of sheet metal

or canvas, with a vent provided in the top for the excape of the moisture-laden air. The warm air must be adequately circulated over all surfaces to be dried, and if natural draft is not sufficient to accomplish this, small fans should be used to force circulation. Small machines may be conveniently dried out by heating in an oven. Regardless of method used, the temperature should not be permitted to exceed 90°C.

The time required for thorough drying out will depend to a considerable extent on the size and voltage of the machine, and on the method of heating. Insulation resistance measurements should be taken at intervals of several hours, until the readings become fairly constant. The normal insulation resistance value as established by AIEE Standards is as follows:

$$\text{Megohms} = \frac{\dfrac{\text{Rated Voltage of Motor}}{\text{Rating in KVA}} + 1000}{100}$$

In event the KVA rating is not known, the Hp rating may be used to arrive at a sufficiently accurate value for practical purposes. Dry machines in good condition will have an insulation resistance value considerably higher than that obtained from the formula. A megohmeter offers the simplest method of measuring this resistance as it gives a direct reading, but the voltmeter method can be used providing a proper direct current source is available.

DIELECTRIC TESTS

After the windings have been thoroughly dried out, and insulation resistance readings are satisfactory, a high potential test may be applied to determine the dielectric strength of the insulation. New windings should successfully withstand a high potential test of twice

normal voltage plus 1000. Old windings, of course, will not stand such a test; but it may reasonably be assumed that they should withstand 1-1/2 times normal voltage for one minute. High potential tests should not be applied repeatedly, as frequent application of high potential tends to weaken the insulation. After a dielectric test, insulation resistance readings should again be taken to ascertain whether or not the insulation has been damaged by the high potential.

A periodic insulation resistance check is advisable, especially on large machinery. A record of such readings should be kept. Consistent readings will indicate continuing satisfactory condition of the insulation. Declining readings will provide advance warning of troubles which may be corrected before breakdown occurs.

PERIODIC CLEANING

If top performance is to be expected from the machine, it must be kept clean. The frequency and extent of the cleanings will, of course, depend upon the conditions under which the machine is required to operate. In most cases, the machine should be given a complete overhauling and thorough cleaning at least once a year.

Suction is the most desirable method of cleaning, and is expecially recommended where metallic and abrasive dusts are encountered. If compressed air is used to blow out the machine, it must be dry and of moderate pressure (about 25 to 30 psi). Even lower pressure is advisable if conducting and abrasive dusts are present, as such dusts are extremely harmful if driven into the insulation. Wherever possible, the air should be so directed as to prevent the least possibility of such damage.

GENERAL OVERHAULING

Machines should be given a complete overhauling and thorough cleaning at least once a year or oftener if conditions warrant. Smaller machines, whose windings are not sufficiently accessible, should be taken apart for cleaning.

Loose dust and dirt can be removed by suction or compressed air as outlined previously. Heavy dirt and grease may be removed by cloths, brushes, or scrapers, using caution not to damage vulnerable parts of the machine.

Carbon tetrachloride is the most efficient and the safest cleaning agent for the removal of grease, oil, and sticky dirt. It is non-inflammable, but sufficient ventilation should be provided to avoid toxic effects. Inflammable liquids such as gasoline are not recommended because of the fire and explosion hazard involved. The most effective method of applying the cleaning liquid is to spray it on with an atomizer. The pressure may be about 80 lb. for insulation in good condition, but should be no more than about 40 lb. for old insulation. If an atomizer is not available the liquid may be applied by a cloth or paint brush, a brush being handier for getting into corners and between small coils. Regardless of the method of application, care should be taken not to soak the insulation with the cleaning liquid.

While the cleaning methods described permit the insulation to dry quickly at ordinary room temperatures, it is advisable to make certain that all moisture has been driven off by heating it as previously discussed under "Drying of Windings" especially if varnish is to be applied.

The application of a high-grade insulating varnish will renew the insulation and greatly prolong its life. The windings should be thoroughly dried out, and the varnish applied while they are still warm. For oil or excessive dust conditions, a clear varnish should be used; but where excessive amounts of acid, alkali, or moisture is encountered, a plastic baking varnish is recommended. The varnish may be sprayed or brushed on. In the case of small rotors and stators, the most effective method is to dip the windings into the varnish. After varnishing, all metal parts adjacent to the insulation should be cleaned off with a varnish solvent. The windings should then be baked for 6 or 7 hours at a temperature not exceeding 90°C. The condition of the insulation, or the conditions under which the machine is to operate, may indicate a repetition of the foregoing varnishing and baking operations to be desirable. If time is at a premium and the machine cannot be spared from service long enough for adequate baking, or if facilities are not available for baking, fair results can be obtained by applying a quick air-drying varnish which will dry in a few hours at ordinary room temperature.

COMMUTATION

Satisfactory commutation can be maintained by periodic examinations of the commutator surface and brush rigging. Faults detected in the early stages of formation can usually be corrected at little loss of time or expense.

The machine has been properly adjusted at the factory for successful operation. The position of the brush studs on the brush yoke has been determined for the correct brush angle and should never require any change. The brushholders have been properly aligned and the correct brush stagger established on the commutator.

If during the course of service or repairs, the commutation appears unsatisfactory and warrants immediate attention, the source of poor operation may be attributed to several causes. The connections should be checked to insure good electrical contact and the brushes replaced if they are worn dangerously short. Care should be exercised to use the same grade and size of carbon brush, as these characteristics were determined when the machine was designed and are important contributing factors for satisfactory operation.

If there is excessive sparking in the machine, the brushes may be improperly positioned on the commutator resulting in unbalanced commutation. This can be remedied by shifting the brush yoke to where there is the least amount of sparking.

A rough or a dirty commutator, high mica, high or low bars, burned bars, and flat bars represent the chief causes producing chattering and noise. It may be necessary to clean the commutator with fine grain sandpaper applied to the surface with moderate pressure. The brushes must first be lifted from the commutator surface, and, if possible, the machine should be driven without load to provide a constant rotation of the armature at normal speed. Emery paper and emery cloth should never be used on a commutator because emery is an electrical conductor and particles are likely to become imbedded in the mica segments between the bars and cause short circuits.

While sandpapering offers the most satisfactory method for removing dirt and small surface irregularities, it may become necessary to resurface a commutator which is badly out of true, by grinding or turning with a tool having a rigid support. The commutator connections should first

be checked and resoldered if necessary and the commutator examined carefully to make sure that it is tight on the shaft.

It is generally preferred to remove the armature from the machine and place it in a lathe, as this offers the best accessibility and more rigid support for turning, although the commutator may be turned with the armature left intact within the machine. The choice between the two methods depends largely on the size of the machine.

Before starting to turn or grind a commutator, the windings of the armature should be carefully protected from metal chips by wrapping them with canvas or some other closely woven material. This serves to shield the windings from any chips or metal dust which are certain to result in short circuits.

When turning or grinding the commutator, extreme caution must be taken to give the cutting tool a rigid support. It is best to take a light cut, take several if necessary, to remove all bad flat spots on the commutator. A fine grain sandpaper or commutator stone may be used for final surfacing, with care taken to eliminate all scratches, especially those running diagonal on the commutator surface, until the commutator has a highly polished surface.

For satisfactory operation of a commutator, it has become standard procedure to undercut the mica segments, as mica wears at a slower rate than the commutator bars, and soon results in an uneven surface, flat bars, and even flashovers. A hack saw blade mounted in a wooden handle serves as a satisfactory undercutting tool where the amount of work to be done does not warrant the purchase of special equipment. Care should be taken not to cut more than 1/32 inch deep, as a deeper slot will accumulate foreign particles, and metal and carbon dust.

After the commutator has been undercut and carefully inspected, the surface should be lightly polished with fine sandpaper or commutator stone. Windings should be thoroughly blown out and all copper dust wiped from the commutator surface and adjacent parts.

A close watch on all electrical equipment with periodic servicing will give years of dependable and uninterrupted performance. A little time spent at regular intervals to keep the machines in first-class condition will avoid costly repairs and shutdowns.

DISASSEMBLY

Refer to the assembly drawing of the machine and the parts list.

Uncouple the machine and remove the foot bolts holding it to the foundation, and transport the complete unit to some area permitting easy accessibility.

Remove the dripproof cover from the frame and raise the brushes away from the commutator. Place a piece of cardboard or heavy canvas between the brushholders and the commutator to prevent the holders from scratching the bars when the armature is removed. Disconnect the armature leads from the brush studs.

Take off the bearing cap and the bracket on the commutator end of the machine, and remove the ball bearing lock nut and lcck washer, and press off the ball bearing with the bearing spacer as described in the section on "Maintenance". Note the marked position of the brush yoke on the bracket for reference in assembly before removing the brush yoke.

Take off the bearing cap and the bracket on the drive end of the machine, and remove the ball bearing lock nut and lock washer, and press off the ball bearing with the bearing spacer as described in the section "Maintenance".

Slide the armature out of the machine taking care not to damage any coils or coil connections. Remove the screws holding the fan to the fan hub on the armature and take off the fan.

To thoroughly clean all the field coils it is often necessary, especially on the smaller machines, to disconnect the field coil connections and take out the field coils and pole pieces. Care should be exercised during assembly to replace the windings exactly as they were before disassembly.

See the section on "Maintenance" for complete details on cleaning, servicing, and replacement of parts for the machine.

ASSEMBLY

Reverse the preceding procedure, taking care not to damage the windings or the commutator surface, and being sure that all machine surfaces are clean so that all the parts will fit together properly. All electrical connections should be checked for good contact, and proper clearance established between live parts and ground, and between terminals of opposite polarity.

ESTIMATED PARTS REQUIRED TO MAKE AVERAGE OVERHAUL AND REPAIR OF DIESEL ENGINES AFTER A PERIOD OF ONE YEAR OR 8000 HOURS OF OPERATION FOR THE FOLLOWING ENGINES:

NUMBER AND SIZE OF ENGINES ON EACH SITE:

Eniwetok	5 - 6 cyl. and 1-8 cyl.
Parry	6 - 6 cyl.
Japtan	1 - 5 cyl.
Runit	3 - 5 cyl.
The Aomon Group	2 - 5 cyl. and 1 - 8 cyl.
Engebi	2 - 5 cyl. and 1 - 8 cyl.

Totals	11 - 6 cylinder engines
"	3 - 8 cylinder engines
"	8 - 5 cylinder engines

PARTS FOR FAIRBANKS-MORSE MODEL 31A6¼
EN BLOC DIESEL ENGINES

PART NUMBER	DESCRIPTION	NO. REQUIRED
DEA3A7	Cylinder Head	24
DEA632A1	Cylinder Head gasket (Copper)	270
DEA5A5	Piston	50
DEA8C2	" Ring (Compression #1)	140
DEA5705A2	" " (Scrapper)	140
DEA8C3	" " (Compression 2-3-4)	456
DEA5705B1	" " (Oil Drain)	276
DEA7A2	" Pin	130
DEA17A6	" " Bushings	130
NFA6B	" " Dowel Pin	130
18DEA-A2	Connecting Rod	3
DEA305A	Header Flange Gasket	220
DFB6878A1	Injection Nozzle Tube	75
ND1353D1	" " " Gaskets	150
DEA204A2	" " Tip	130
DEA6382A	" " Gaskets	130
DEA4440A2	Water Outlet Fitting	25
DEA1520A2	" " " Gasket	25
A-1091	Oil Filters	528
A-3095	Camshaft Thrust Control bearing	22
A-531C	Injection Pump (Stationary)	44
DFB585A2	Air Valve (Scavenger air & blower)	1056
DEA595A	" " Springs	1056

PARTS FOR FAIRBANKS-MORSE MODEL 31A6¼
EN BLOC DIESEL ENGINES

PART NUMBER	DESCRIPTION	NO. REQUIRED
DFB7305B2	Air Valve Gasket	88
ND479B	Companion Flange Gasket	22
ND480B	" " "	22
A531C	Fuel Injection Pump	22
ND459B1	Water Header Flange	22
ND460B1	Water Pump Flange 2½"	22
16FM39C2	Thermometers	88
15FM1A	Packing (1/4" x 4 3/8")	132
B603C	Water Pump Complete (Bronze)	11
854A-C	Air Start Check Valve	22
1549	" " " Gasket	22
1084-C	Lube Oil Pump Complete	6
1088-A	" " " Strainer	6
2753	Thermocouples	30
5921A-8	Bearing Shell for Con. Rod (Blower)	22
4018	Cylinder Liners	130
DEA4025A-1	Rubber Seal	130
DEA6340A-2	Water Inlet Gasket	130
NGA33E-1	Water Tube Gaskets	420
DEA5659A2	Timing Chains	6
A749A-C	Complete basic set of gaskets	22
7091	Oil Separator	22
DEA632A1	Gaskets Liner to Head	130

PARTS FOR FAIRBANKS-MORSE MODEL 31A6¼
EN BLOC DIESEL ENGINES

PART NUMBER	DESCRIPTION	NO. REQUIRED
DEA19A11	Con. Rod. Bearing Shell	646
A201C	Injection Nozzle Complete	130
DEA29A2	Governor Drive Gear	22
C-80C	Woodward Governor Complete 4G8	5
DEA2659A	Governor Drive Pinion	12
DEA2544A	Bearing retainer	22
DEA416A	Hand Hole Gaskets	150
DEA3586A-1	Air Valve Seat	300
CKC6256B	Air Valve Insert	3220
DEA7293A1	Air Valve Retainer	300
A603-C	Water Pump Complete	6
659-C	Crosshead, Inj. Pump Tappet	130
D5EA30A4	Camshaft complete section	3
DEA5367A1	Fuel Pump Pinion	15
DFB3400A	Governor Gasket	22

PARTS FOR FAIRBANKS-MORSE
TYPE "ZC" ENGINES

PART NUMBER	DESCRIPTION	NO. REQUIRED
A3-C	Cylinder Head Complete	2
9A-C	Suction Valves	6
10B-C	Exhaust Valves	6
5-C	Pistons (Complete)	6
7	Piston Pins	6
17	Piston Pin Bushings	6
6	Piston Rings (Compression)	12
6A	Piston Rings (Oil regulating)	6
18-C	Connecting Rod - Complete	2
110	" " Shim	6
150	" " Bolt	12
317	Exhaust Valve Spring	6
11A	" " Collar	6
122A	" " " Lock	6
310A	Suction Valve Spring	6
121A	" " Collar	6
122B	" " " Lock	6
120	" " Drag Spring	6

ESTIMATED PARTS REQUIRED TO MAKE AVERAGE REPAIRS FOR PERIOD OF ONE YEAR. QUANTITY IS FOR 6 CYLINDER ENGINE.

PART NUMBER	DESCRIPTION	5 cyl.	6 cyl.	8 cyl.	TOTAL REQ. PER ENGINE PER YEAR
DEA 3A7	Cylinder Head	5	6	8	1
DFB 6878A1	Injection Nozzle Tube	5	6	8	3
ND1353D1	" " Gasket	10	12	16	6
DEA4440A2	Water Outlet Fitting	5	6	8	1/6
DEA1520A2	" " " Gasket	5	6	8	18
DEA632A1	Cyl. Head Gasket (Copper)	5	6	8	12
DEA545	Piston	5	6	8	2
DEA8C2	" Ring (Compression #1)	5	6	8	6
DEA5705A2	" " Scrapper	5	6	8	6
DEA8C3	" " (Compression 2-3-4	15	18	24	18
DEA5705 B1	Piston Ring (Oil Drain)	10	12	18	12
DEA 7A2	" Pin	5	6	8	3
DEA 17A6	" " Bushing	5	6	8	6
NFA6B	" " Dowel Pin	5	6	8	6
18DEA-A2	Connecting Rod	5	6	8	1/12
DEA305A	Header Flange Gasket	10	12	16	2
DEA204A2	Injection Nozzle Tip	5	6	8	6
DEA6382A	Gasket - Inj. Nozzle	5	6	8	6
A-1091	Oil Filters	2	2	2	24
A3095	Camshaft Thrust Control Bearing				

ESTIMATED PARTS REQUIRED TO MAKE AVERAGE REPAIRS FOR PERIOD OF ONE YEAR. QUANTITY IS FOR 6 CYLINDER ENGINE.

PART NUMBER	DESCRIPTION	5 cyl.	6 cyl.	8 cyl.	TOTAL REQ. PER ENGINE PER YEAR
1549	Air Start Valve Gasket				
	Browning "V" Belts	2	2	2	2
	Woodward Governor Complete	1	1	1	1
DEA 29A2	Governor Drive Gear #29	1	1	1	1
DEA 416A	Hand Hole Gaskets				
DEA2544A	Bearing Retainer				
DEA2659A	Governor Drive Pinion				12
SKF1322M	Generator Bearing				
DEA3586A1	Air Valve Seat	13	13	8	14
CKC6256	Air Valve Insert	130	140	80	140
DEA7293A1	Air Valve Retainer	13	14	18	14
A603C	Water Pump Complete	1	1	1	1
659C	Crosshead Inj. Pump Tappet	5	6	8	6
A531-C	Fuel Injection Pump (Stationary)	5	6	8	2
DFB 585 A2	Air Valve, Scavenger Air & Blower	143	154	188	48
DEA 595 A	Air Valve Spring for above	143	154	188	48
DFB7305B2	Gasket	14	15	16	4
ND479B	Companion Flange Gasket	1	1	1	2
ND 480B	" " "	1	1	1	2
A 531-C	Fuel Injection Pump	5	6	8	2
ND 459 B-1	Water Header flange	1	1	1	1

ESTIMATED PARTS REQUIRED TO MAKE AVERAGE REPAIRS FOR PERIOD OF ONE YEAR. QUANTITY IS FOR 6 CYLINDER ENGINE.

PART NUMBER	DESCRIPTION	5 cyl.	6 cyl.	8 cyl.	TOTAL REQ. PER ENGINE PER YEAR
ND 460 B-1	Water Pump Flange 2½"	1	1	1	1
16FM39C2	Thermometer	4	4	4	4
15FM1A	Packing (1/4 x 4 3/8")	6	6	6	6
B 603-C	Water Pump Complete (Bronze)	1	1	1	1/2
854A-C	Air Start Check Valve	5	6	8	2
1084-C	Lube Oil Pump	1	1	1	1/4
1088A	Strainer Lube Oil Pump	1	1	1	1/4
2753	Thermocouple	5	6	8	1
5921 A-8	Shell for Con. Rod-Blower	1	1	1	1
4018	Cylinder Liners	5	6	8	6
DEA-4025A-1	Rubber Seal	5	6	8	6
DEA-6340A-2	Water Inlet Gasket	5	6	8	6
NGA-33E-1	Water Tube Gasket	20	24	32	24
DEA-5659-A-2	Timing Chain	1	1	1	6*
A749-A-C	Complete basic set of gaskets	1	1	1	1
7091	Oil Separator	1	1	1	1
DEA-632-A-1	Gaskets Liner to head	5	6	8	6
DEA019A-11	Bearing Shell Con. Rod	26	30	36	30
A201-C	Injection Nozzle Complete	5	6	8	6

*6 for all sites.