ARROW 2

RE-OILING OF IROQUOIS ENGINE, ACCESSORIES GEARBOXES & CONSTANT SPEED DRIVE SYSTEM

Report No. 72/GEQ/18
October, 1958

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Requirements, Alternative Proposals and Recommendations for Ground Re-Oiling Rig

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INTRODUCTION

This report summarizes the re-oiling requirements of the Iroquois engine, the aircraft accessories gearboxes and the constant speed drive system on the Arrow 2.

An appraisal of the Arrow 1 re-oiling rig is made with a view to its use on the Arrow 2. A brief description is included of three possible types of re-oiling rig which could be used in place of the one presently employed on the Arrow 1 aircraft.

The conclusions and recommendation of G.S.E. Engineering appear at the end of this report.

2. SUMMARY OF ARROW 2 RE-OILING REQUIREMENTS

2.1 Iroquois Lubricating System

Type of Oil - MIL-L-7808

Filter - 5 Micron

Tank Capacity (per engine) - 4 Imp. Gals. plus 1 Imp. Gal. Air Splace.

Fill Fitting - On engine - Wiggins W3F8-2.
On G.E. Hose - Wiggins W1F8-1.
(Socket & Plug Assembly - W1F8-5).

Overflow Fitting - On engine - Wiggins M6E8-2.
On G.E. overflow hose - Wiggins M6E8-1.
(Socket & Plug Assembly - M6E8-5).

Location of Fittings - Engine Shroud - bottom.
Access via No. 1 Engine Door.

Re-Oiling Pressure - 2 GPM at 10 - 20 psi.

Re-Oiling Operation

(a) To check oil level

Open access panel to the master refueling panel (E-21) located forward of speed brake. Master panel includes two lights per engine - indicating oil level is "LOW" (one more sortie) or "FULL". Action as follows:

1. Low Level Light

No Light - Tank needs filling before further flight.
Action - Fill till "FULL" indication light appears.
Green Light - Oil level satisfactory for at least one more sortie.

2.1 Iroquois Lubricating System (Cont'd)

(a) To check oil level

2. Full Indication Light

No Light - Tank may be topped up.
Action - Fill till "FULL" indication light appears.
Green Light - Oil tank full.

(b) To fill or top up oil tank

Open No. 1 Engine Door. Attach oil supply hose to engine fill fitting. Attach overflow hose to engine overflow fitting. Pump oil to engine. Stop pumping when a flow of oil appears in sight glass of overflow hose, indicating oil tank is full. It is therefore not necessary to have another man stationed at the E.21 master panel to watch the indicator lights when filling or topping-up. These lights need only be used while checking the oil level as described at (a) above.

2.2 Iroquois Hydraulic System

Type of Oil	- MIL-L-7808
Filter	- 5 Micron
Capacity (per engine)	- Reservoir, 90 cu. in. = 2½ Imp. pints. Accumulator, 25 cu. in = 3/4 Imp. pints.
Fill Fitting	- On engine - Aeroquip 340209-6. On G.E. hose - Aeroquip 320509-6.
Location of Fitting	- Engine Shroud - bottom. Adjacent to lubrication fitting. (Access via No. 1 Engine Door).
Re-Oiling Pressure	- ½ GPM at 50 psi.
Re-Oiling Operation	- Open No. 1 Engine Door. Check oil level on sight gauge fitted adjacent to filling point. If oil is required, attach hose coupling and pump oil into system until gauge registers "FULL".

2.3 Aircraft Accessories Gear boxes (2 per A/C)

Type of Oil	- MIL-L-7808
Filter	- 5 Micron
Capacity	- 1300 c.c. = approx. 0.3 Imp. Gal. (per gearbox)
Fill Fitting	- On G.B. - Wiggins W1F8-2. On G.E. hose - Wiggins W1F8-1.
Location of Fitting	- Forward face of gearbox. Access via No. 1 Service Door.
Re-Oiling Pressure	- 2 GPM at 10 - 20 psi.
Re-Oiling Operation	- Open No. 1 Service Door. Check oil level on sight gauge fitted adjacent to filling point. If oil is required, attach hose coupling and pump oil to gearbox until gauge register "FULL".

2.4 Constant Speed Drive Oil Tanks (2 per A/C)

Type of Oil	- MIL-L-7808
Filter	- 5 Micron
Tank Capacity	- 0.8 Imp. Gals. (per tank).
Fill Fitting	- Open neck - $1\frac{1}{2}$" dia.
Location of Fitting	- Top surface of tank. Access via No. 3 Service Door.
Re-Oiling Pressure	- 2 GPM at 10 - 20 psi.
Re-Oiling Operation	- Remove No. 3 Service Door. Check oil level in tank by viewing panel in side of tank. If oil is required fit suitable adaptor to open self-sealing coupling on end of ground rig hose and insert into filler neck of tank. Fill tank until oil reaches the "FULL" level on the viewing panel. While filling, air in the tank will be vented past the hose adapter in the neck of the tank.

2.5 Summary of Re-Oiling Capacities, assuming system fully primed with exception of the Reservoirs

Engine Lubrication	4 gal. per engine.
Engine Hydraulics	0.4 gal. per engine.
Accessories Gearbox	0.3 gal. per gearbox.
C.S.D. unit	0.8 gal. per tank.
	5.5 Imp. gal.

Total per aircraft = 11.0 Imperial Gallons.

3. APPRAISAL OF ARROW 1 RE-OILING RIG AND ITS ADAPTABILITY FOR THE ARROW 2 AIRCRAFT

The detail design and arrangement of a number of features on the present rig could very well be improved but as they do not materially affect the function of the rig they need not be discussed at this time.

The rig is fitted with a standard semi-rotary type hand pump and generally these cannot develop a pressure in excess of 35 psi. and still maintain a reasonable rate of flow.

To meet the Iroquois hydraulic system requirements the present 30 micron filter would be changed to a 5 micron filter. It will be seen from Fig. 1 that a pressure drop across the 5 micron filter of 25 to 30 psi. must be considered. This, added to the 50 psi. re-oiling pressure, would preclude the use of the present rig for re-oiling the engine hydraulic system.

Providing the hose coupling were changed to suit the Iroquois fill fitting, there would be no difficulty in using the present rig for re-oiling the lubrication system for the engine, gearboxes and constant speed unit.

It would be necessary to use a separate rig for the engine hydraulic system.

4. ALTERNATIVE PROPOSALS FOR ARROW 2 RE-OILING RIG

The basic requirement is for a reservoir having a usable capacity of 22 Imp. gallons and fitted with an oil delivery system capable of providing a flow rate of 2 GPM at a pressure of 10 - 20 psi. or a rate of $\frac{1}{2}$ GPM at an increased pressure of 50 psi.

The oil in the delivery line must be filtered through a 5 micron filter.

ALTERNATIVE PROPOSALS FOR ARROW 2 RE-OILING RIG (Cont'd)

Due to the very high viscocity of MIL-L-7808 oil over the low temperature range, it will be necessary to heat the oil prior to use. The characteristics of this oil preclude the use of an immersion heater, therefore it will be necessary to incorporate an external heating jacket on the reservoir. This should be capable of raising the oil temperature from -65°F to, and retaining it at, 70°F within a period of not more than one hour. The system should be so arranged that the filter and delivery lines are stowed in close proximity to the heater in order that the residual oil may also be warmed.

Three alternative proposals are made for this rig and a brief description of each is given in the following.

4.1 Hand Pump Method (See Fig. 2)

Due to the use of identical oil (MIL-L-7808) in each system, it will be possible to use a common oil reservoir for both lubricating and engine hydraulic systems.

Pressure:	Engine Hydraulic	½ GPM at 50 psi.
	Lubricating	2 GPM at 10 - 20 psi.

A hand operated, rotary or semi-rotary pump which will fulfill both of the above functions is not available.

It will therefore be necessary to mount two pumps on a trailer using a common reservoir having a capacity not less than 22 Imp. gallons and at least a 2 gallon space below the outlet port for collecting moisture and other impurities.

Pumps suitable for this purpose would be as follows:

(a) Topping-up engine lubricating system and accessories gearboxes and also the CSD. oil tank.

LEAR-ROMEC TYPE RXD-1563.

Capacity - 2.66 GPM at 120 strokes per min.
Available with a special spring to give a range of 10 - 20 psi.

(b) Topping-up engine hydraulic system

ELECTROL HAND PUMP - MODEL 770.

Operating pressure - 0 to 1,500 psig.
Handle load - approx. 2½ lb. at 50 psi.

4.1 Hand Pump Method

(b) (Cont'd)

Capacity - 2.0 cu. in. per cycle (2 strokes).
i.e. ½ GPM at 58 cycles per minute

The reservoir shall be fitted with three flexible hoses, suitable for use with MIL-L-7808 oil.

These shall be as follows:

(a) Connected to the LEAR-ROMEC TYPE RXD-1563 pump, via a 5 micron filter, to supply oil to the engine lubricating system, aircraft accessories gearboxes and the C.S.U. de-aerating oil reservoir tank. The free end of the hose shall be fitted with a Wiggins coupling W1F8-1.

This will mate with the couplings on both the engine lubricating "fill" port and the accessories gearbox "fill" port.

To "top-up" the C.S.U. oil tank an adaptor is required to be fitted to the hose end connector. This would consist of a tube formed into a "U" at one end and the other fitted with the mating half of the Wiggins coupling on the end of the hose. A simple two-way shut-off valve would be required between the tube and coupling. The "U" tube would then be entered into the filling port on top of the tank and oil pumped to the correct level as shown in the viewer on the side of the tank.

(b) Connected to the ELECTROL HAND PUMP, MODEL 770, via a 5 micron filter, to supply oil to the engine hydraulic system. Downstream of the filter would be incorporated a relief valve set at a 50 psi. The free end of the hose shall be fitted with an aeroquip socket no. 320509-6 to mate with aeroquip no. 340209-6 fitted to the engine.

(c) Connected to a sump tank on the trailer to collect the overflow oil from the engine lubricating system. This line shall include a sight glass to indicate the flow of oil.

To the free end shall be fitted a Wiggins M6E8-1 coupling to mate with the overflow connector on the engine.

A simple, manually operated valve shall be installed in a return line from each pump back to the reservoir to enable pressure trapped in the hose to be released.

This valve should preferably be lever operated with two positions positively marked PRESSURE DUMP - "ON" and "OFF".

4.1 Hand Pump Method (Cont'd)

A measuring device shall be included in each delivery line to meter the dispensed oil to the accuracy of a quarter of an Imperial pint. The rig would be mounted on a chassis having two wheels, a skid, and a towing bar. The whole unit would be made sufficiently low to enable the operator to manipulate the pumps from a position immediately below the aircraft and at the same time watch the oil level indicators.

4.2 Pressurized Method (See Fig. 3)

Reservoir

To consist of a pressure vessel of a capacity not less than 22 Imp. gallons in addition to which an adequate volume will remain above the normal full level for pressurizing and at least a 2 gallon space below the outlet port for collecting moisture and impurities.

It should be designed for a working pressure of 80 psig.

To the outlet port shall be attached a 5 micron filter. (TYPICAL - BENDIX-SKINNER TYPE 3110 DH).

An access panel of sufficient size to allow visual examination and manual cleaning of the reservoir would be required.

Approx. Size of Reservoir = 18" dia. x 36" high.

Pressure System

Provision would be required on the reservoir tank to mount a nitrogen pressure bottle.

The size would be determined by the capacity of the reservoir, number of "fills" of the reservoir desired before changing nitrogen bottles, pressure of nitrogen etc. It would be advisable to use a bottle that is already in service with some other equipment. A suitable bottle might be the one presently employed on the missile pack hoist.

i.e.	Walter Kidde	#870834
	Pressure	3000 psi.
	Capacity	500 cu. in.
	Dia.	7" O/D
	Length	19½"

4.2 Pressurized Method

Pressure System (Cont'd)

This would provide sufficient nitrogen to pressurize approx. three tanks full of oil at regulated pressure of 80 psi. (i.e. the hydraulic system).

In practice this would be increased considerably as the majority of the oil requirement is at a pressure of 10 - 20 psi. i.e. the lubricating system, gearboxes and C.S.U. tanks.

In the nitrogen line from the bottle to the reservoir would be introduced a regulator/relief valve.

Its function would be to regulate the pressure in the reservoir to a pre-determined figure and to relieve the pressure in the reservoir should there be a pressure build-up due to temp. rise etc.

The required pressure should be simple to adjust by the operator in the range 10 to 80 psi.

Hose Assembly & Nozzle

A flexible hose, approx. 15' long and suitable for use with MIL-L-7808 oil would be connected to the 5 micron filter. A flow-meter would be installed in the line capable of measuring the dispensed oil to the accuracy of a quarter of an Imperial pint.

To the free end of the hose would be fitted a trigger operated, automatic shut-off nozzle, thus giving the operator complete control at the filling point where the contents gauges are situated.

Three short lengths of flexible hose would be provided as alternative attachments to the outlet port of the nozzle.

These would serve for either:

re-oiling the lubrication system.
re-oiling the hydraulic system.
re-oiling the C.S.U. tanks.

Overflow Tank

An overflow tank of a capacity not less than 5 Imp. gallons shall be permanently fitted to the rig. Leading from the top of the tank shall be a 15 foot length of flexible hose suitable for use with MIL-L-7808 oil. The free end of the hose shall be fitted a sight glass and a Wiggins self-sealing coupling no. M6E8-5,

4.2 Pressurized Method

Overflow Tank (Cont'd)

to mate with the overflow fitting on the Iroquois engine.

The base of the tank shall be provided with a drain plug and sufficient space allowed below it to collect the drained oil in 1 gallon containers.

Chassis

The rig shall be suitably mounted on a dolly and should be easily manoeuvred by one man.

4.3 Air Operated Pump Method (See Fig. 4)

This rig would consist of a reservoir tank, overflow tank, air operated pump, a length of flexible hose and trigger operated, automatic shut-off nozzle.

In addition there would be a 5 micron filter, a flow meter and an overflow hose complete with sight glass.

The reservoir tank should have a minimum capacity of 22 Imp. gallons plus a 2 gallon volume below the outlet for collecting impurities. To the reservoir is fitted an air operated pump, complete with a 5 micron filter, flow meter and a 15 foot length of flexible hose suitable for use with MIL-L-7808 oil. To the free end of this hose is fitted a trigger operated nozzle with alternative outlet adapters for coupling to either the lubricating or engine hydraulic systems and also for filling the C.S.D. oil tanks.

An oveflow tank of a capacity not less than 5 Imp. gallons shall be permanently fitted the rig. Leading from the top of this tank shall be a 15 foot length of flexible hose suitable for use with MIL-L-7808 oil. To the free end of the hose is fitted a sight glass and a Wiggins self-sealing coupling, No. M6E8-5, to mate with the overflow fitting on the Iroquois engine. The base of the tank shall be provided with a drain plug and sufficient space allowed below it to collect the drained oil in 1 gallon containers.

Both tanks shall be provided with access panels of sufficient size to allow visual inspection and manual cleaning.

The whole rig shall be suitably mounted on a dolly and should be easily manoeuvred by one man.

The possibility of making the air pump assembly as a separate unit and inserting it in the regulator oil supply container is discarded due to the small capacity and general lack of uniformity in the MIL-L-7808 containers.

CONCLUSION

The merits and de-merits of each system appear as follows:

(a) Hand Pump Method

Merits
- Not dependent upon a secondary system for oil delivery.
- Simple to operate and maintain.
- Reliable.
- A minimum of loose adapters etc.
- Could re-oil two systems at one time (with two operators).
- Could also be used to pressure test oil lines etc. up to 1,500 psig. if required.

De-Merits
- The use of separate pumps, filters etc. in this system would result in a bulkier rig than the other two proposals and therefore less convenient for handling and stowing.

(b) Pressurized Method

Merits
- Compactness of size.
- Ease of handling.
- Trigger nozzle gives good control of filling operation.
- Manual effort at a minimum.

De-Merits
- Dependent upon a regular supply of nitrogen.
- Re-charging of unit involves two systems.
- Pressure in nitrogen bottle requires close attention to avoid the necessity of re-charging during a re-oiling operation.

(c) Air Pump Method

Merits
- Simple to operate.
- Compactness of size.
- Ease of handling.
- Trigger nozzle gives good control of filling operation.
- Manual effort at a minimum.

De-Merits
- Dependent upon an external source of compressed air, which is not generally available on flight line. This would involve piping a permanent supply to various points on the flight line or providing a mobile compressor for this purpose.

RECOMMENDATION

We recommend that the hand pump method should be employed because of its inherent reliability and its independence from a secondary system for oil delivery.

7. ILLUSTRATIONS

Fig. 1 - Pressure drop through a 5 micron filter.
Fig. 2 - Schematic arrangement - hand pump method.
Fig. 3 - Schematic arrangement - pressurized method.
Fig. 4 - Schematic arrangement - air pump method.

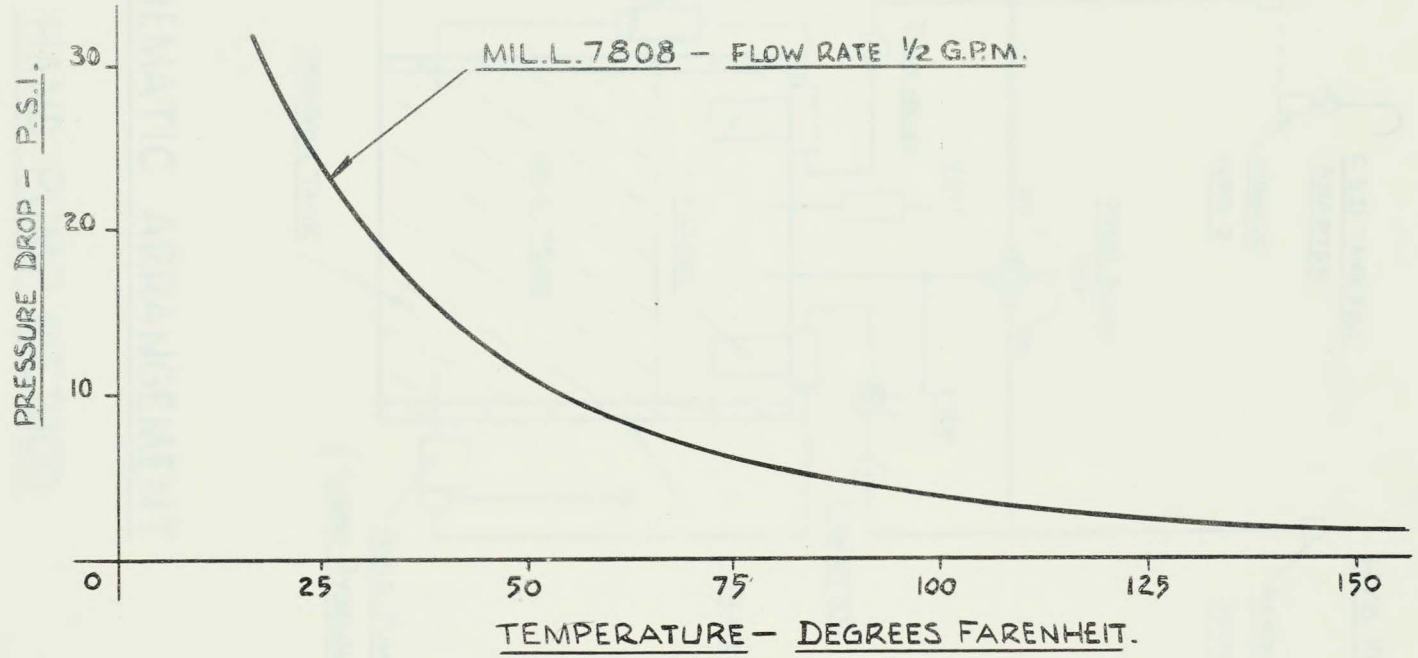
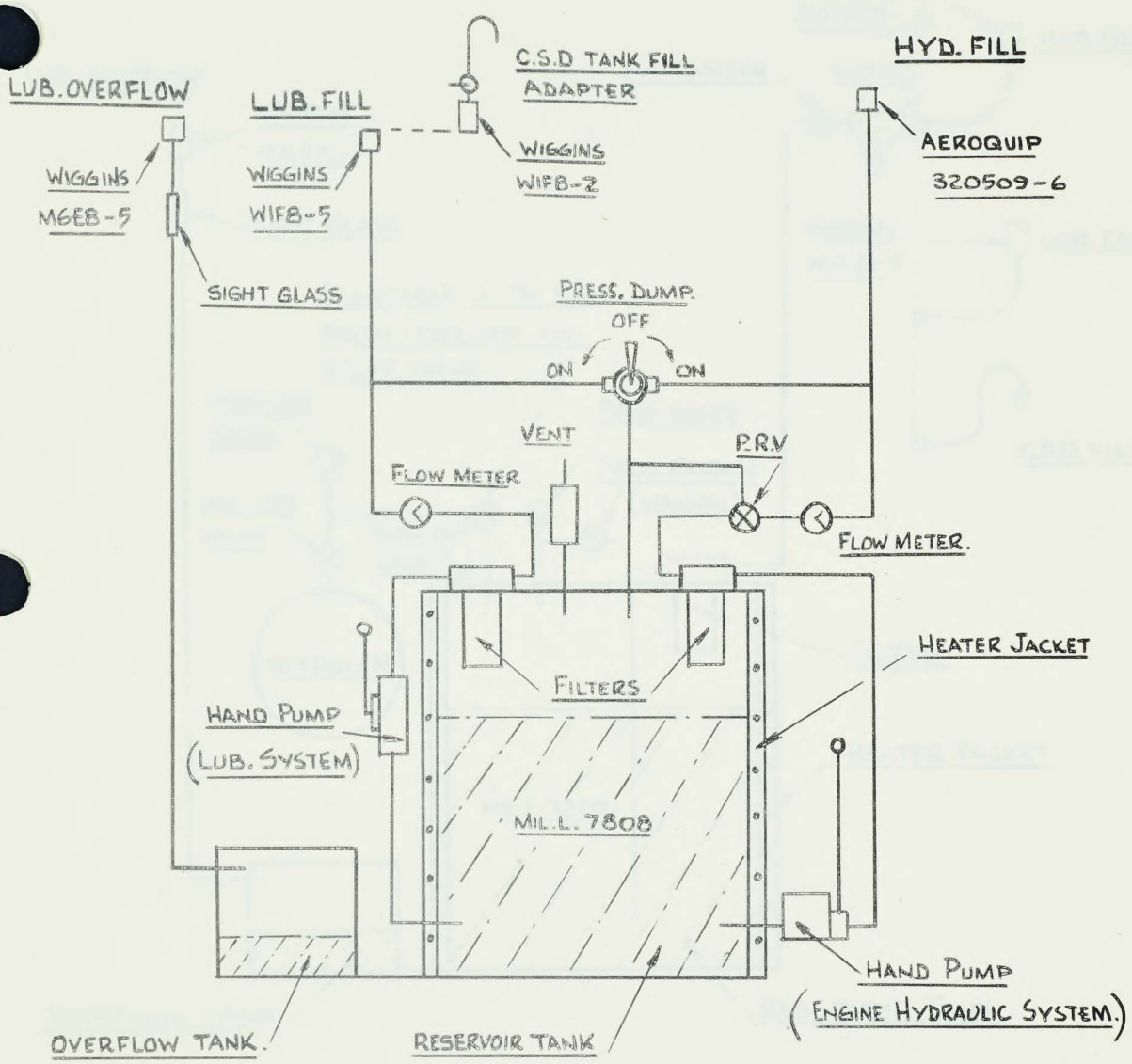


FIG. 1

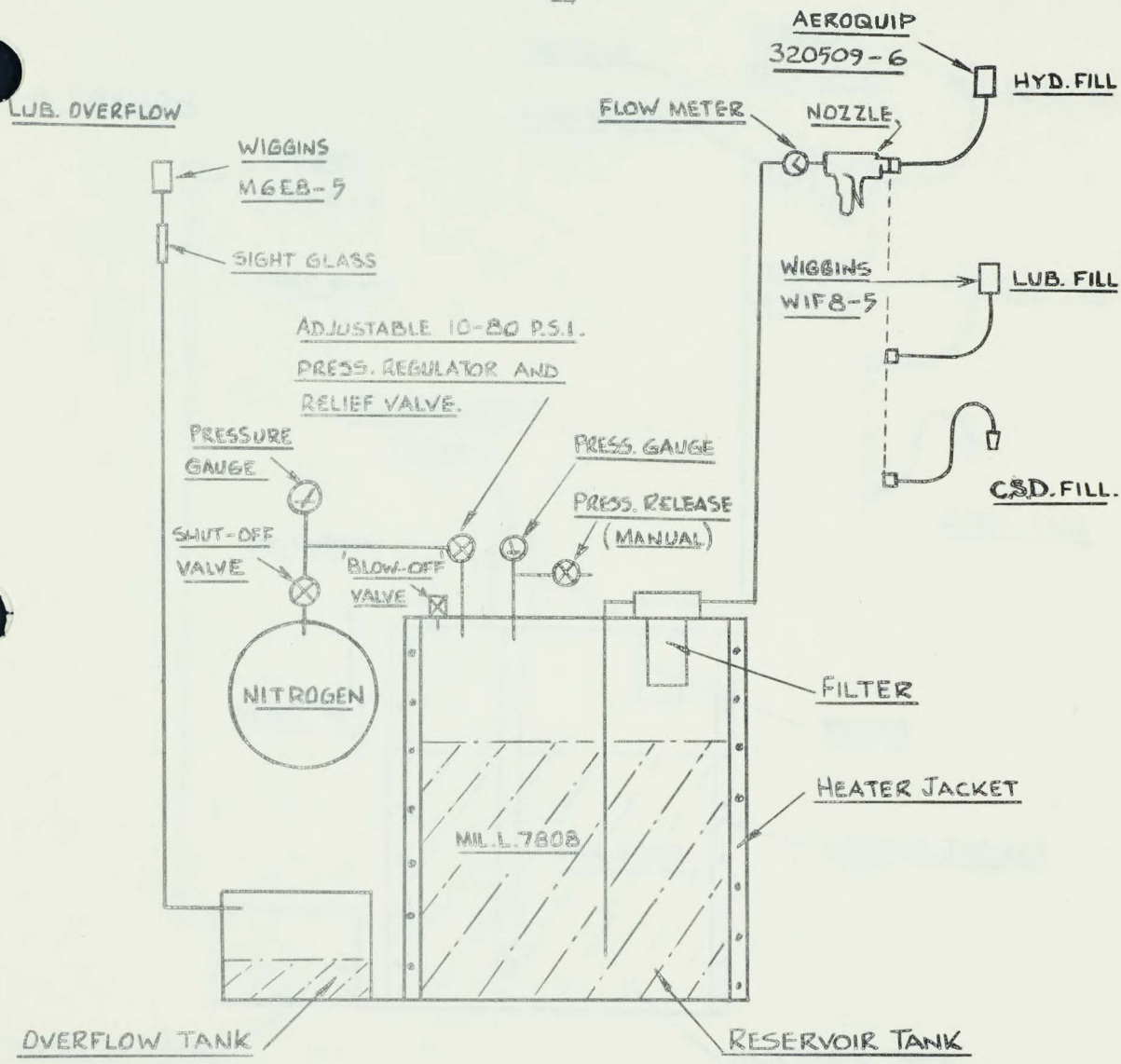
ESTIMATED PRESSURE DROP ACROSS A 5 MICRON FILTER



SCHEMATIC ARRANGEMENT

HAND PUMP METHOD

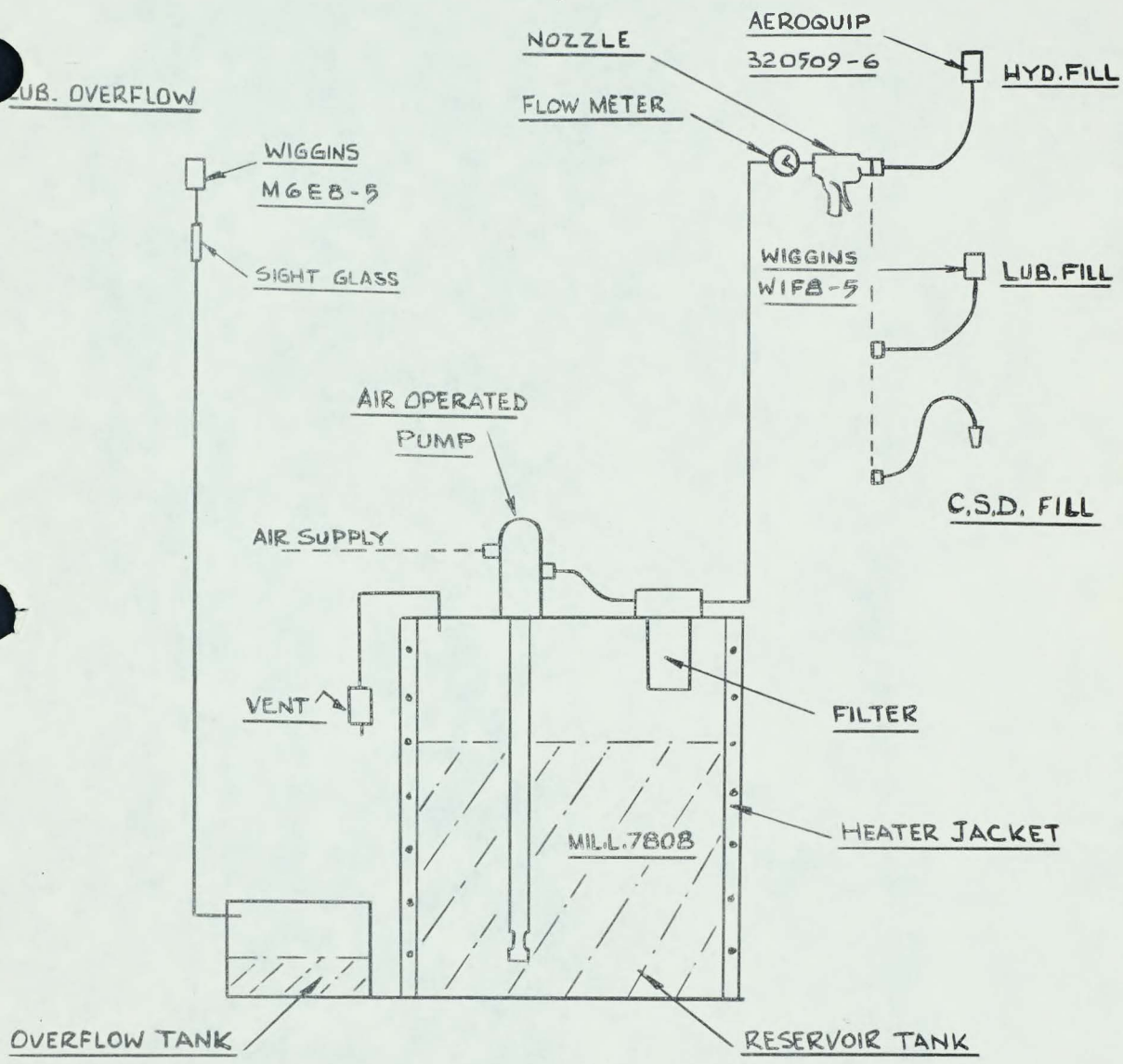
FIG.2.



SCHEMATIC ARRANGEMENT

PRESSURIZED METHOD

FIG. 3.



SCHEMATIC ARRANGEMENT

AIR PUMP METHOD

FIG. 4.