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ROYAL CANADIAN AIR FORCE

EXPERIMENTAL PROJECT

REPORT 2024

EXPEDITOR 3NM - COLD WEATHER TESTS

CENTRAL EXPERIMENTAL AND PROVING ESTABLISHMENT

CLIMATIC DETACHMENT

NAMAO - ALBERTA

JUNE 1954

ISSUED BY AIR OFFICER COMMANDING AIR MATERIEL COMMAND ON AUTHORITY OF THE CHIEF OF THE AIR STAFF

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NAMAO, ALBERTA

REPORT 2024

EXPEDITOR 3NM - COLD WEATHER TESTS

REFERENCE: AMC EP 53/130 dated 23 Sep 53

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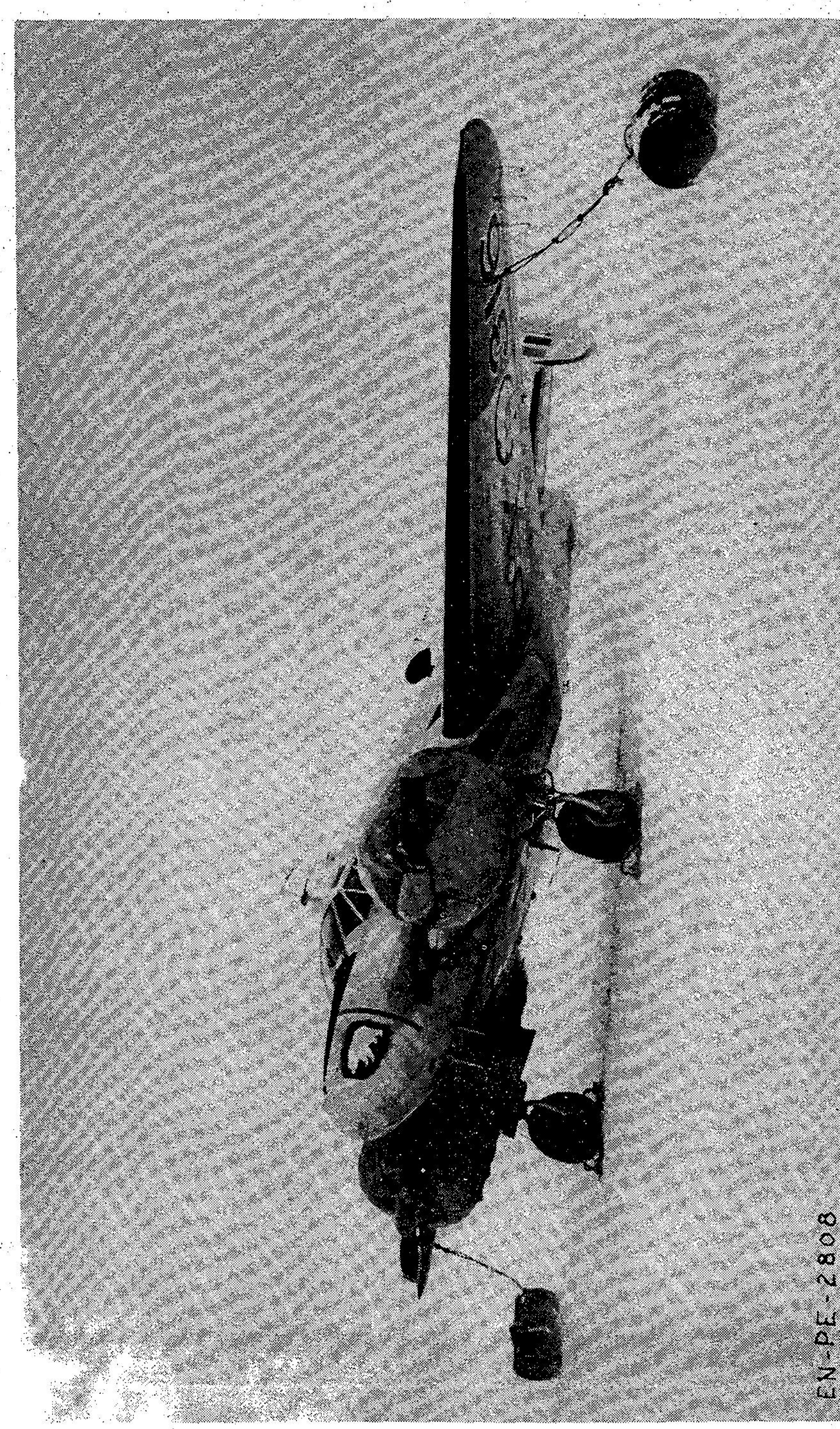

Frontispiece - Beechcraft Expeditor 3NM 2316 at Fort Churchill

Frontispiece - Beechcraft Expeditor 3NM 2316 at Fort Churchill

EXPEDITOR 3NM - COLD WEATHER TESTS

SUMMARY

Introduction

This report describes cold weather tests conducted by the Central Experimental and Proving Establishment, Climatic Detachment, on a Beechcraft Expeditor 3NM aircraft (RCAF serial number 2316) during the winter of 1953-54. The aircraft was a twin-engined navigation trainer bult by the Beech Aircraft Corp and powered with Pratt and Whitney Wasp Jr (R985-AN-14B) engines. The tests were conducted under the authority of AMC EP 53/130 dated 23 Sep 53.

Purpose

The tests were conducted to:

(a) test the weatherization of the Expeditor 3NM generally;

(b) investigate methods of starting the engine satisfactorily in cold weather;

(c) investigate cabin temperatures during cold weather; and

(d) test modifications to several aircraft systems and make recommendations regarding their suitability.

Method

The aircraft was ferried to Fort Churchill, Manitoba, on 11 Jan 54 where cold weather tests were conducted until 13 Mar 54, when the aircraft was returned to Namao, Alberta. A total of 43:20 hours were flown during this period. The aircraft was dispersed outside and was exposed to a minimum temperature of -36°C, falling and blowing snow, frost, wind and general winter weather. On returning to Namao, tests were continued until 4 May 54 on the high pressure feathering dilution system to assess its operation during warm weather.

Conclusions

It was concluded that the aircraft was not suitable for cold weather operation and did not meet RCAF cold temperature specifications.

Recommendations

It is recommended that the aircraft be retained for tests on several of the aircraft systems and/or components.

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EXPEDITOR 3NM - COLD WEATHER TESTS

INTRODUCTION

1 A Beechcraft Expeditor 3NM aircraft (RCAF serial number 2316) was supplied to the Central Experimental and Proving Establishment, Climatic Detachment, Namao, Alberta, for cold weather tests during the 1953-54 season under the authority of AMG EP 53/130 dated 23 Sep 53. The aircraft was fitted with two Pratt and Whitney Wasp Jr (R985-AN 14B) engines. A Hamilton Standard two-bladed, full feathering, hydromatic propeller was fitted to each engine.

2 The objectives of the tests were:

(a) to test the weatherization of the Expeditor 3NM generally;

(b) to investigate methods of starting the engine satisfactorily in cold weather and to evolve techniques or modifications as required to improve cold weather starting;

(c) to investigate cabin temperatures during cold weather and make or recommend modifications as necessary to improve cabin heating; and

(d) to test modifications to the following systems and make recommendations regarding their suitability:

(i) crankcase breather vent line;

(ii) windscreen defrosting;

(iii) carburettor hot air valve;

(iv) engine controls;

(v) propeller feathering; and

(vi) nose fuel tank vent line.

3 The aircraft was received on 24 Nov 53 and an extensive modification program was undertaken which consisited of several local modifications including changes to, and installation of, components

supplied by the Beech Aircraft Corp, as well as incorporation of test equipment. Because of the extensive modification program, winter tests did not commence until 11 Jan 54. The aircraft was ferried to Fort Churchill, Manitoba, on 11 Jan 54 where cold weather tests were conducted until 13 Mar 54 when the aircraft was returned to Namao, Alberta. A total of 43:20 hours were flown during this period. During the test program at Fort Churchill, the aircraft was dispersed outside except for certain maintenance operations, and was exposed to a minimum temperature of -36°C, falling and blowing snow, frost, wind and general winter weather. On one occasion the aircraft was dispersed during a blowing snow storm with windspeed peak gusts as high as 90 mph. Most of the maintenance required was done in the hangar because of limited manpower available for the project. A chronological resumé of exposure data, flying and ground running times, and general serviceability state, is shown in Appendix "A".

4 On returning to Namao on 13 Mar 54, a minor inspection was carried out and the aircraft was used for general transport duties. However, tests were continued until 4 May 54 on the high pressure feathering dilution system, to assess its operation during warm weather.

5 The publications and engineering drawings available during the test season are listed in Appendix "B". The modification status, including local modifications incorporated on the aircraft before and during the test period, is shown in Appendix "C". Details of the local modifications are given in the appropriate paragraphs of this report.

TESTS AND RESULTS

Sec 1 - AIRFRAME GENERAL

Lubrication

6 Before the test season began the aircraft was lubricated as detailed in EO 05-45B-7A, Sec I. No lubrication difficulties were encountered with the airframe throughout the tests at temperatures down to -36°C.

Aircraft Finish

7 During the acceptance check the aircraft was spray-painted with northern markings, and unit identification letters were added. The surfaces were first washed with soap and water. One coat of Zinc Chromate Primer (RCAF Ref 33A/462) was applied, followed by

two coats of Bright Red Enamel (RCAF Ref 33A/147) or Black Enamel (RCAF Ref 33A/145). The RCAF roundels on the wings and fuselage, presumably put on by the manufacturer, showed no signs of scaling when the aircraft was accepted. After two weeks of cold weather operation in temperatures down to -36°C, scaling of paint from the roundels on the undersurface of the wings and on the fuselage, was noticed. By the end of the test program these roundels had scaled sufficiently to require repainting. Figure 1 shows the condition of the paint at the end of the test period. No noticeable deterioration of the northern markings or unit identification letters occurred. It was concluded that the RCAF roundels had scaled due to insufficient preparation of the metal surface before painting. It is recommended that the manufacturer be advised of this defect.

Fig 1 - Roundel on Lower Surface of Port Wing

Cabin Wall Covering

8 The leatherette upholstery on the cabin walls split, presumably because of excessive shrinkage of the leatherette at low temperatures. During the test season splits occurred at seven positions on the cabin wall. In all cases discovery was made during the

daily inspection after the aircraft had been dispersed overnight at temperatures from -30°C to -35°C. One of the larger splits which occurred is shown in Fig 2. In Fig 3, which shows the leatherette on the aft cabin wall, previous damage is indicated by the mark in the insulating material underneath at the centre of the star-shaped split. This was

Fig 2 - Split in Leatherette on Starboard Cabin Wall

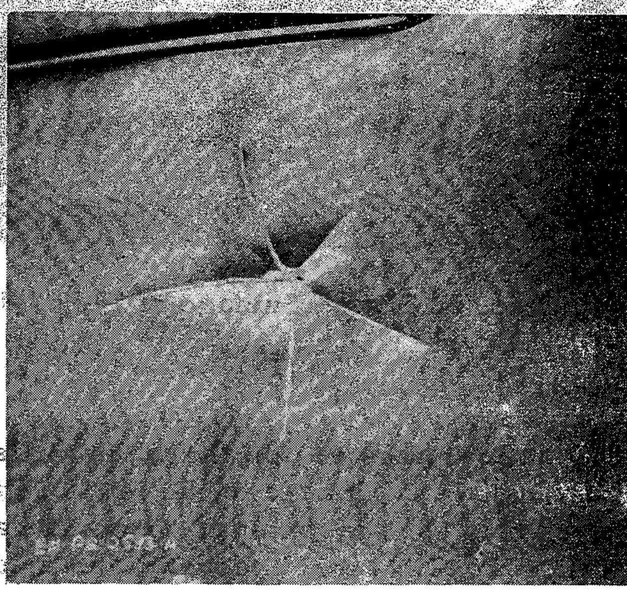

Fig 3 - Split in Leatherette on Aft Cabin Wall the only instance where evidence of previous damage was discovered. Examination of the damaged fabric revealed that, although it became quite stiff at low temperatures, it did not become brittle. The leatherette was not easily damaged further after the tautness had been relieved by the original split. If it is found that the damage to the test aircraft was not an isolated case, it is recommended that a more suitable upholstery material be used. It is believed that if the leatherette had been fitted more loosely the difficulty would not have occurred.

Sec 2 - AIRCRAFT COVERS AND BLANKING PLATES

General

9 The following covers were supplied for use with the aircraft:

(a) cockpit cover - (RCAF Ref 27D/654);

(b) wing and wheel covers - (RCAF Ref 27D/644 and 27D/645);

(c) tail cover - (RCAF Ref 27D/646); and

(d) engine covers - (RCAF Ref 27D/652 and 27D/653).

10 In addition, the following covers and blanking plates were manufactured locally for use during the test period:

(a) carburettor air inlet covers;

(b) pitot head covers;

(c) blanking plugs for heating and ventilating system air inlets; and

(d) blanking plugs for oil cooler air inlets.

11 The aircraft was dispersed at Namao with all covers and blanking plates installed, from 23 Dec 53 to 27 Dec 53, and again from 31 Dec 53 to 3 Jan 54. During the dates mentioned the aircraft was in the process of modification for winter tests. On the first occasion wet snow and freezing rain occurred. The cockpit cover, tail cover, and wing and wheel covers froze to the aircraft surfaces and could not be removed without damage to the covers. To expedite the modification

program, the aircraft was moved into the hangar to melt the ice rather than apply heat to thaw and free the covers. When the aircraft was again dispersed on 31 Dec 53, the time required to install the covers was recorded. Two men, wearing winter clothing, installed all the covers and blanking plugs in 1:25 hours. The temperature was -15°C and the wind speed was 15 mph. A breakdown of the time required to install each of the larger covers is mentioned later in this section. During dispersal from 31 Dec 53 to 3 Jan 54, only light blowing snow occurred and no difficulty was encountered.

12 During the test program at Fort Churchill, it was found that the tail cover, and wing and wheel covers were not necessary. The aircraft was dispersed throughout the test program at Fort Churchill without using these covers and no unserviceabilities occurred from frost, snow or blowing snow. Less time was required to remove frost and snow from the aircraft surfaces than would have been required to install, and later remove, the covers.

Cockpit Cover

13 The cockpit cover was made of nylon and weighed two pounds. Two men, wearing winter clothing could install the cover without difficulty, in five minutes in winds of up to 20 mph. Figure 4 shows the cover on the aircraft. The cover was not tailored properly around the antennae at the top of the fuselage, nor did it fit securely along the sides of the cockpit.

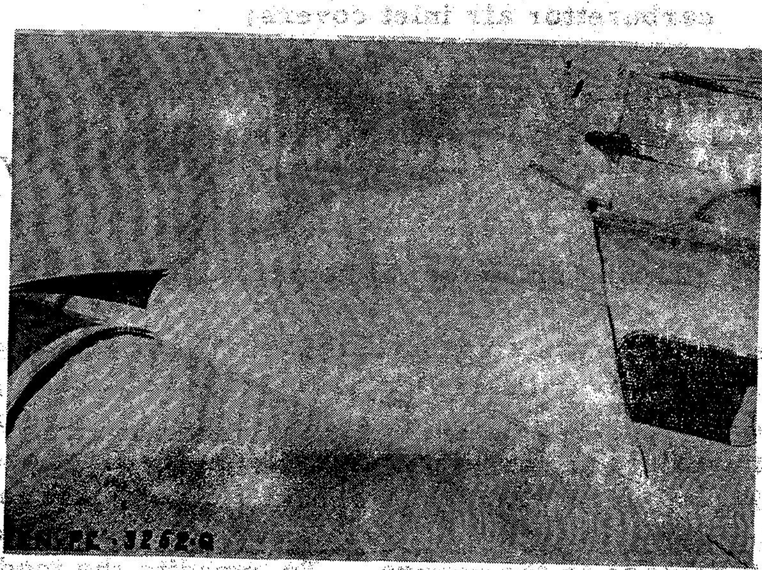

Fig 4 - Cockpit Cover Installed on the Aircraft

14 The cover prevented the formation of frost on the windscreen and cockpit windows but during conditions of blowing snow with a windspeed in excess of 40 mph the cover did not prevent snow from entering the cockpit through the sliding windows. Figure 5 shows the accumulation of snow on the port cockpit wall. The snow was removed before it melted and no damage resulted.

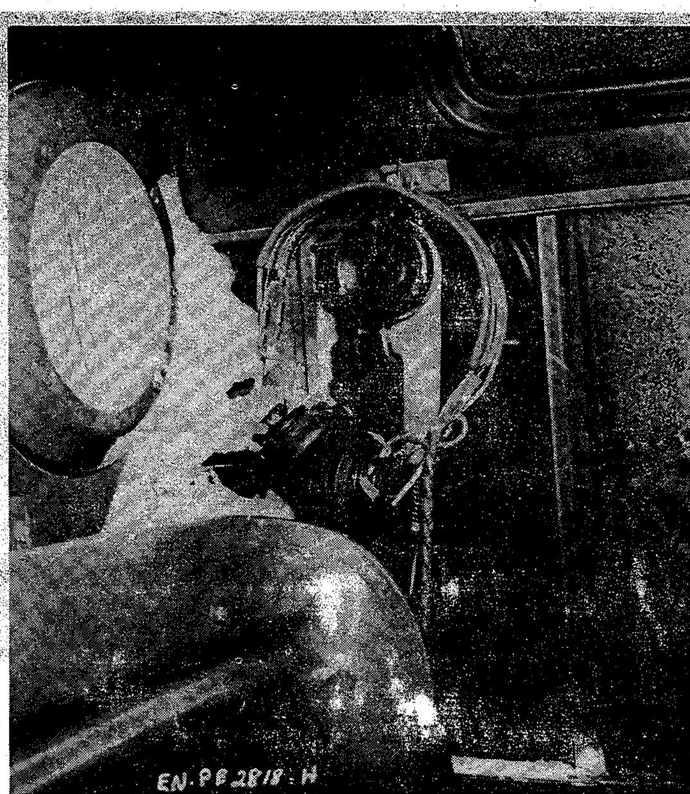

Fig 5 - Accumulation of Snow on Port Cockpit Wall

15 It was concluded that the cover was of little value except in preventing formation of frost on the windscreen and windows. It is recommended that the cover be redesigned to provide a closer fit around the cockpit windows, and that a material be used that will not freeze to the aircraft in conditions of wet snow and freezing rain.

Wing and Wheel Covers

16 The wing and wheel covers were made of the same nylon material as the cockpit cover. Each wing and wheel cover weighed ten pounds. Two men, wearing winter clothing, installed the cover

in 35 minutes. The windspeed was 15 mph and the temperature -15°C. The aircraft with all covers installed is shown in Fig 6. The covers did not extend right up to the wing root and were not tailored properly over the inboard wing section between the nacelle and fuselage. It was necessary to provide access holes in the lower surface of the covers, near the wing tip, in order to use the tiedown lugs.

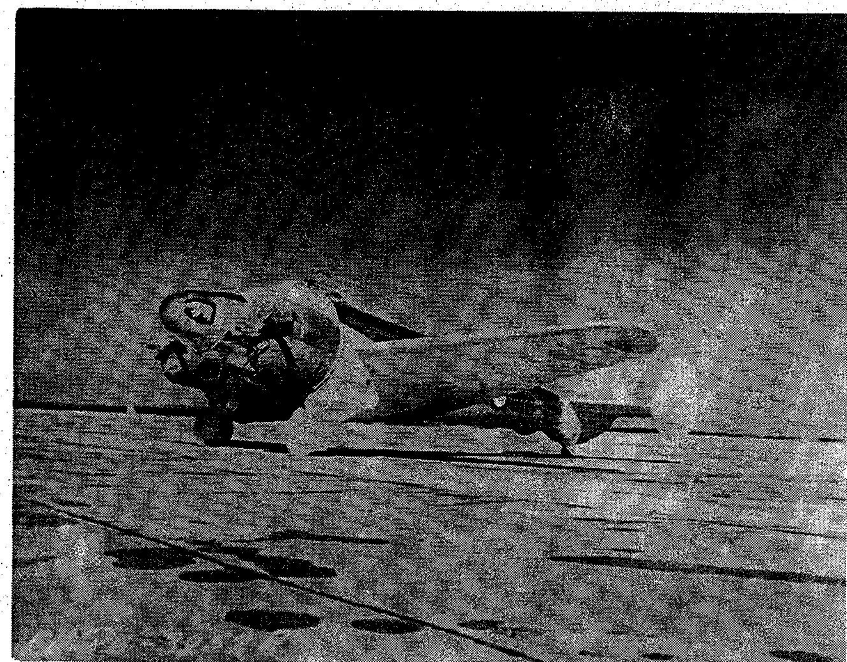

Fig 6 - Aircraft with Covers Installed

17 The covers were not used during the test season at Fort Churchill. No difficulty arose from snow or frost on the wings, or from snow in the wheel-well or in the control surface hinge lines. It was concluded that these covers would be of little use during winter operations because snow or frost could be removed from the aircraft in less time that would be required to install and remove the covers. On the one occasion when they were used during wet snow and freezing rain they froze to the upper wing surface and could not be removed without damage to the cover. It is recommended that these covers be dispensed with.

Tail Cover

18 The tail cover, which was a single unit that covered the entire empennage and tail-wheel-well, weighed 12 pounds and was made of the same material as the cockpit cover. This cover, which

is also shown in Fig 6, was installed by two men wearing winter clothing, in 25 minutes. The windspeed was 15 mph and the temperature was -15°C.

19 The cover was installed on two occasions only, as mentioned in para 11. This cover was found to be unnecessary during winter operations. The conclusions and recommendations for this cover are identical to those stated in para 17 regarding the wing and wheel covers.

Engine Covers

20 The engine covers were made of quilted canvas duck and each weighed 22 pounds. The covers were used throughout the test season and both covers were readily fitted during cold weather in 20 minutes by one man wearing winter clothing. Little difficulty was experienced fitting the covers at windspeeds of 30 mph. Figure 7 shows one of the covers installed on the starboard engine.

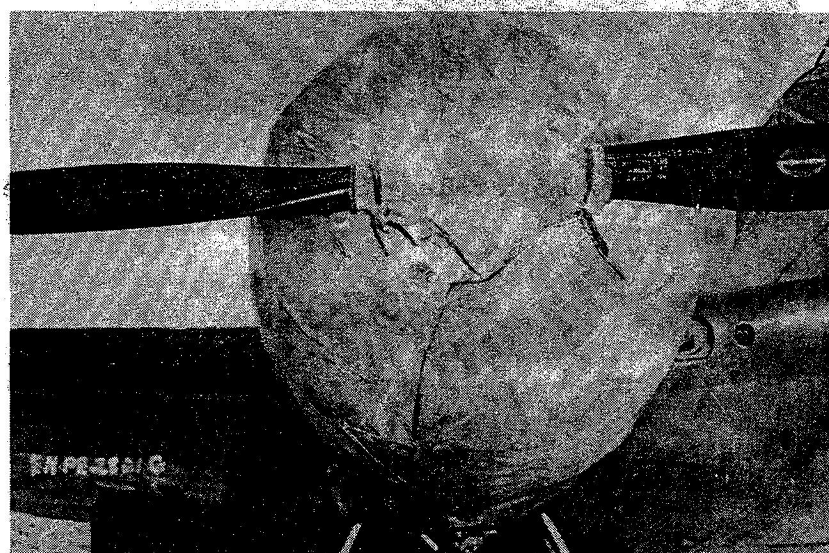

Fig 7 - Engine Cover Fitted to Starboard Engine

21 During most blowing snow conditions there was little or no snow entry into the engines when the covers were fitted. However, during blizzard conditions with the wind strength greater than 40 mph, snow entered through the overlap at the front of the cover, immediately below the propeller dome, and resulted in a heavy accumulation of snow around the front of the lower cylinders. The rear portion of the cover fitted loosely around the lower engine nacelle as can be seen in

Fig 8, and permitted snow to enter the crankcase and accessory sections through the space between the lower engine nacelle and wrappers. Fig 9 shows the spaces through which the snow entered.

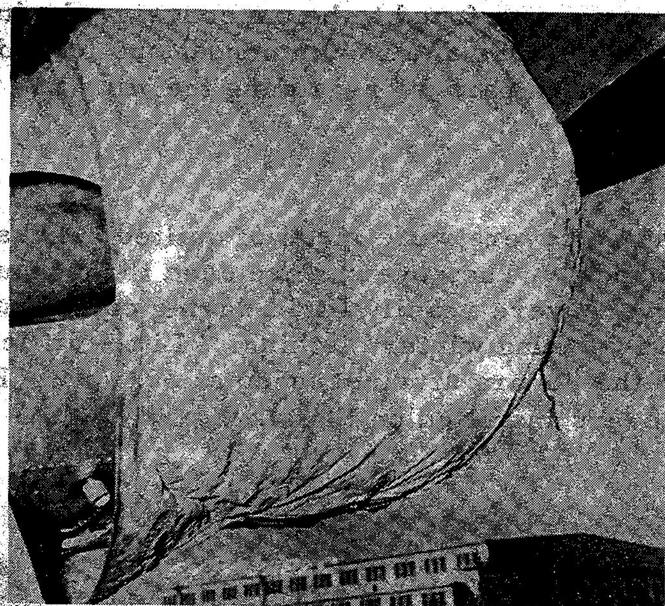

Fig 8 - Loose Fit of Lower Rear Section of Engine Cover

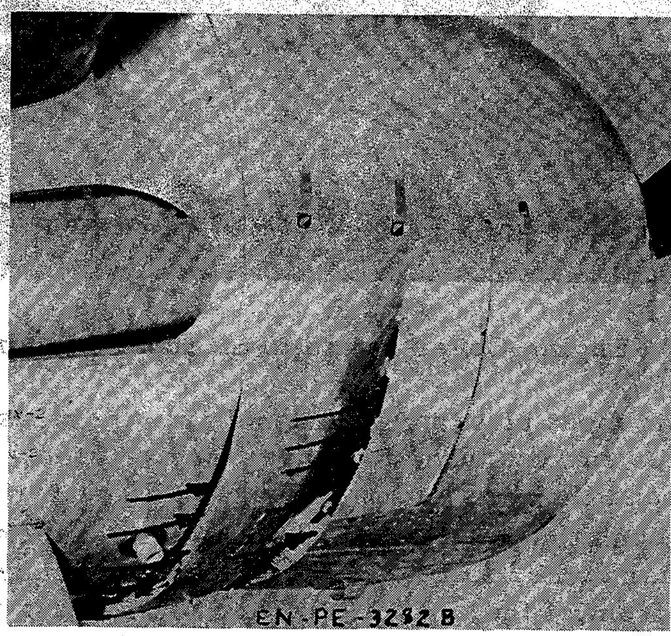

Fig 9 - Positions where Snow Entered into Crankcase and Accessory Sections

22 On one occasion after the aircraft had been dispersed into the prevailing wind during a blowing snow storm with windspeeds of 40 mph, the lower halves of the accessory sections of both engines were filled with snow. Although as much snow as possible was removed through the space provided by removing the wrapper assemblies, the remaining snow melted during engine warm-up and the resulting water froze on the port landing gear safety switch and gear door, as shown in Fig 10. The conditions on the starboard side was similar but the ice formation was lighter. The adhesion between the ice and metal was low, and the ice was easily broken away from the safety switch, shock absorber, and gear door retracting arm without the use of heat.

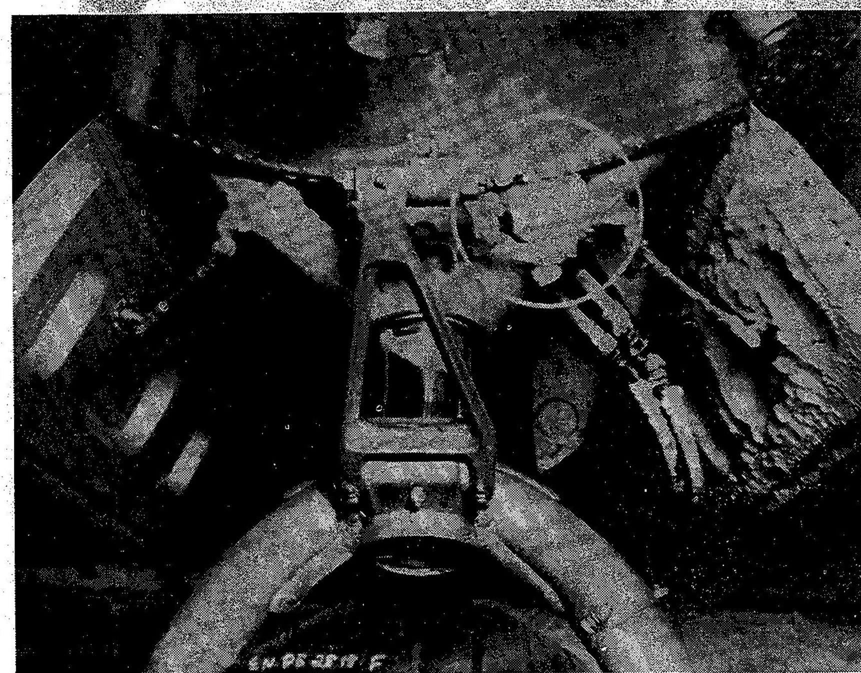

Fig 10 - Accumulation of Ice on Landing Gear Door and Safety Switch

23 To prevent the ingress of snow through the front of the engine cover, six canvas ropes were sewn to the cover and tied in pairs as shown in Fig 11. To provide a close fit between the rear of the cover and the nacelle, and thus prevent the entry of snow into the accessory and crankcase sections, a canvas strip, folded to accommodate a draw rope was sewn around the back of the cover as shown in Fig 12. An opening was provided in the canvas strip at the bottom of the cover to allow the rope to be pulled tightly and tied. No

opportunity arose to test these modifications during blizzard conditions. However, it was felt that the changes would provide complete protection against the ingress of snow.

Fig 11 - Modification to Front of Engine Cover

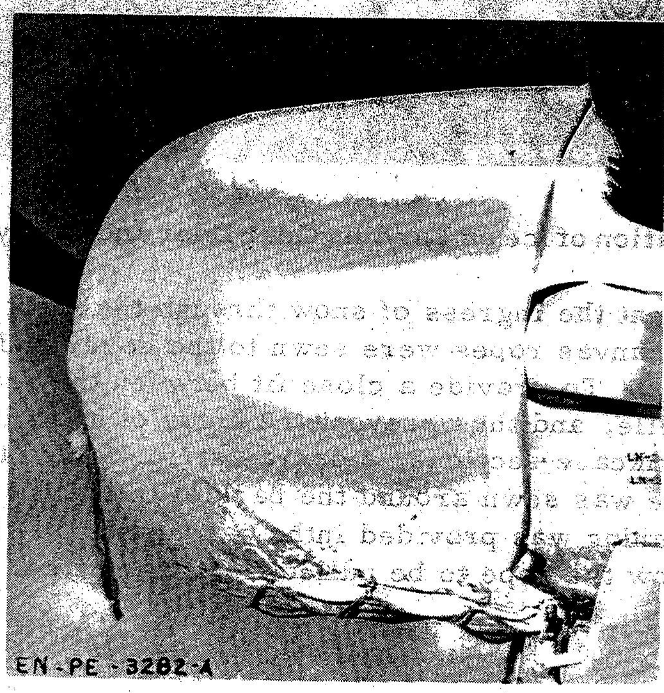

Fig 12 - Modification to Rear of Engine Cover

24 In view of the problems that were encountered with the landing gear discussed in para 22, and with the engine controls and carburettor heat valves as discussed later in Sec 5, it is considered essential that the engine covers be modified to ensure that snow cannot enter the engines under any conditions in which the aircraft might be dispersed. It is recommended that the modifications detailed in para 23 be adopted.

Carburettor Air Inlet Covers

25 The carburettor air inlet covers were made locally of ten ounce canvas duck (RCAF Ref 32B/253) and were fitted at all times when the aircraft was dispersed. The cover fitted over the lip of the air inlet and was secured by a draw-string around the bottom of the cover. Figure 13 shows the covers in place over the inlets on the starboard engine. The covers were effective in keeping snow from entering the inlets. These covers would not be necessary when the engine covers, modified as shown in Fig 11, are fitted. However, if engine covers are not used, it is considered essential that covers of this type be used during dispersal at near freezing temperatures or at temperatures below 0°C, if precipitation is anticipated. This would prevent ice from forming in the carburettor air scoop assembly during dispersal, or on a subsequent flight at temperatures below 0°C, and help to overcome the problem of the hot air valve freezing in the cold position as discussed in Sec 5.

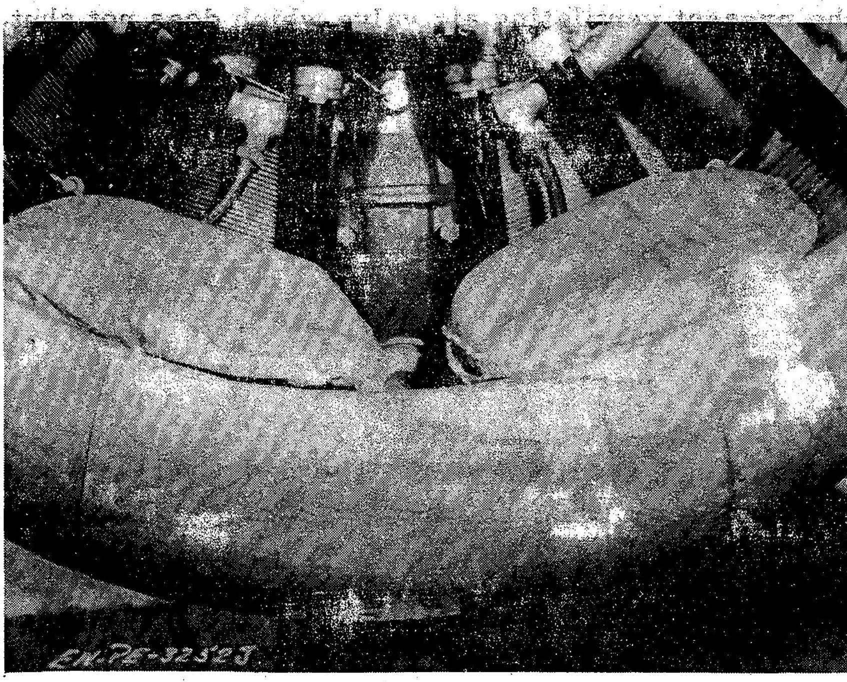

Fig 13 - Carburettor Air Inlet Covers

Pitot Head Covers

26 Pitot head covers were not supplied with the aircraft. Covers, of the type normally used on Expeditor aircraft, were manufactured locally of ten ounce canvas duck (RCAF Ref 32B/253). They were used throughout the test season when the aircraft was dispersed and were found to be effective under all conditions encountered.

Blanking Plugs

27 Blanking plugs were fitted to the heating system cold air inlets, and the ventilating air inlets. The ventilating air inlet plugs were left in place during flight to ensure that the ventilating system would be completely blocked off, while the plugs for the cold air inlets to the cabin air valves were used during dispersal only. The plugs consisted of a three-eighths-inch thick sponge-rubber disk between aluminium discs, each one-sixteenth inch thick and one and five-eighths inches in diameter. A bolt passing through the centre held the three pieces together. By tightening the wing nut on the end of the threaded bolt, the sponge-rubber expanded sufficiently to hold the plug securely in place. Figure 14, item A shows one of these plugs in the starboard ventilating air inlet. The plugs for the cabin air valve inlets were identical but locking wire was not used and a red canvas streamer was attached to the plug. The plugs were considered necessary to prevent damage that would be caused by snow entry during dispersal. It is also recommended that the plugs for the ventilating air inlet be left in place during flights in cold weather until a suitable valve is supplied to replace the present ventilating air valve which does not shut off the cold air completely.

Fig 14 - Oil Cooler Air Inlet and Ventilating Air Inlet Blanking Plugs

28 The blanking plugs for the oil cooler inlets were fabricated locally of half-inch spruce with a five-eighths inch felt stripping around the edge. Figure 14, item B shows one of these plugs in position. The plugs were effective in stopping snow entry and are recommended for use during dispersal when snow or freezing rain is anticipated.

Sec 3 - ACCESS PANELS, HATCHES, WINDOWS AND DOORS

Access Panels

29 All access panels were provided with Dzus fasteners and no difficulty was encountered in removing any of the panels during the test season, providing gloves were worn rather than mitts.

Hatches and Windows

30 The emergency escape panel in the cabin fitted securely at all temperatures encountered, and no snow entry occurred during dispersal even in blizzard conditions. The panel was not opened during the cold weather test period.

31 The cockpit sliding windows could be opened and closed without difficulty under all conditions encountered but did not fit tightly enough to prevent the entry of snow during blizzard conditions even when the cockpit cover was fitted, as discussed in para 14. The entry of snow into the cockpit from the port window is shown in Fig 5. Less snow entered through the starboard window because the wind direction was from the port front quarter. It is believed that a more effective cockpit cover as recommended in para 15, would remedy the fault.

Doors

32 The cabin door opened and closed without difficulty at all temperatures encountered except on one occasion when the rubber seal around the door frame froze to the fuselage after the aircraft had been dispersed in freezing rain. The door was opened without damage to the rubber seal by first tapping around the edge of the door with the fist. The ice around the door frame was then broken off by hand, after which the door opened and closed normally. There was no snow entry from around the door during dispersal even in blizzard conditions.

Sec 4 - FLYING CONTROLS SYSTEM

Main Controls

33 No quantitative tests were conducted on control forces or cable tensions but the controls were operated without difficulty at temperatures as low as -36°C. There were no instances of the controls becoming jammed with snow or ice although the aircraft was dispersed without wing or tail covers in blowing snow.

Trim Tabs

34 No difficulty was experienced with the operation of the elevator or aileron trim control systems either on the ground or in the air. The rudder trim control system, however, did not always function properly at temperatures below -25°C. It was believed that differential contraction in the system was sufficient, below -25°C, to cause slack in the cables which allowed the drive pulley to slip on the cable. The rudder trim position indicator could not be relied upon because slippage could also occur between the cable and the pulley which operated the indicating mechanism. Slippage did not occur unless the adjusting handle was moved rapidly. However, to ensure "zero" trim for the take-off, it was necessary to make a visual check of the trim tab by looking out the pilot's side window. During the test period a cable tension indicator could not be obtained which would measure the low cable tension of 10 ± 2 pounds specified for the cables so no adjustments were made. The difficulty with the trim indicator had been reported previously by other units and the present indicator will be replaced by an indicator with a gear and chain mechanism. The new indicator will overcome the difficulty. Information on this difficulty is the subject of EO 05-45B-5A/14.

Sec 5 - ENGINE CONTROLS SYSTEM

General

35 The throttle, CSU, mixture, oil shutter, carburettor heat and cowl flap control systems were operated by cables enclosed in spiral-wound spring steel conduit control assemblies. The inner fittings on each cable were telescoping tube assemblies. The inner fixed tube was swaged to the cable housing, and the outer movable tube was swaged to the cable end. Neither portion of the telescoping assembly was removable. The clearance between the inner tube and outer tube was approximately 0.006 inches. The cables are referred

to by the trade name "Teleflex" in EO 05-45B-7A but no RCAF reference or manufacturer's part number could be found on any of the cables. On the carburettor heat and cowl flap control systems the "Teleflex" cables actuated push-pull rod mechanisms which passed through the inner cowl and fire wall. The other systems were connected directly between the cockpit and the respective engine components by "Teleflex" cables.

36 The AMC directive stated that there had been several reports of all engine controls being stiff and difficult to operate, and of the carburettor hot air valve seizing in the "COLD" position. The Beech Aircraft Corp supplied silicone rubber grommets to replace the neoprene grommets installed at the inner cowl and firewall for the carburettor heat and cowl flap push-pulls rods, which it was felt would reduce the stiffness of these controls. The Beech Aircraft Corp considered that oil and foreign matter within the control housings was causing most of the trouble. A lubricating and cleaning adapter for the "Teleflex" cables, recently developed by the RCAF, was manufactured by 6 Repair Depot and supplied to the detachment for cleaning and lubricating the "Teleflex" cables.

37 The Beech Aircraft Corp developed a ducting system to supply a continuous flow of hot air around both sides of the carburettor air scoop assembly which, it was believed, would keep the carburettor hot air valve from freezing in the cold position. Parts for this "heater-muff" system were supplied to the detachment and the "heater-muff" was incorporated as a local modification to the starboard air scoop assembly. The port assembly was left unmodified for comparison tests.

Rubber Grommets

38 The grommets supplied by the Beech Aircraft Corp for the cowl flap and carburettor heat push-pull rods were identical in size and shape to the black neoprene rubber grommets (part number 73-2909) but were made of red silicone rubber. Both types were tested in the detachment's cold chamber and it was found that the silicone grommets remained pliable when cold soaked at a temperature of -28°C while the neoprene grommets were very stiff when cold soaked to the same temperature. The silicone grommets were fitted to the controls of the starboard engine and the port engine controls were left unmodified.

39 Because of problems encountered with the cowl flap and carburettor heat systems discussed later in this section, which resulted in extremely high operating forces, it was not possible to assess the difference in operating forces between the port and starboard systems.

It was concluded that any difference in operating force that may have occurred, because of two types of grommets, would be negligible in comparison to the extremely high forces encountered due to other causes. It is recommended that the neoprene grommets not be replaced on Expeditor aircraft at the present time. However, when replacement becomes necessary due to deterioration or wear, it would be adviseable to use silicone rubber grommets.

Control Cable Lubrication

40 A cleaning and lubricating adapter (RCAF Ref 4G/1764) was supplied for cleaning and lubricating the engine control cables. Naptha gas (RCAF Ref 33E/26) was used for cleaning, and a mixture of naptha gas and powdered graphite (RCAF Ref 33C/51) was to be used for lubricating.

41 The end of a "Teleflex" cable inserted in the adapter, is shown in Fig 15; at (A) is a removable rubber plug, (B) is a clamp to hold the plug and cable in position inside the rubber hose (C), and (D) is the metal cylinder filled with the cleaning fluid. A threaded hole at the end of the cylinder was attached to the grease fitting to supply pressure to force the cleaning fluid between the slide tubes and along the inside of the cable housing to remove oil and foreign matter, after which naptha gas and powdered graphite was to be placed in the cylinder to lubricate the entire cable.

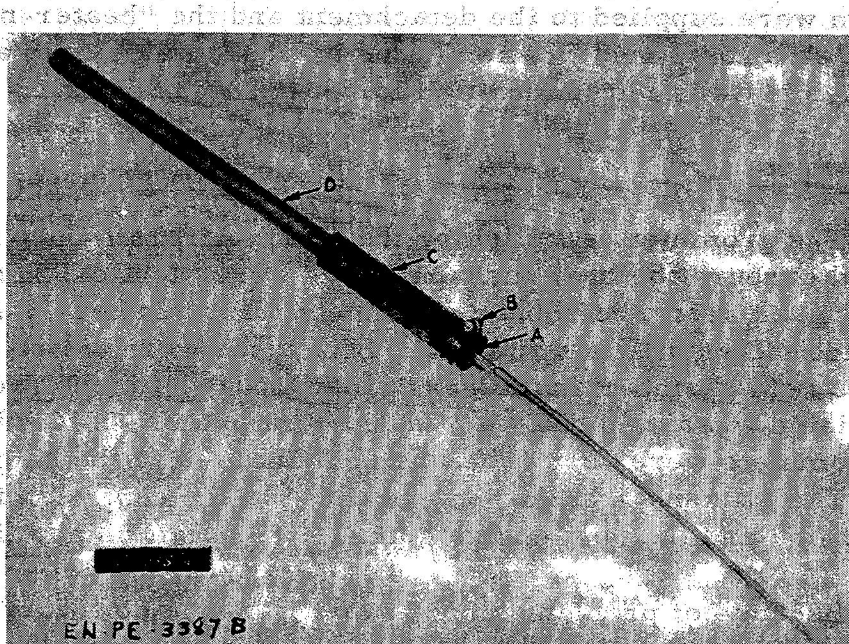

Fig 15 - "Teleflex" Cable Inserted in Cleaning and Lubricating Adapter

42 All efforts made to clean or lubricate the cables on the test aircraft were unsuccessful. When naptha gas was forced from the adapter into the end of the cable under a pressure of 100 psi, the gas leaked out through the spiral-wound covering approximately 18 inches down the cable. The adapter was used successfully to clean and lubricate an oil cooler control (part number 26 JQ/2119041) from a Dakota aircraft. This control had a lacquered fabric covering. Figure 16 shows diagramatically the construction of the two cables and the flow of the fluid through each. It was concluded that the adapter was developed for use with cables similar to the Dakota type and could not be used on the type of cable installed on the Expeditor.

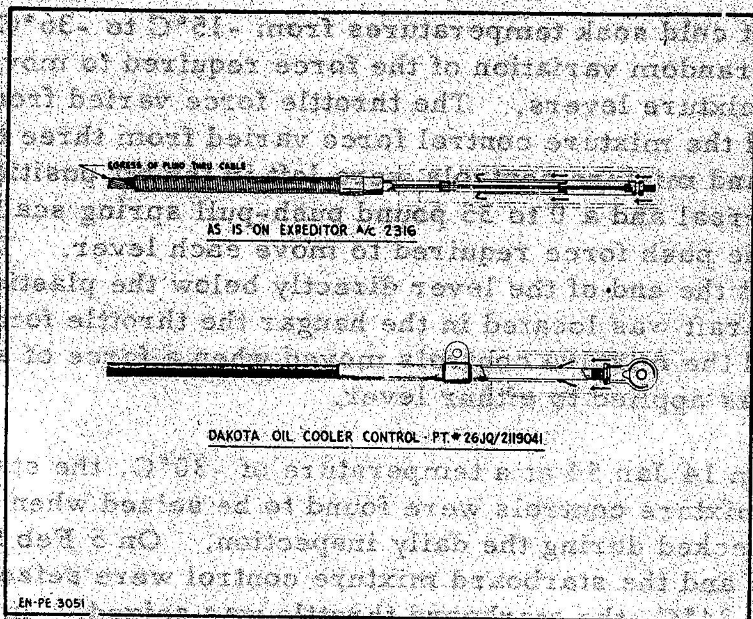

Fig 16 - Method of Cleaning and Lubricating Cables Using Adapter

43 Since it was not possible to lubricate the control cables internally, the slide tubes at the end of each CSU, oil shutter, throttle, mixture, cowl flap, and carburettor heat control cable were cleaned with naptha gas and lubricated with powdered graphite.

44 Difficulty arose early in the test season from stiff and seized controls. The slide tubes at both ends of the controls on the port engine were lubricated with low temperature grease (RCAF Ref 34A/192) on 6 Feb 54, to compare this lubricant with graphite lubrication. Low temperature grease did not reduce control operating forces when used on the slide tubes but there was some evidence to indicate that it would prevent, or reduce the frequency of seized controls. It was determined that seized and stiff controls resulted from

frozen condensate and not from oil and foreign matter in the cable housing because control forces were not a function of the cold soak temperature but depended on operating conditions in blowing snow. If oil in the cable housing was causing stiff controls, the control forces would have increased at low temperatures instead of having a random variation. Other factors, in addition to slide tube stiffness, affected the operation of the cowl flap and carburettor heat control systems. The difficulties encountered with each control system are described in the following paragraphs of this section.

Throttle and Mixture Controls

45 At cold soak temperatures from -15°C to -36°C there was a completely random variation of the force required to move the throttle and mixture levers. The throttle force varied from three to 30 pounds and the mixture control force varied from three to 28 pounds. The throttle and mixture controls were left in the aft position during aircraft dispersal and a 0 to 35 pound push-pull spring scale was used to measure the push force required to move each lever. The force was applied at the end of the lever directly below the plastic knob. When the aircraft was located in the hangar the throttle forces were negligible and the mixture controls moved when a force of approximately two pounds was applied to either lever.

46 On 14 Jan 54 at a temperature of -30°C, the starboard throttle and mixture controls were found to be seized when engine controls were checked during the daily inspection. On 5 Feb 54 at -20°C, both throttles and the starboard mixture control were seized, and on 13 Feb 54 at -34°C, the starboard throttle was seized. In all cases the engines had been ground run the previous day during blowing snow conditions just prior to overnight dispersal of the aircraft. No snow or ice was found on or near the end fittings of the controls, although on two of these occasions there was a little snow in the crankcase and accessory sections of the engines. The throttle and mixture levers had been left in the aft position so that the outer slide tube of each control cable was covering the inner slide tube. On each seized control the outer slide tube could not be moved or rotated. The slide tubes on the ends of the other engine control cables could be rotated freely by hand. By applying heat into the cowling of each engine, through the space provided by removing the wrapper assemblies, the controls were freed. No method was available to apply heat locally at the slide tubes so heat was supplied from one duct of a Herman Nelson BT400 heater (RCAF Ref 4G/1634). On 14 Jan 54 and 5 Feb 54, heat was applied for five minutes to each engine after which the controls operated

normally. On 13 Feb 54 heat was applied for approximately two minutes, after which a droplet of water was observed at the end of the outer slide tube of the starboard throttle control. No water was found on the slide tubes of the other controls. The throttle operated normally after the heat had been applied. On one occasion after the engines had been ground run during blowing snow conditions, the starboard mixture control was found to be frozen when engine controls were checked 25 minutes after the engines were stopped. The temperature was -18°C and the wind strength approximately 30 mph.

47 It was concluded that the frozen controls resulted from ground running during blowing snow conditions. It was believed that snow, on entering into the cowling, melted and water or moisture formed on the exposed inner slide tubes of the throttle and mixture controls. After engine shut down the throttle and mixture control levers were always moved to the aft position which would move the outer slide tube forward over the inner slide tube. During engine cooling after ground running, the water or moisture between the outer and inner slide tubes formed a film of ice or frozen condensate. It was not determined whether the throttle and mixture controls would freeze if the levers were placed in the forward position after engine shut down.

48 The throttle and mixture controls operated normally during flight except on one occasion. After a rapid descent at 2000 feet/minute from 6000 feet to 1000 feet at an indicated airspeed of 200 knots with the engines operating at reduced power, difficulty was experienced in operating the starboard throttle. The OAT was -25°C at 6000 feet and -28°C at 1000 feet. A force, estimated at approximately 30 pounds, was required to move the throttle from the idle position. The throttle remained extremely stiff throughout the remainder of the flight. The control was inspected when the engine was stopped immediately after landing. A mixture of graphite and water was found on the slide tube of the throttle control at the engine connection. The mixture was partly solidified. During the daily inspection preceding this flight, excessive snow had been discovered in the crankcase and accessory sections of both engines. As much of the snow as possible was removed before the engines were started and there was no snow or ice left in the immediate vicinity of any of the engine controls. However it is believed that water formed on the slide tube, after engine start, from snow which could not be removed from the engine without removing the cowlings. During the rapid descent at reduced power, the temperature in the engine bay probably decreased sufficiently to freeze the mixture of graphite and water on the slide tube causing the excessively high throttle force.

49 A more thorough investigation into the problem of frozen throttle and mixture controls could not be conducted during the test period without seriously interfering with other phases of the test program. There were two instances of frozen throttle or mixture controls after low temperature grease was used on the port controls. In both of these cases, only the starboard controls, which were graphite lubricated, froze. However it was not definitely established whether low temperature grease would prevent slide tube seizure.

50 On returning to Namao, tests were conducted in the detachment's cold chamber to determine the effect of moisture on the telescoping assembly of the "Teleflex" control cable when graphite or low temperature grease lubricants were used. A "Teleflex" cable, of the type used on the engine controls of the test aircraft, was cold soaked in the chamber for 30 minutes at a temperature of -30°C under each condition investigated. At the conclusion of each cold soak interval the cable was removed from the chamber and the force required to move the control cable was measured using a spring scale. When the slide tubes at each end of the cable were lubricated with graphite, the operating force, measured after the cold soak period, was four pounds. The same operating force was required when the cable was cold soaked under identical conditions but with low temperature grease used for slide tube lubrication.

51 With the cable end fittings graphite lubricated a thin film of moisture was applied to the inner tube at one end of the cable and the cable placed in the chamber with the slide tubes at this end in the overlapping position. When the cable was removed from the chamber, it was seized and a force of 200 pounds was not sufficient to operate the cable. After the cable had been exposed for three minutes at room temperature the cable operated normally. Narrow strips and small pellets of ice were observed on the inner slide tube. The same procedure was followed with low temperature grease used as the slide tube lubricant. At the end of the cold soak period an operating force of eight pounds was required. Frozen condensate was observed on the inner slide tube but the particles were small and no strips or pellets of ice were present.

52 It was concluded that lubrication of the telescoping end fittings of the engine "Teleflex" controls with low temperature grease would prevent seized engine controls during cold weather operation or at least reduce the frequency of it occurring. It is recommended that low temperature grease (RCAF Ref 34A/192) be used to lubricate the telescoping end fittings of all engine controls on Expeditor aircraft. It is further recommended that additional tests be conducted during winter conditions.

CSU and Oil Shutter Controls

53 No difficulty was encountered with the operation of the CSU or oil shutter controls during the test season. At cold soak temperatures from -15°C to -36°C, which was the range in temperature encountered during the test season, the force to move the CSU lever varied from four to 12 pounds, and the force to move the oil shutter lever varied from two to ten pounds. The force was measured by a 0 to 25 pound spring scale attached to the end of the lever just below the plastic knob. The forces measured, were not a direct function of temperature. The CSU control force was two pounds when the aircraft was located in the hangar at a temperature of 15°C while the force required to move the oil shutter lever was negligible under the same conditions. Operating forces were not decreased when the slide tubes of the port controls were lubricated with low temperature grease. Under all conditions encountered during flight, these controls operated freely and the friction lock was used to maintain levers at the desired settings.

Cowl Flap Control System

54 Before the test season commenced, the slide tubes at each end of the "Teleflex" type control cables were lubricated with powdered graphite. However, the controls were extremely difficult to operate at temperatures below -10°C both on the ground and in flight. In an effort to reduce the operating force required, each cowl flap control plunger was cleaned and left dry. The port and starboard cowl flap assemblies were cleaned and checked for wear and for rubbing. The nuts on the port and starboard engine cowl flap hinge bolts were adjusted finger tight to ensure that there would be no excess friction at the hinge points and the overlapping flap segments were checked for rubbing. The overlapping areas of the cowl flap segments and the "Teleflex" control slide tubes on the port cowl were lubricated with low temperature grease and the overlapping areas of the tubes on the starboard cowl were relubricated with graphite.

55 The reduction in operating force obtained by adjusting the cowl flaps, and lubricating the surfaces where the flap gills overlapped, is shown graphically in Fig 17. The forces shown were those required to open the cowl flap. The forces were measured with a 0 to 200 pound spring scale which was attached to either cowl flap control operating handle. The greatest reduction in operating force was obtained by lubricating with low temperature grease in conjunction with adjustment of the cowl flap assemblies. However, the operating force was still considered excessive at temperatures below -15°C. Because

there was very little difference between operating forces measured immediately after cold soak and those measured after the cockpit and nacelle had heated up, it was established that the high forces resulted mainly from friction between the flap segments. It is recommended that low temperature grease (RCAF Ref 34A/192) be used as the lubricant between flap segments.

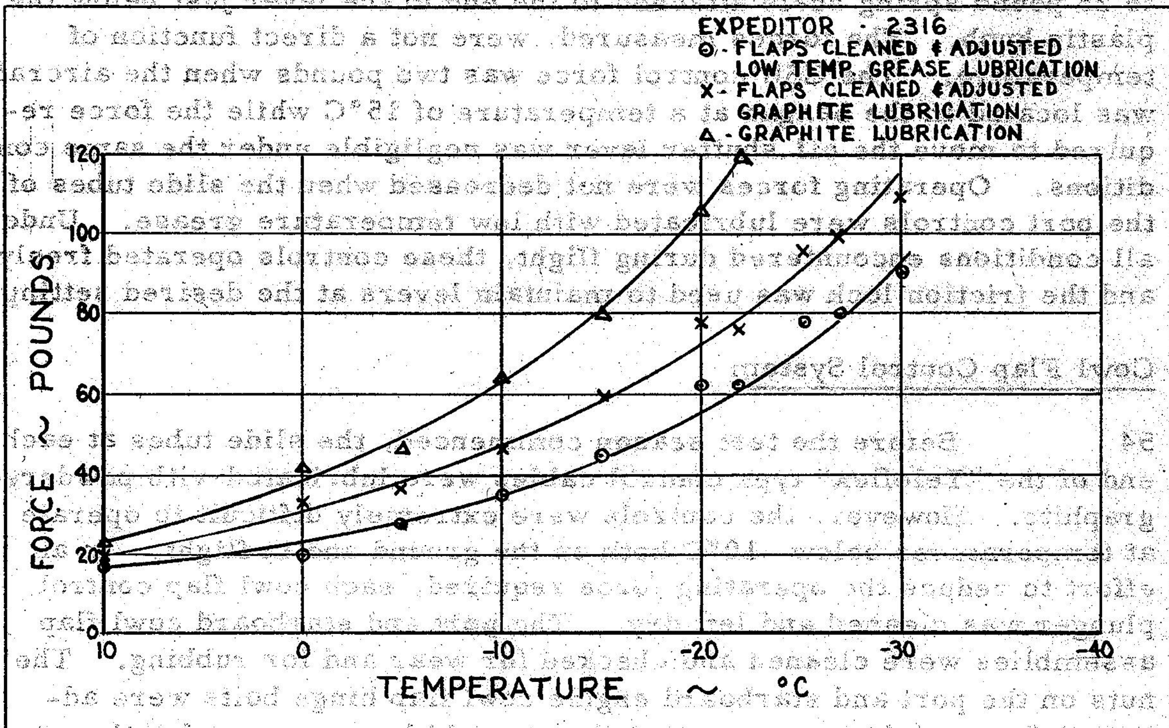

Fig 17 - Cowl Flap Operating Forces Vs OAT

Carburettor Heat Control

56 The Beech Aircraft Corp developed a ducting system designed to supply a continuous flow of hot air around both sides of the carburettor air scoop assembly during flight which it was believedwould keep the carburettor hot air valve from freezing. The "heater-muff" was fitted to the starboard air scoop assembly and the port assembly was left unmodified for comparison tests. Fig 18 shows the unmodified carburettor air scoop assembly (A), one of the hot air ducts (B), ,and the cold air ducts (C). Fig 19 shows the inboard side of the starboard carburettor air scoop assembly: (A) is the "heater-muff" and (B) is the flexible hose that supplied heat to the "heater-muff" from the carburettor hot air supply duct (C). The installation on the outboard side of the assembly was identical.

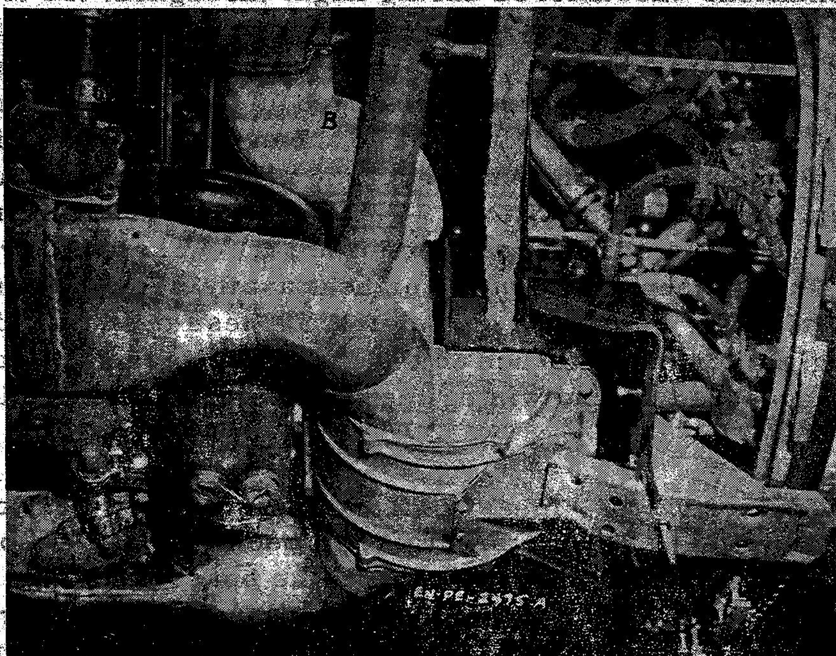

Fig 18 - Carburettor Air-Scoop Assembly

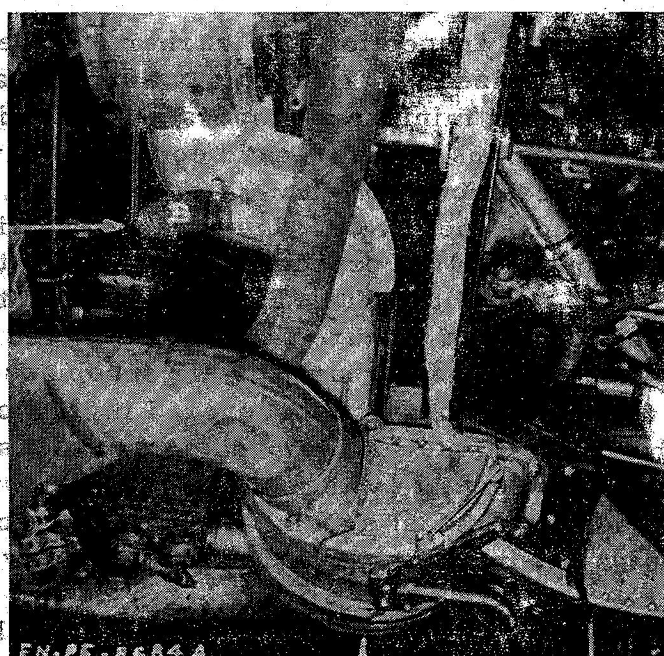

Fig 19 - "Heater-Muff" Modification

57 The carburettor heat control system operated normally under all conditions encountered during flight throughout the test season. There were no instances of frozen or stiff controls on either the modified or unmodified systems during flight. The fuel/air mixture temperature measured at the carburettor throat averaged 1°C to 5°C higher on the system with the "heater-muff" installation than on the unmodified system under all flight conditions encountered, when the carburettor heat controls were in the "COLD" position. This temperature difference included a correction factor for instrument error. The "heater-muff" did not decrease the amount of carburettor heat available when it was selected to the "HOT" position. The effectiveness of the modification in preventing the formation of ice in the air scoop assembly during flight could not be assessed during winter tests because airframe icing was not encountered.

58 Control forces, measured at the carburettor heat control levers, varied widely after the aircraft had been cold soaked overnight. At temperatures between -15°C and -36°C the operating force varied from 12 to 50 pounds but it was not in proportion to the temperature change. When the aircraft was located in the hangar at a temperature of 15°C the operating force required to move either lever was three pounds. The slide tubes of the port "Teleflex" cable was lubricated with low temperature grease but there was no apparent decrease in the operating force.

59 During the dailyinspection, the carburettor heat control levers were found to be seized on 12 occasions after the aircraft had been dispersed overnight at minimum temperatures ranging from -23°C to -36°C. On four occasions the starboard control only was seized and on the other eight occasions both levers were seized. A force of 150 pounds would not move the lever. In all cases the aircraft had been flown and/or ground run the preceding day. At no time was the slide-tube fitted on the end of the "Teleflex" cable found to be frozen. Investigation revealed that the seizure was caused by the formation of ice or frozen condensate in the carburettor air scoop assembly. Figure 20 shows the formation of ice discovered in the port air scoop assembly when the cover plate was removed on one occasion. The drain pip fitted to the cover plate was found to be filled with ice on this occasion. This was the heaviest accumulation of ice encountered and resulted from engine ground running during blowing snow conditions.

60 The air scoop assembly was not checked in all instances when seized controls were discovered because the time required would have interfered with other phases of the test program. On three

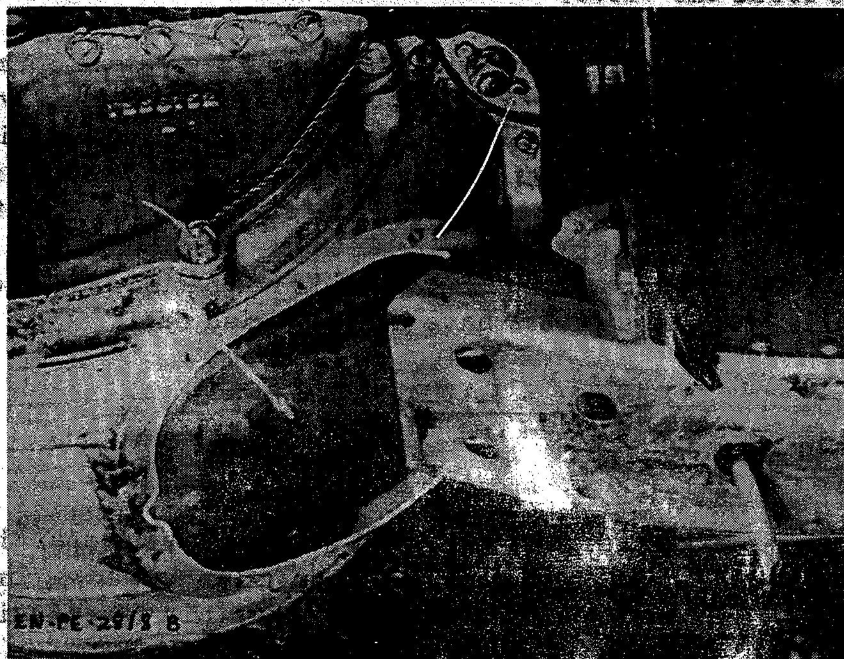

Fig 20 - Ice Formation in Air Scoop Assembly

occasions the controls were freed when heat was directed into the engine to free throttle and mixture controls as mentioned in para 46. In four instances engine cold starts were made with the carburettor heat frozen in the "COLD" position and it was found that the controls could be operated three to five minutes after engine start. The assembly with the "heater-muff" modification required the same time to unfreeze as did the unmodified assembly.

61 On the four other occasions, the carburettor air scoop assembly was checked and lesser amounts of ice than that shown in Fig 20, were discovered. During one of these checks the port control was seized although no ice could be seen during a visual check. However, after heat was applied to each side of the air scoop for 30 seconds from an electric heater gun (RCAF Ref 2T/562), obtained for this test, the valve operated normally when a force of 20 pounds was applied to the lever. It was concluded that when snow entered the air scoop intakes during engine ground operation, the water resulting from the snow melting, formed a film between the hot air valve and the sides of the assembly. The clearance between the valve and assembly was 0.012 inches which would not be sufficient to allow the

water to drain from between these surfaces. When the assembly cooled after the engine was stopped, the resulting film of ice or frozen condensate froze the valve.

62 Although the carburettor heat control system operated normally in flight during the test season, no airframe icing was encountered. It is believed that the problems encountered during ground operation could occur during flight in icing conditions and it is recommended that further tests be conducted to determine the effectiveness of the "heater-muff" modification under these conditions. It is recommended that the "heater-muff" modification not be incorporated on other aircraft until these tests have been carried out.

Sec 6 - LANDING GEAR

General

63 The Expeditor was equipped with a conventional three-wheel retractable landing gear. Gear retraction and lowering was accomplished electrically and emergency operation was possible with a hand crank. The main gear position indicator consisted of a green "DOWN" light and a red "UP" light. No indicator was provided for the position of the retractable tailwheel. A safety switch was located on each shock absorber strut to prevent accidental retraction of the landing gear while the aircraft was on the ground.

Retraction and Lowering

64 The landing gear was retracted and lowered without difficulty at temperatures down to -33°C, which was the coldest OAT experienced in flight. The emergency lowering system was tested in flight at temperatures down to -27°C and it functioned normally on each test. On one occasion, during engine warm-up, snow which had accumulated in the crankcase and accessory section of the engine melted, and was blown back and froze on the gear door and landing gear safety switch. Figure 10 shows the accumulation of ice on the safety switch and gear door. The safety switch and actuating lever, shown in the circled area of Fig 10, were completely covered with ice. The adhesion between the ice and the metal surfaces was low and most of the ice was easily chipped off. If the ice had not been removed before take-off, retraction of the landing gear would not have been possible without using the manual release on the landing gear lever solenoid switch latch. Modification of the engine covers as recommended in para 23 should prevent the snow accumulation which resulted in this ice.

Wheels and Brakes

65 The aircraft was fitted with Key-Type Wheel Assemblies (RCAF Ref 27A/2659) and Key-Type Brake Assemblies (RCAF Ref 27A/2673). No difficulty was experienced with wheel and brake operation at OAT's down to -33°C, the coldest at which they were tested. The aircraft was dispersed with parking brakes on, and without wheel covers installed, during most of the test season. At no time did either brake assembly freeze. The brakes operated smoothly and were effective under all conditions encountered.

66 The layout of the rudder pedals made operation of the brakes difficult, and was not considered acceptable when winter flying clothing and flying boots were worn by the pilot. The pedals were nearly perpendicular to the floor and the bottom of the pedal was four and seven-eighths inches from the floor. To operate the brakes it was necessary to raise the foot off the floor and place it squarely on the pedal. In this position the foot was bent upward forming an angle between the foot and the leg of less than 90° which proved to be very awkward when flying boots were worn. An alternate method used was to place the instep on the top of the rudder pedal. However, in this position the toe of the flight boot touched the lower part of the instrument sub-panel or components behind the panel. If the rudders were moved from the neutral position the pilot's feet were in a position which permitted brake operation, it was not possible to apply rudder effectively. When his feet were being repositioned on the pedals during the take-off or landing there was a transition period when neither the brakes or the rudder could be applied effectively. This resulted in a flying hazard during the two most critical periods of aircraft operation. It was concluded that the fault could be overcome by moving the rudder pedal two inches closer to the floor, and inclining it forward at an angle of 15 degrees to the vertical so that the top of the pedal would be forward of the present position. The pedal could be redesigned so that no major change to the rudder pedal assembly or brake rod assembly would be necessary. It is recommended that a modified rudder pedal be developed to overcome this fault.

Shock Absorbers

67 No difficulty was experienced with the main or tail gear shock absorbers during the test period.

Tires

68 Tire pressures were maintained as specified in EO 05-45B-7A. On 19 Feb 54, a blow-out occurred on the port main tire while

the aircraft was in the hangar. When the tire was removed a large star-shaped crack was found in the inner casing of the tire which had pinched the tube. It was believed that the tire was damaged during landing on the east-west gravel runway at Fort Churchill, which was very rough during the early part of the test season when there was no snow covering over the gravel. Thirteen take-offs and landings had been made from the time the aircraft was received at the detachment until the blow-out occurred. Nine of the take-offs and landings were on the gravel runway. A total of 12 further take-offs and landings were made during tests up to 13 Mar 54. No further tire difficulties were experienced during the test period.

Sec 7 - HEATING AND DEFROSTING SYSTEM

General

69 Heating and defrosting was provided by port and starboard systems with hot air supplied from intensifier tubes incorporated on the exhaust systems of the port and starboard engines. A separate ventilating system was incorporated which was also made up of identical components on the port and starboard side of the aircraft. The heating, defrosting, and ventilating systems are shown in Fig 21. During flight, ram air entered the intensifier inlet (1), was heated on passing through the intensifier (2), and distributed to the cockpit and cabin after passing through the cabin air valve (3). A sectional view of cabin air valve is shown in detail "D" of Fig 21. The cabin air valve could be adjusted to allow part or all of the hot air to be exhausted to atmosphere. The hot air entered the cabin through the fixed outlet (4) and was directed to the astrodome defroster through the duct (5). The adjustable, cockpit air valve (6), which functioned as a mixing chamber, allowed hot air, or mixed hot and cold air, to enter the cockpit and defroster, or the defroster only. The starboard side of the aircraft had an identical system except that no astrodome defroster system was incorporated. Figure 21 also includes details of modifications to the system developed by the Beech Aircraft Corp. These modifications are described later in this section.

70 During the winter months of 1951-52, field reports were received by AMC regarding the inadequacy of the defrosting system on Expeditor 3 aircraft. The Beech Aircraft Corp investigated the problem and developed modifications to the system which were expected to provide a better defrosting air pattern. Additional field reports indicated that cabin temperatures were below the comfort range at outside air temperatures below -20°C. The detachment was instructed

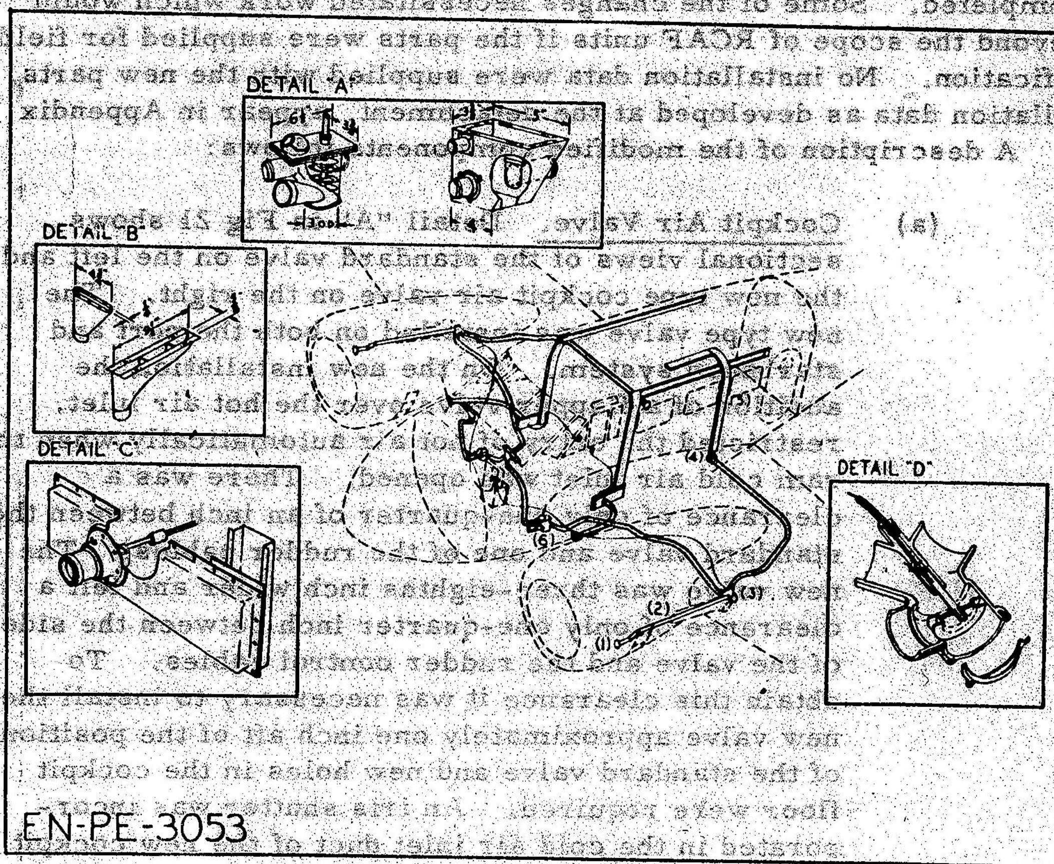

Fig 21 - Heating, Defrosting and Ventilating Systems

to test the heating and defrosting system, with the Beech modifications incorporated, and to recommend methods of improving the system, if required.

71 To obtain heating and defrosting data the cabin and cockpit were instrumented with 14 resistance type temperature bulbs. The instrumentation is described in Sec 14.

Beech Modifications

72 As a result of an investigation conducted by the Beech Aircraft Corp new components were supplied and were installed on the aircraft prior to the test season. None of these components was considered acceptable because of the difficulties encountered during the installation on the test aircraft. Minor modifications to the aircraft and the modification kit parts were necessary before installation could

be completed. Some of the changes necessitated work which would be beyond the scope of RCAF units if the parts were supplied for field modification. No installation data were supplied with the new parts. Installation data as developed at the detachment, appear in Appendix "D". A description of the modified components follows:

(a) Cockpit Air Valve. Detail "A" in Fig 21 shows sectional views of the standard valve on the left and the new type cockpit air valve on the right. The new type valve was installed on both the port and starboard system. On the new installation the addition of a flapper valve over the hot air inlet, restricted the entry of hot air automatically when the ram cold air inlet was opened. There was a clearance of only one-quarter of an inch between the standard valve and one of the rudder cables. The new valve was three-eighths inch wider and left a clearance of only one-quarter inch between the side of the valve and the rudder control cables. To obtain this clearance it was necessary to install the new valve approximately one inch aft of the position of the standard valve and new holes in the cockpit floor were required. An iris shutter was incorporated in the cold air inlet duct of the new cockpit air valve to regulate the flow of cold air. Considerable modification was required to the valve to obtain a suitable linkage to operate the iris fully from the open to the closed position.

(b) Windscreen Defroster Outlet. Modified defroster outlets were supplied to replace the standard outlets. In Detail "B" of Fig 21, sectional views of the two types of outlet are shown. The modified components shown below the standard one, had a greatly increased outlet area and incorporated flow deflectors in the outlet. The top of the outlet was not shaped properly to fit the instrument panel cowl assembly and modification was necessary. The new outlets were installed on both the port and starboard defrosting systems.

(c) Ventilating Air Valve. Beech supplied an iris valve to replace the normal air valve which is shown in Detail "C" of Fig 2', because of reports that ventilating air could not be closed off completely. However, due to the late arrival of the test aircraft, and the minor nature of the modification, the new valve was not installed. Blanking plugs, as described in Sec 2, were left in place during flight to ensure that the ventilating system would be completely closed off during cold weather tests.

Defrosting

73 Since the heating and defrosting system required ram air for operation, it did not function on the ground. During high relative humidity and overcast sky conditions, a heavy layer of frost would form on the inside of all cockpit windows prior to take-off. The formation of frost could be delayed slightly be leaving the cockpit sliding windows open. Even when the aircraft was brought out from the hangar just before flight, at OAT of -25°C and below, heavy frost would form within 15 minutes after the cockpit was occupied. To obtain sufficient visibility for take-off a windscreen scraper had to be used, but the cleared area would refrost within 30 seconds. Cockpit heat was left in the "OFF" position on take-off to allow all hot air available to go through the defroster outlets. Although the flow of air from the outlets could be increased by partially opening the ram air inlets to the cockpit air valves, the lower outlet air temperature then obtained resulted in slower defrosting. With the ram air inlet closed, the defroster outlet temperature normally stabilized at 50°C (± 5°C) during cruising flight at OAT's from -10°C to -25°C.

74 For the first 15 to 20 minutes of flight, there was not sufficient visibility to fly by visual reference. Defrosting progressed slowly from the lower inside corner of each windscreen until approximately 75% of the area would be clear after 45 to 50 minutes of flight. The flow pattern of the defrosting air was poor because of the pronounced slope of the windscreen. Make-shift flow deflectors were attached to the instrument panel cowl assembly to change the flow but they helped very little. It was concluded that the flow patten could not be improved substantially unless the defroster ducting was changed so that the airflow at the outlet would be approximately the same angle as the windscreen. This would probably necessitate rerouting of the defroster hose into the rear of the nose baggage compartment.

75 The centre windscreen panel and all the side windows remained completely coated with frost on test flights of up to two hours duration when overcast sky conditions prevailed. After initial defrosting tests were completed, plastic frost shields, of the type used on ME vehicles, were installed on all windscreen and cockpit windows

with the exception of the panel directly in front of the pilot. The frost formed on the shields during ground operation but the coating was light and scattered, giving acceptable but somewhat restricted visibility. The shields would be almost completely clear of frost within 30 minutes after take-off. The shield on the curved windscreen panel in front of the co-pilot did not fit the curvature completely and although it was effective in preventing frost formation, it was not considered acceptable because of the distortion to vision that resulted.

76 In an effort to achieve some measure of windscreen defrosting before take-off, a small centrifugal blower (RAF Ref 10D/16670) driven by a 24-volt electric motor, was installed in the cockpit on the panel immediately in front of the pilot's rudder pedals, and was connected to the port defroster hose. In Fig 22, the electric blower is shown attached to the removable panel. Cockpit air entered through the centre of the blower and was forced into the defroster line through a "T" fitting. During ground trials the airflow from the defroster outlet was about the same as obtained from ram air in flight at normal crusing airspeed. However, the maximum outlet temperature that could be obtained for the first 20 minutes after engine start was 5°C. Because of the poor flow pattern and low temperature of the air, frost was not removed. By joining the port cabin hot air outlet to the blower inlet by a long flexible tube of two inch diameter, the defroster outlet temperature was increased to 20°C at an outside air temperature of -20°C. Defrosting was fairly effective, but due to the poor flow pattern along the windscreen, only the bottom half was cleared after 20 minutes of operation.

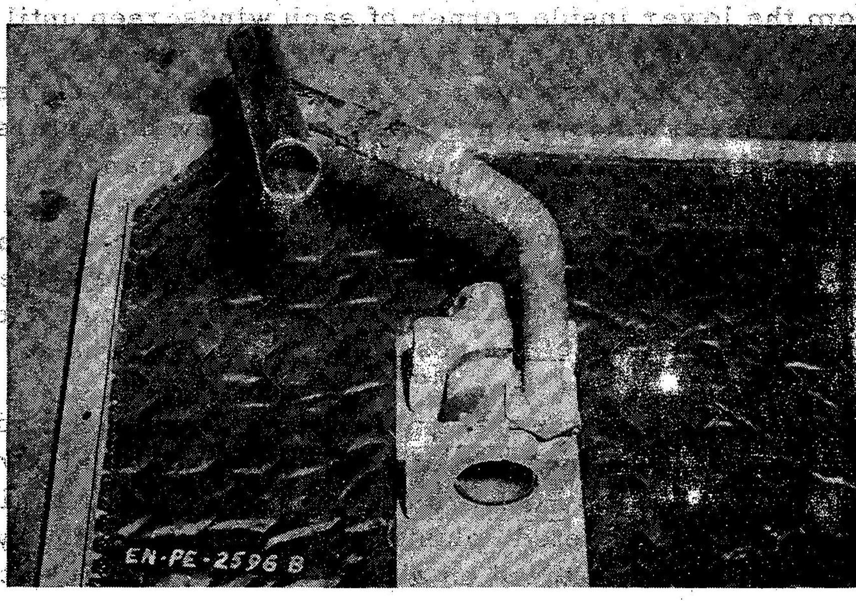

Fig 22 - Cockpit Defroster Blower

77 An additional test device was installed to determine whether an emergency ground and flight defrosting system would be effective. An electrically driven, centrifugal blower (RCAF Ref 27JQ/3784) was installed on the cabin floor under the second navigator's seat. The blower inlet was connected to the port cabin hot air outlet. A flexible hose of two inch diameter, long enough to reach to the astrodome and cockpit windscreen, was attached to the blower outlet. The installation is shown in Fig 23. The outlet temperature was 30°C during ground operation with engines running at an OAT of -25°C. In flight the hose outlet temperature was 60°C, as compared with the normal cabin hot air outlet temperature of 75°C. The outlet velocity was approximately 25% greater than the normal cabin outlet velocity. The defroster hose was held a few inches from the surface being defrosted and was moved back and forth until the frost was removed. It was very effective in defrosting the windscreen, side windows and astrodome, both on the ground and during flight.

Fig 23 - Defroster Blower Installed on Cabin Floor

78 It was concluded that the defrosting system on the test aircraft was not acceptable. The main fault was an insufficient flow of air from the windscreen defroster outlets and the poor flow pattern

over the windscreens. It is recommended that the modified defroster outlet ducts and the modified cockpit air valve developed by the Beech Aircraft Corp, not be installed on Expeditor aircraft. Although it could not be determined whether these components would be an improvement over the standard components, since comparison tests were not made, it was established that windscreen defrosting was far from adequate on the test aircraft in which they were installed. It is recommended that one of the following changes be made to improve the defrosting system:

(a) install defroster outlets that will provide an adequate flow pattern over the windscreens and incorporate a small blower to increase the volume of air through these outlets;

(b) provide an emergency ground and flight blower that could be used to defrost the windscreen, cockpit windows, and astrodome; or

(c) replace the curved windscreen panels in front of the pilot's and co-pilot's positions with duo-pane panels.

It is further recommended that the heating system be modified so that all the heat available from the exhaust intensifier tubes can be directed to the defrosting system, and that clear vision frost shields be provided to all units operating Expeditor aircraft for use on the cockpit side windows during winter operation.

Cockpit and Cabin Heating

79 Twelve test flights were conducted during which the temperature was recorded at fourteen positions in the cockpit and cabin at regular intervals for one hour from time of take-off. The flights were conducted at cruising power at an altitude of 5000 feet. Typical temperature curves from time of take-off appear in Figs 24 and 25. All data presented were obtained with the cockpit and cabin heat controls in their fully "HOT" positions. It was found that cabin temperatures could be increased 2°C to 3°C by partially opening the cold air inlet to the cockpit air valve, but the cockpit temperature would be reduced by approximately 5°C. In addition to the twelve flights conducted specifically to record cockpit and cabin temperatures, temperatures were recorded on seven other flights after approximately one hour of flight. The temperatures shown in Table I are averages of the temperatures recorded on the 19 flights.

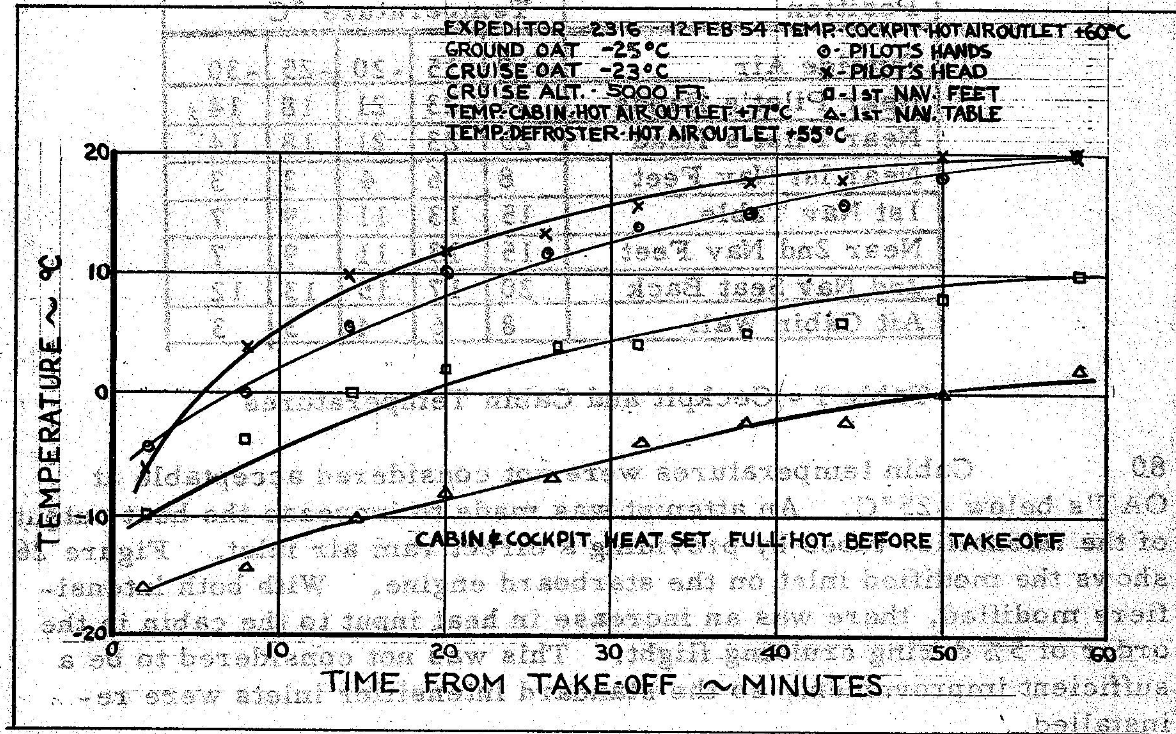

Fig 24 - Cockpit and Cabin Temperature Increase from Time of Take-Off

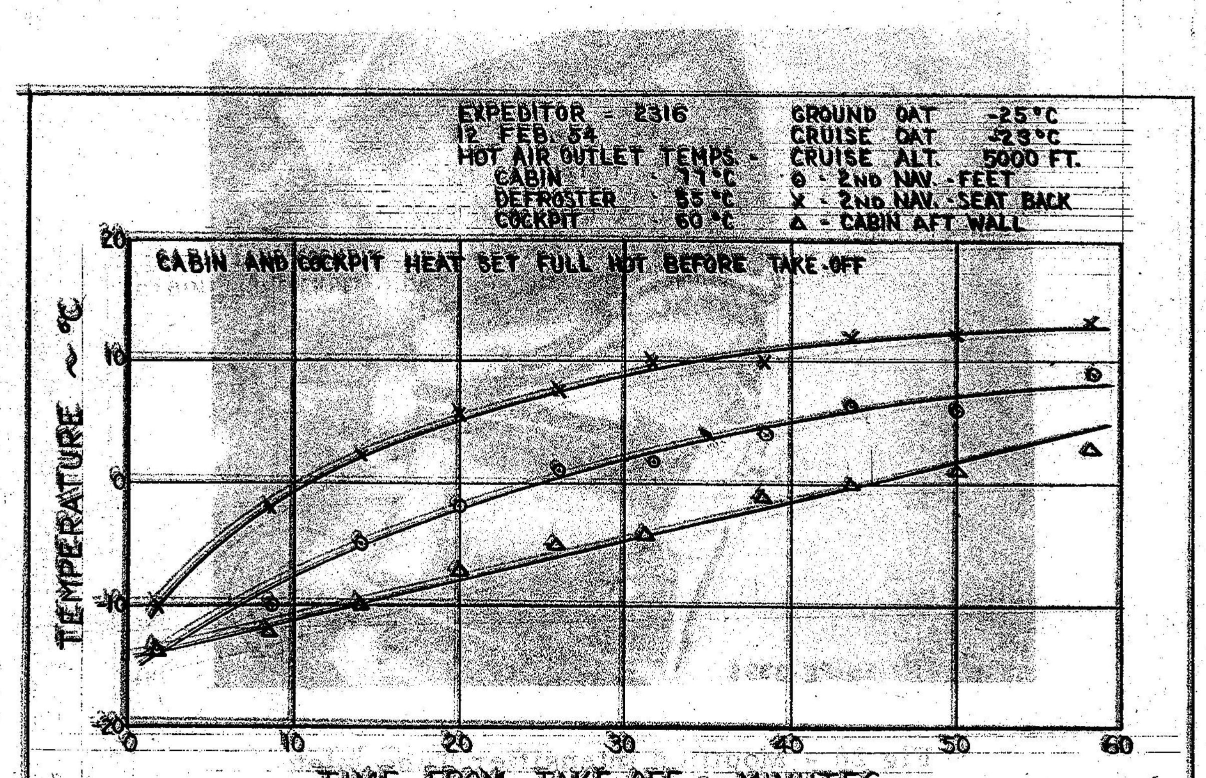

Fig 25 - Cabin Temperature Increase from Time of Take-Off

Position	Temperature °C				
Outside Air	-10	-15	-20	-25	-30
Near Pilot's Hands	25	23	21	18	14
Near Pilot's Head	25	23	21	18	14
Near 1st Nav Feet	8	6	4	3	3
1st Nav Table	15	13	11	9	7
Near 2nd Nav Feet	15	13	11	9	7
2nd Nav Seat Back	20	17	15	13	12
Aft Cabin Wall	8	6	4	3	3

Table I - Cockpit and Cabin Temperatures

80 Cabin temperatures were not considered acceptable at OAT's below -25°C. An attempt was made to increase the heat output of the intensifier tubes by providing a direct ram air inlet. Figure 26 shows the modified inlet on the starboard engine. With both intensifiers modified, there was an increase in heat input to the cabin in the order of 5% during cruising flight. This was not considered to be a sufficient improvement, so the standard intensifier inlets were re-installed.

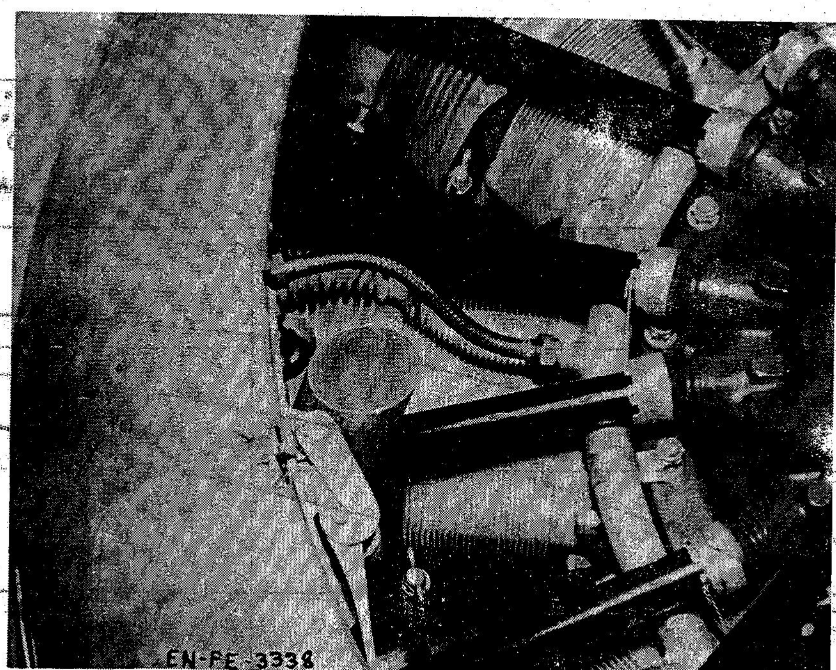

Fig 26 - Modified Intensifier Tube Inlet

81 It was concluded that sufficient heat was not provided by the hot air system and it is recommended that consideration be given to redesigning the intensifier tubes or that a gasoline burning heater of 20,000 to 30,000 BTU/hr be added to supplement the heating system. In addition, it is recommended that the cockpit air valve be redesigned so that the amount of hot air entering the cockpit can be reduced without allowing cold air to enter.

Sec 8 - FUEL SYSTEM

General

82 A schematic diagram of the fuel system is shown in Fig 27. The suction cross-feed incorporated in the system could be used to deliver fuel from the tanks in one wing, to the opposite engine, if required during single-engine flight, but would not supply fuel under pressure to the opposite engine if an engine driven fuel pump failed.

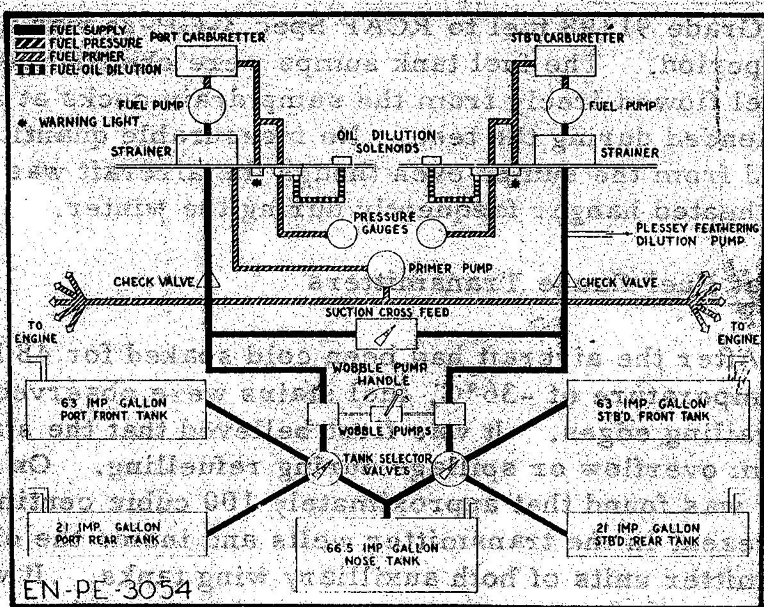

Fig 27 - Schematic Diagram of Fuel System

A wobble pump handle located on the floor, inboard of the pilot's seat, could be used to maintain fuel pressure during starting, when changing the tank selector, or in the event of an engine-driven fuel pump failure. The hand operated priming pump could be selected to prime either engine separately. The priming fuel was directed into the top five cylinders of each engine through 0.020-inch priming jets (RCAF Ref 28/17185). The priming pump, (RCAF Ref 37J/3) had a 10 cc capacity giving approximately two cc's per cylinder on each stroke. It was necessary to maintain fuel pressure with the wobble pump when operating the priming system.

83 The fuel system operated normally under all conditions encountered during engine ground runs and in flight. Fuel leaks, discovered after the aircraft had been dispersed at an overnight low temperature of -36°C, are discussed later in this section.

84 Several cases were reported to AMC of the nose fuel tank vent line freezing, which resulted in a loss of fuel pressure, giving pilots a false indication of an empty tank. It was not possilbe to conduct tests on the vent line because the nose fuel tank of the test aircraft was unserviceable throughout most of the test season.

Type of Fuel

85 Grade 91/98 fuel to RCAF Spec 3-GP-25 was used throughout the test period. The fuel tank sumps were checked before each flight and fuel flowed freely from the sump drain cocks at all temperatures experienced during the test. No measurable quantities of water were drained from the sumps even though the aircraft was moved in and out of a heated hangar frequently during the winter.

Fuel Leaks at Fuel Gauge Transmitters

86 After the aircraft had been cold soaked for 48 hours, at a minimum temperature of -36°C, fuel stains were observed at both wing-root trailing edges. It was first believed that the stains had resulted from overflow or spillage during refuelling. On further inspection it was found that approximately 100 cubic centimetres of fuel were present in the transmitter wells and inside the electric fuel gauge transmitter units of both auxilliary wing tanks. It was believed that sufficient fuel was present in the transmitter wells to cause a fire hazard.

87 The fuel was leaking from around the gasket that fitted between each tank and the fuel gauge transmitter unit. Figure 28 shows the fuel stains and the fuel trapped in the transmitter well of the port auxiliary wing tank. The gaskets were not of the cork composition type (part number 189631), but had apparently been made of a gasket material that appeared to be soft setting yellow

chromate. Since cork composition gaskets were not available for repair, replacement gaskets were made of one-sixteenth inch gasket material (RCAF Ref 32B/58) and were installed using Gasket and Joint Sealing Compound Number 1 Hard (RCAF Ref 33C/359). A daily inspection was carried out for the remainder of the test season, and although the aircraft was exposed to temperatures of -36°C, no further leakage occurred.

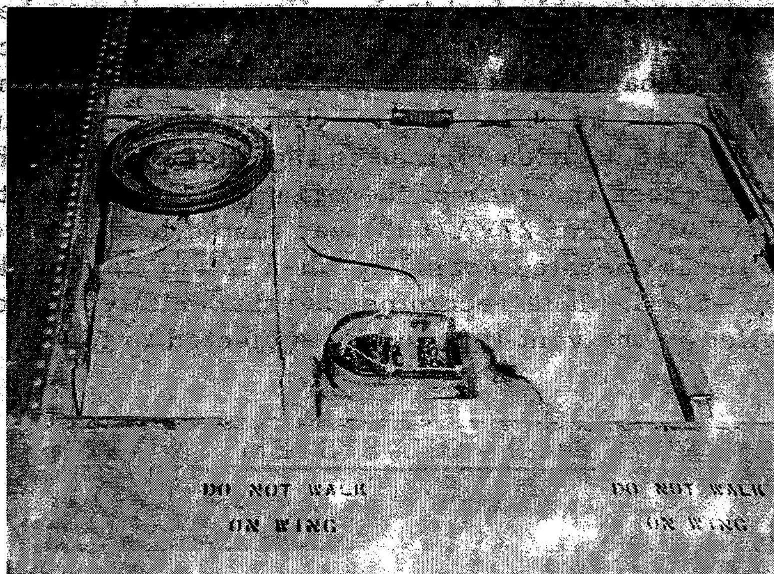

Fig 28 - Fuel Leak at Port Auxilliary Tank Fuel Gauge Transmitter Unit

88 It was concluded that the failure was an isolated case caused by the installation of poorly manufactured gaskets using an improper sealing material that did not provide a proper seal at low temperatures.

Nose Fuel Tank Unserviceability

89 On 20 Jan 54, after the aircraft had been dispersed at an overnight low temperature of -31°C a fuel leak developed in the nose fuel tank. Fuel appeared to be leaking from around the drain cock. Although a new gasket was installed to replace gasket (part number 404-184414), which was fitted to the drain cock adapter plate, and all components of the drain cock were removed, inspected and found to be serviceable, the leakage continued after the drain cock was re-installed.

Further efforts to repair the leak while on detachment at Fort Churchill were unsuccessful. To expedite the test program the nose fuel tank was drained and was not used for the remainder of the test program. After returning to Namao, a new fuel cell was installed during the minor inspection.

Nose Fuel Tank Vent Line

90 No tests were conducted on the nose fuel tank vent line because of the unserviceable fuel tank. However, it was believed that an air check valve fitted into the vent line by a "T" fitting, close to the tank in the nose baggage compartment, would permit venting into the tank to continue if the outlet became blocked during flight in icing conditions, or if condensation formed in the flat portion of the line where it passes across the rear of the baggage compartment. An air check valve (RCAF Ref 27VA/668) was tested in the detachment's cold chamber and it operated normally when it was cold soaked to a temperature of -38°C. It is recommended that this type of check valve be installed in the vent line and be subjected to test at the detachment.

Sec 9 - OIL SYSTEM

General

91 A separate oil system was provided for each engine. A schematic diagram of the oil system is shown in Fig 29. This diagram includes details of the propeller feathering system discussed later in Sec 13. The air inlet duct to each oil radiator was equipped with a butterfly valve, operated by an oil-shutter lever in the cockpit, to control the flow of cooling air through the radiator and hence the oil temperature. For cold weather operation oil could be routed around the radiators by operating a manual oil by-pass valve in each system. The valve was also spring loaded to open automatically at a pressure of 25 to 45 psi to ensure oil circulation if the radiator cored. An oil shut-off valve was incorporated in each system to shut off the oil supply to the engine in the event of fire. Grade 100 oil (RCAF Spec 3-GP-100A) was used throughout the test period. The oil system operated normally at all times except for the oil pressure gauges which are discussed later in Sec 14.

92 During the winter of 1951-52, reports were received by AMC that ice occasionally formed in the crankcase breather vent lines. A modification was developed which involved rerouting of the lines forward of the firewall to provide a positive slope throughout so that

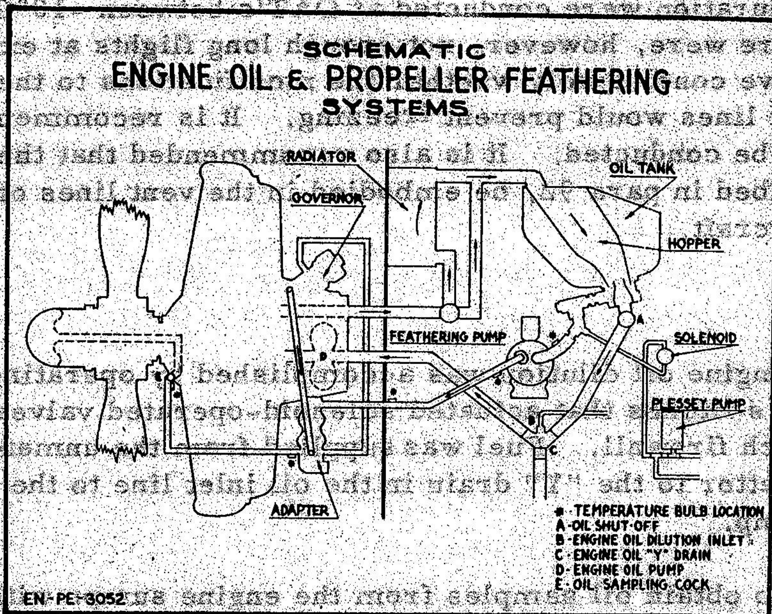

Fig 29 - Schematic Diagram of Oil and Propeller Feathering Systems

no flat spots would be present in the pipe and also to take advantage of the engine heat in the nacelle and thus avoid freezing. This modification was issued under EO 05-45B-6A/1 and was incorporated on the test aircraft by MacDonald Bros Aircraft Ltd. The AMC directive stated that there were still reports of vent line freezing after this modification had been made, and requested that the modified vent lines, with relief holes incorporated near the outlet, be tested by the detachment. The relief holes had been previously recommended by the detachment since it was felt that they would permit venting even if the vent outlet became plugged with condensation or slush. Two one-quarter inch holes were drilled in each vent line, five and one-half inches from the outlet in such a position that oil and condensate would normally drain overboard. In addition to these modifications, AMC message T4562 dated 10 Nov 53, advised of a minor change to the position of the vent line outlets; this change was made before the test program started.

93 No instances of vent line freezing or oil spewing were encountered during the test season. Seven flights of over one hour duration were conducted at OAT's between -10°C and -28°C when percentage of oil dilution in the sump of each engine was between 20% and 34% at the time of engine cold starts. One of these flights, of 1:20 hours duration, was made at an OAT of -28°C; the percentage of

oil dilution was 34% at engine start. In addition four flights of over three hours duration were conducted at OAT's between -10°C and -20°C. There were, however, not enough long flights at extreme OAT's to prove conclusively whether the modifications to the crankcase breather vent lines would prevent freezing. It is recommended that further tests be conducted. It is also recommended that the relief holes, described in para 92, be embodied in the vent lines of all Expeditor aircraft.

Oil Dilution

94 Engine oil dilution was accomplished by operating spring-loaded toggle switches that actuated solenoid-operated valves on the aft side of each firewall. Fuel was supplied from the unmetered side of the carburettor to the "Y" drain in the oil inlet line to the engine driven oil pump.

95 To obtain oil samples from the engine sumps without having to remove the lower cowl on each engine, access panels were installed in the bottom side of each cowl as a local modification. The panels could not be located directly below the sump drain because a leather air seal was located on the inside of the cowl at this position. One of the access panels is shown in Fig 30. The panel was placed two and one-quarter inches behind the centre of the sump drain, and a modified sump plug, incorporating a drain cock as shown in Fig 31, was made locally. The drain cock at the "Y" drain provided an additional sampling point.

Fig 30 - Access Panel on Lower Engine Cowl

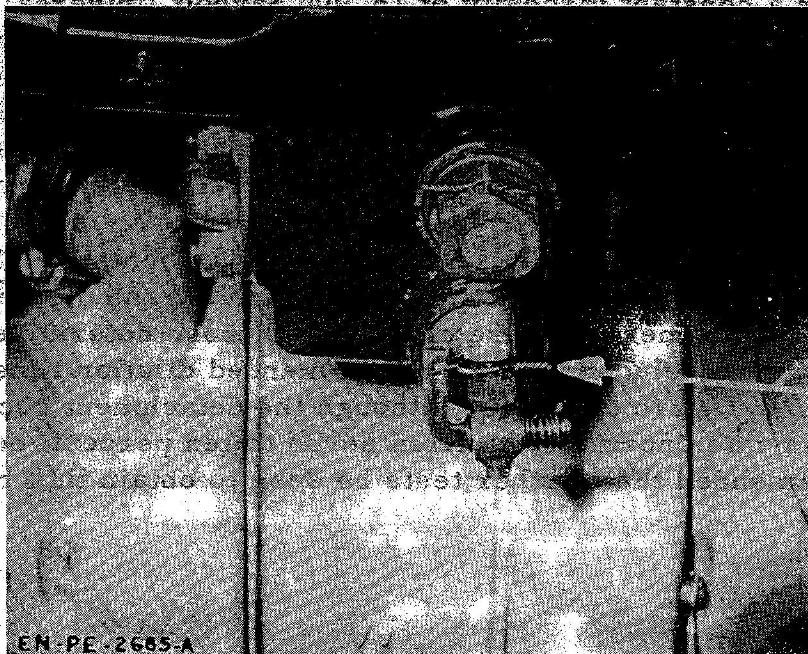

Fig 31 - Modified Sump Plug Fitted with Drain Cock

96 Oil Samples were taken throughout the test period to determine the percentage of oil dilution after diluting for various periods of time and also during boil-off tests. A graph of the average percentage of oil dilution versus time appears in Fig 32.

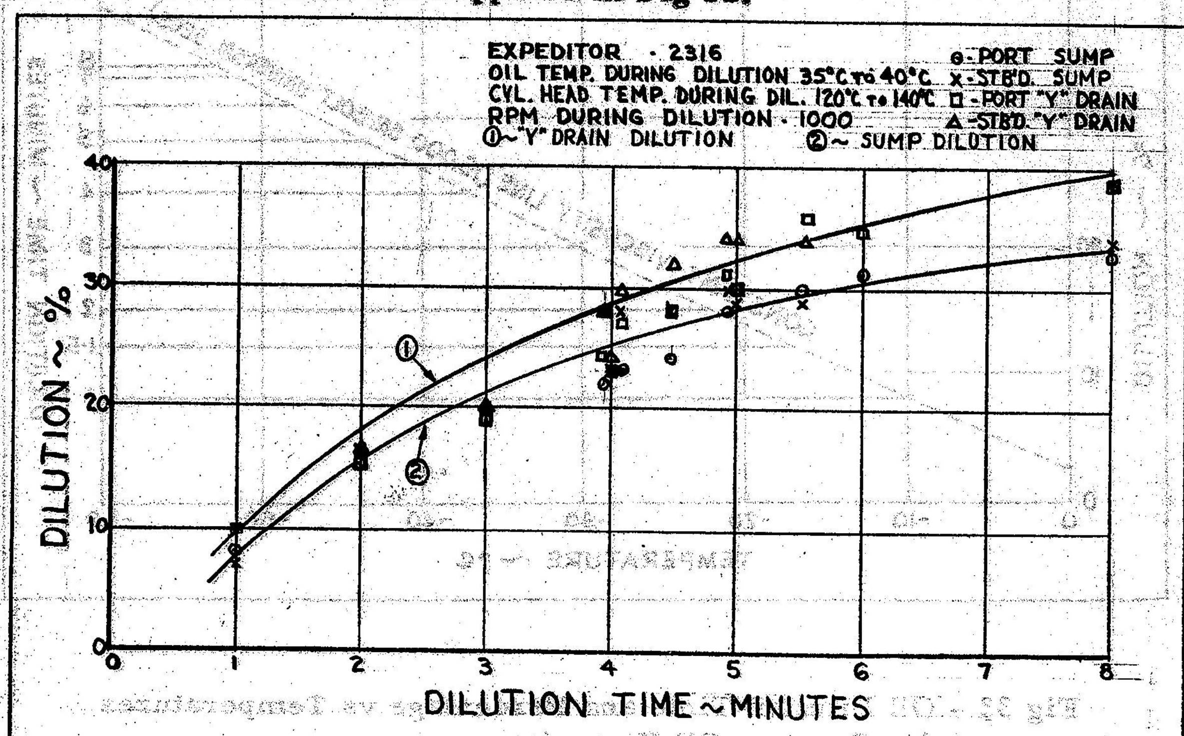

Fig 32 - Oil Dilution Percentage vs Dilution Time

97 The graph in Fig 33 shows the percentage dilution required to maintain a constant viscosity of 15,000 Saybolt Universal Seconds (SUS) at temperatures between 0°C and -60°C, and the dilution time found necessary to obtain the required dilution for temperatures between 0°C and -52°C. The dilution time was based on the curve of sump dilution shown in Fig 32. Table II shows the dilution time recommended in EO 05-45B-1 for various expected low temperatures and the dilution time required to maintain a viscosity of 15,000 SUS for the same temperatures based on test results shown in Figs 32 and 33. As can be seen by comparing columns 2 and 3, the recommended dilution times compare closely with those determined from tests. It was concluded that the recommended dilution times quoted in EO 05-45B-1 were adequate, although the detachment recommends that dilution rates normally be from seven to ten percent per minute. It is recommended that further tests be done to obtain this rate of dilution.

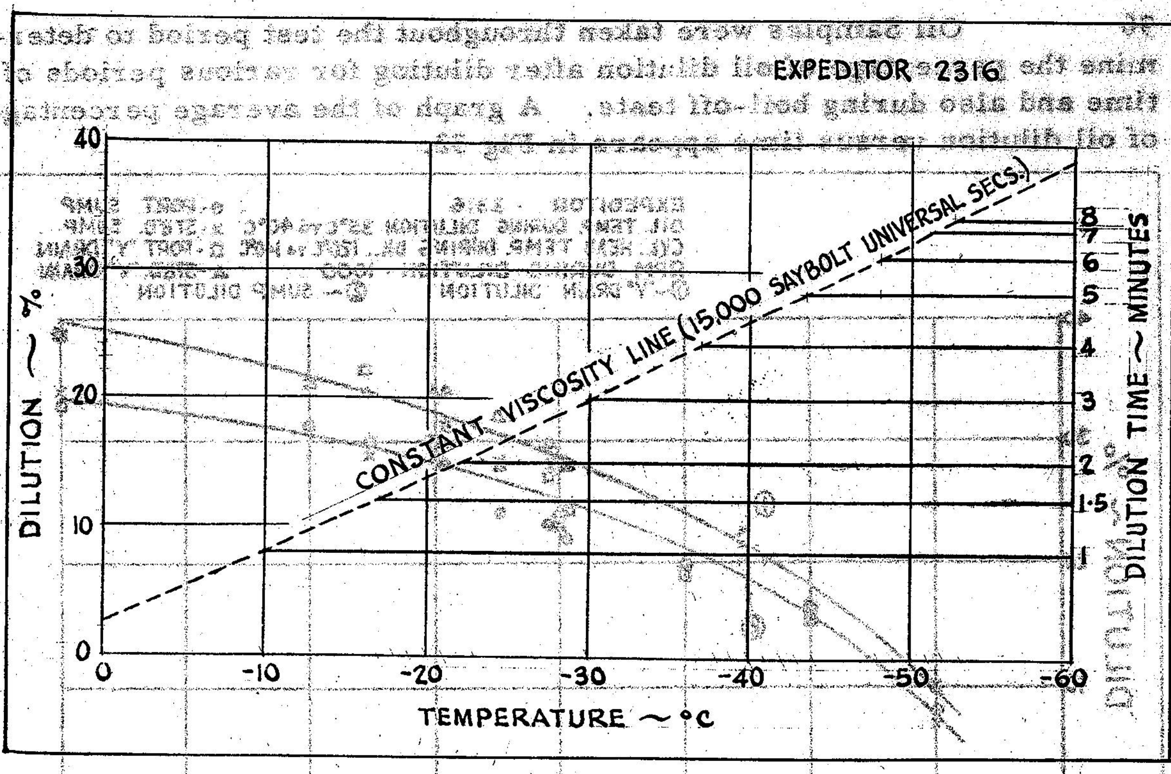

Fig 33 - Oil Dilution Time and Percentage vs Temperatures for Constant Oil Viscosity

Anticipated Low Temp °C	Recommended Dilution Time (Mins)	Required Dilution Time from Tests (Mins) *
-12	1.5	1.2
-29	3	2.8
-46	5	5.7
-51	6	7
-56	7	-
-61	8	-

* To obtain oil viscosity of 15,000 SUS at anticipated low temperature.

Table II - Oil Dilution Times vs OAT

98 A test was made to determine the amount of diluent remaining following typical engine operation prior to take-off and after a series of short flights. Before the engine cold starts were made the percentage dilution in the sumps was 24% and 27% for the port and starboard engines respectively. At the end of 20 minutes of ground operation, during which a warm-up, run-up, and a pre-take-off check were done, the engines were stopped to take oil samples. The percentage dilution in the port and starboard sumps was 17% and 18% respectively. The engines were restarted after five minutes and a take-off was made three minutes later. After six minutes of flight and three minutes of taxiing time, the engines were again stopped and oil samples were taken. The sump dilution was found to be 7% and 8% in the port and starboard engine sumps respectively. No spewing of oil occurred from the crankcase breather vent lines. At the end of a second flight of six minutes the dilution had been reduced to 5% in each sump and after a third flight of 16 minutes there was not sufficient diluent in the oil to measure it. The OAT during the test averaged -20°C. During the test season, percentages of dilution as high as 35% were measured after dilution and at no time did spewing occur on take-off or at any time during flight. It was concluded that, when normal operating procedures were followed as laid down in EO 05-45B-1, no additional ground running was necessary to allow time for diluent boil-off.

Sec 10 - ENGINE STARTING

General

99 Field reports received by AMC indicated that difficulty had been encountered with cold weather starting. It was suggested that the

difficulty might be due to an inadequate supply of fuel from the carburettor, for smooth running while the engine was cold. RCAF Station Winnipeg believed that cases of piston seizure, which had occurred, were the result of over-priming during engine start. AMC advised that the problem was referred to Canadian Pratt and Whitney, but the company could offer no solution. The detachment was requested to determine at what temperature normal cold starting procedures, as listed in EO 05-45B-1, became ineffective, and to make recommendations for amendments to the cold weather starting procedure in EO 05-45B-1. It was also requested that the detachment determine if modifications or adjustments to the engine or carburettor would lower the effective cold start temperature.

100 The engines were exposed to temperatures down to -36°C, and cold starts were made at temperatures down to -34°C which was the lowest temperature at start. . Typical cold start data for temperatures between -10°C and -34°C appear in Appendix "E". In addition to the cold starts recorded in this appendix, the engines were started without heat on three occasions at a temperature of -30°C, on four occasions at OAT's between -24°C and -29°C, and on five occasions at OAT's between -20°C and -24°C. At an OAT of -34°C the port engine started on the third attempt but seven attempts were required to start the starboard engine. On this occasion the initial battery cart voltage was only 22 volts, which resulted in low cranking rates.

101 It was concluded that consistant cold starts could be accomplished at -30°C using the procedure given in EO 05-45B-1 amended as detailed in para 104 of this report.

102 On several occasions heat was applied to the accessory section to free frozen engine controls, as discussed in Sec 5, and although heat was not applied to the cylinders, the subsequent engine starts were not recorded as cold starts. In two instances there was insufficient engine oil dilution for the starters to provide an adequate cranking rate and preheat was required before the engines could be started. On the first occasion the percentage dilution of the oil was only 4% in each engine and the OAT was -24°C. The engines were extremely stiff and neither engine could be cranked with the starter. A Herman Nelson heater (RCAF Ref 4G/244) was used, and heat from one duct was directed on to the cylinders of the port engine while heat from the other duct was directed on to the cylinders of the starboard engine. The heat was applied for 20 minutes, after which a duct was directed into the accessory section of each engine for ten minutes

through the space provided by removing the inboard wrapper assembly from each engine. The engines started normally on the first attempt after the heat had been applied and the engine cranking time was only 20 seconds. On the second occasion the aircraft was dispersed for three hours at a temperature of -15°C immediately following a test flight. The engine oil had not been diluted. The engines were too stiff to obtain sufficient cranking rate from the starters so heat was applied to the cylinders of each engine for ten minutes from one duct of the Herman Nelson heater. No heat was applied to the accessory section. After heat had been applied, normal starts were accomplished with a starter cranking time of 15 seconds.

Cold Start Procedure

103 The cold starting procedure usedwasas follows. The propeller was turned by hand through two complete revolutions before start. Fuel pressure was maintained during priming by using the wobble pump. Five to ten full strokes of the priming pump were used according to the OAT. The ignition was turned "ON" and the starter button was pressed. After two to three complete revolutions of the propeller, the ignition booster button was depressed. Continuous operation of the starter was normally limited to 60 seconds, although during one cold start it was operated for 90 seconds. The maximum specified time in EO 05-45B-1 was 30 seconds. The starter was never used intermittently during the attempted start. If after 60 seconds of continuous starter operation a start was no accomplished, a further attempt was made after waiting for three minutes. Five to ten strokes of the priming pump were generally necessary during the cranking period to obtain a start. At OAT's of -30°C and below, prime was required on an average of every three seconds during the 60-second cranking period. Backfiring did not occur if the throttle was set less than one-eighth open. If was necessary to maintain fuel pressure by intermittent use of the wobble pump until smooth running of the engine occurred. Although the engine would run at 400 to 600 rpm with the use of intermittent prime, any attempt to increase rpm by advancing the throttle would result in extremely heavy backfiring at OAT's below -20°C. On early cold start attempts, it was found that the only method by which rpm could be increased, and thus smooth running be accomplished immediately after start, was to pump the priming pump rapidly through four or five strokes and advance the throttle at the same time. After repeating this procedure two or three times, the engine would run normally and respond to throttle movement. It appeared that an adequate supply of fuel or combustible mixture was not being supplied by the carburettor unless farely

heavy priming was used. It was beyond the scope of the project to make any changes or modifications to the carburettor or engine. A change in the starting technique, described in para 104, prevented heavy backfiring without over-priming. If this change in starting technique does not prove to be adequate under all conditions encountered, further investigation will be necessary.

104 The use of rapid priming in conjunction with throttle manipulation to increase the rpm immediately after cold start was believed to be a dangerous procedure which might eventually result in excessive engine wear and possibly piston seizure. After operating on intermittent prime for the first two or three minutes at 400 to 600 rpm, the throttle could be advanced normally to give 800 to 1000 rpm and smooth running would result. During this period the engine would run roughly, and slight backfiring would occur, but a single application of prime each ten to 30 seconds was sufficient to keep the engine going. The use of partial carburettor heat during slow running was of considerable assistance. It is recommended that this procedure be followed rather than attempting to obtain smooth running at 800 to 1000 rpm immediately after engine start. It is suggested that the following note be added to EO 05-45B-1 Pt 2, para 47:

"Note: If the engine will not respond when the throttle is advanced immediately after cold start, run the engine at 400 to 600 rpm for two to three minutes. Use prime intermittently, and only when necessary to keep the engine running. Apply partial carburettor heat during this period. When engine cylinder head temperature begins to rise, normal throttle response should result and rpm can be increased to 800 or 1000 rpm, and further priming should not be necessary."

Position of Engine Starting Controls

105 It was almost a physical impossibility for an operator, sitting in the pilot's seat, to cold start the engines unassisted. The wobble pump and priming pump had to be used during starter and booster coil switch operation, and also immediately after start until the engine ran smoothly. With the right hand being used to operate the starter and booster switches, the throttle and prime could be reached with the left hand, but the wobble pump was inaccessable. When heavy winter flying clothes were worn, even the priming pump was difficult to operate, particularly if one engine was running and the control column was being held in the aft position. Because of the awkward arrangement of engine starting controls, it would seem likely that the situation could arise where unqualified personnel would be

required to operate the priming and wobble pumps, with the risk of over-priming resulting. It is strongly recommended that the starter and booster switches be moved to the left sub-panel, in front of the pilot, to facilitate engine starting. It is further recommended that electrically-driven fuel pressure booster pumps be embodied to replace the wobble pump.

Sec 11 - ENGINE WARM-UP AND OPERATION

106 Engine warm-up was normally done at 1000 rpm until cylinder head temperatures reached 120°C and engine inlet oil temperatures reached 40°C. When these minimum temperatures were reached, an engine run-up check was done as listed in EO 05-45B-1. At OAT's down to -20°C minimum oil temperature was obtained within ten to 15 minutes after engine start with oil shutters "CLOSED" and oil by-pass "HOT". At OAT's below -20°C the time to reach minimum oil temperature was considerably increased if the engine rpm was maintained at 1000 rpm. It was found necessary to increase the rpm gradually to 1200 rpm after the oil temperature reach 25°C. By increasing the rpm, the minimum oil temperature of 40°C could be obtained within 20 to 25 minutes at OAT's down to -30°C instead of the 35 minutes required when rpm was maintained at 1000. The oil by-pass valve was left in the "HOT" position until the oil temperature reached 40°C, and then moved progressively to the "COLD" position in the next five to ten minutes of engine operation. Oil shutters and cowl flaps were in the "CLOSED" position during ground operation except during the engine run-up check.

107 The graphs in Figs 34 and 35 show the cylinder head temperatures and oil temperatures and pressures during ground runs of the port and starboard engines at an OAT of -30°C. These graphs show the oil pressure recorded by both the standard gauges, and the electric transmitter type gauges installed for test purposes. The standard gauge was extremely sluggish at OAT's below -20°C unless the pressure line to the gauge had been primed with varsol. The gauges are discussed fully in Sec 14.

108 No difficulties were encountered with engine operation during warm-up subsequent to cold starts at temperatures down to -34°C. Engine run-up checks were conducted before take-off as specified in EO 05-45B-1. It was noted that although 2250 to 2300 rpm could be obtained in fine pitch at a manifold pressure of 32 inches of mercury at OAT's above -10°C, the maximum rpm obtainable was as low as 1900 rpm during run-up at OAT's between -25°C and -30°C. However, during take-off, rpm increased to 2250 or 2300.

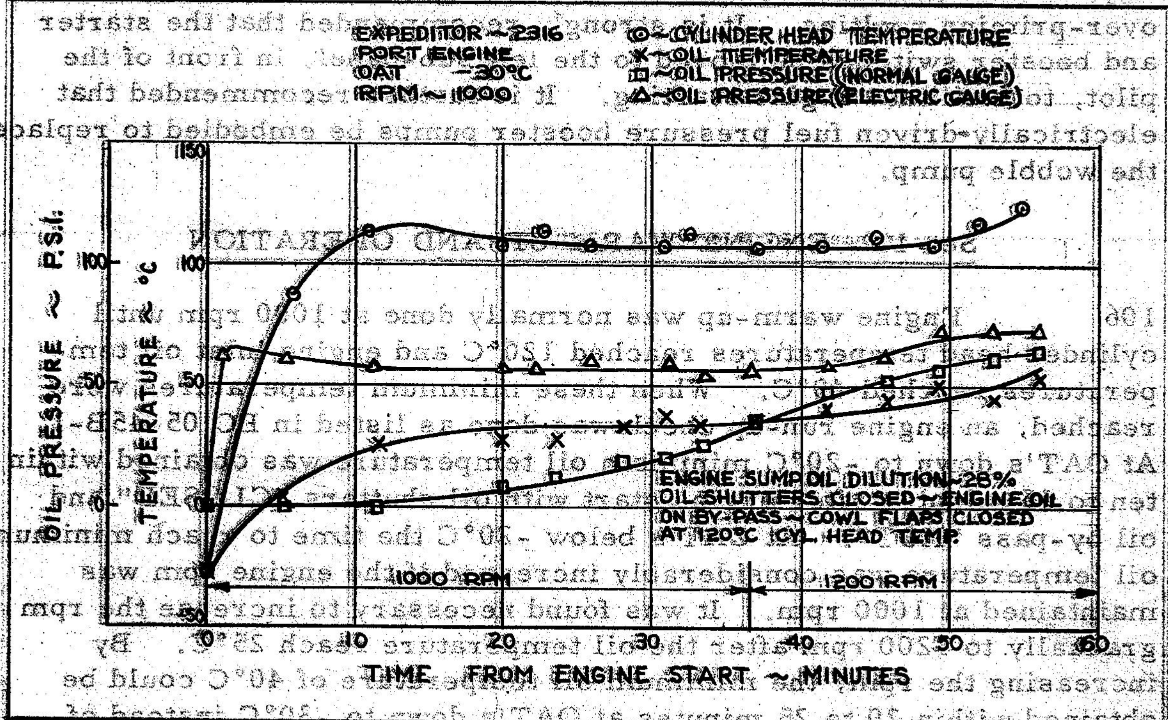

Fig 34 - Engine Warm-Up

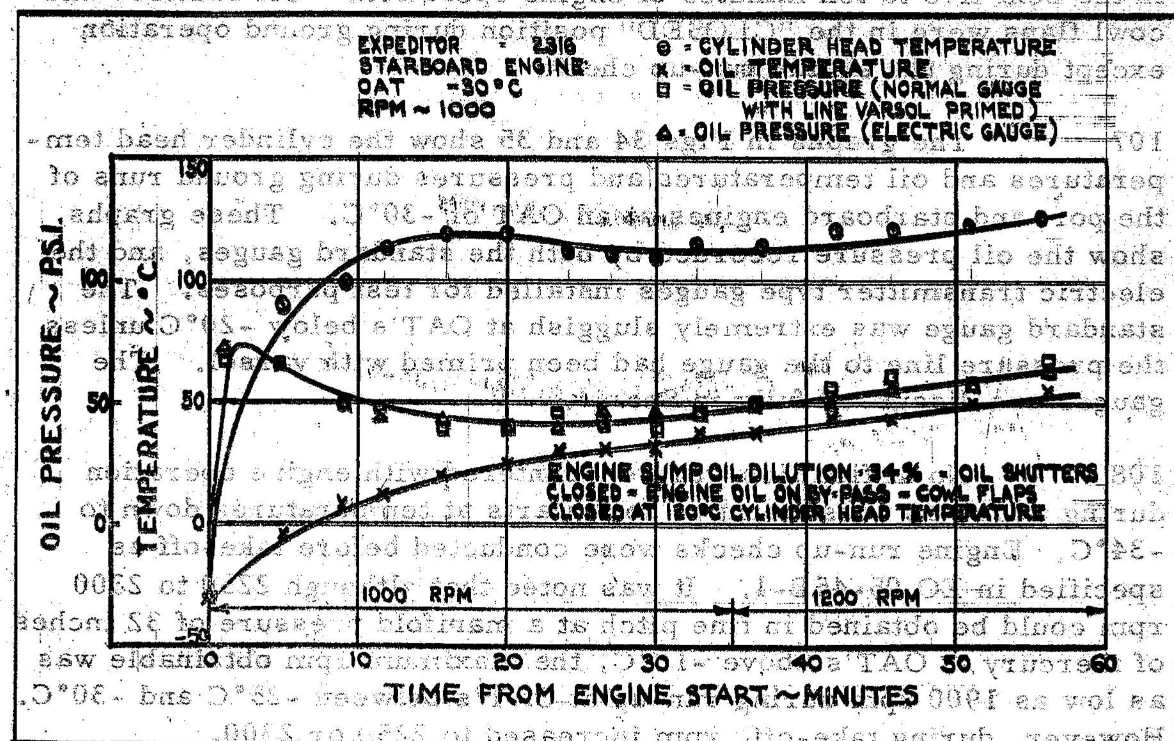

Fig 35 - Engine Warm-Up

Engine Operation During Flight

109 During the take-off and climb, the cowl flaps were set between one-quarter and one-half open to maintain cylinder head temperatures between 150°C and 200 °C. The oil by-pass was always placed in the "COLD" position before take-off. During prolonged climbs the oil shutter controls were partially opened to maintain the desired temperature of between 60°C and 70°C. The engines performed normally at all times during take-off and when climbing. The lowest temperature encountered during take-off was -33°C.

110 The lowest temperature encountered during level flight tests was -28°C since an inversion in the temperature invariable occurred during the winter and extended to an altitude of approximately 10,000 feet. The aircraft was flown at power settings and/or indicated airspeeds for: normal cruise, range, endurance, and maximum cruise in weak mixture. Cylinder head and oil temperatures were allowed to stabilize during each condition of flight. Cowl flaps and oil shutters were in the fully "CLOSED" position and the oil by-pass was in the "COLD" position. Cylinder head temperatures as low as 105°C resulted if the fuel/air ratio was not sufficiently lean. However, when the mixture controls were adjusted as specified in EO 05-45B-1, para 22, the cylinder head temperature stabilized between 140°C and 175°C under the flight conditions previously specified at an OAT of -28°C. Oil temperature stabilized between 60°C and 70°C except during flight conditions for maximum range. In this flight condition at 5000 feet and -28°C, at 127 knots indicated airspeed, with 1800 rpm and a manifold pressure of 23 inches of mercury, the oil temperatures stabilized at 50°C which is the minimum temperature specified.

111 Carburettor heat was normally used during prolonged descents at reduced power and, although a cylinder head temperature of 90°C was recorded on one of these descents at an OAT of -25°C, the engines responded normally when the throttles were advanced and the CSU operated normally. When carburettor heat was not used during descent slight backfiring and rough running resulted when the throttles were advanced.

112 The handling characteristics of the engines were considered acceptable in flight under all conditions encountered during the test season.

113 No difficulties were encountered with any of the engine components or accessories during the test program. The components and accessories fitted to the test aircraft are listed in Appendix "F".

Engine Oil Filter Checks

114 The oil filters of the port and starboard engines were checked during the aircraft acceptance check and were found to be clean. The filters were checked again after 22 hours of flying time and no sludge or foreign material was present. However, when the filters were checked after 36 hours of flying time, a trace of small non-ferrous metal flakes was discovered on the screen of the starboard engine filter. No metal was found in the port engine filter.

115 The starboard oil system was drained and purged with varsol. The propeller dome was removed, and although some rust was present as discussed in Sec 12, no metal particles were found. The dome was replaced and the system was replenished with oil. The engine was ground-run for 35 minutes, after which the filter was checked and found to be clean. The filter was again checked after a test flight of 1:10 hours had been made. When the filter was again checked during the minor inspection no metal particles were discovered. The source of the metal particles was not determined but it was believed to be light alloy swarf from the oil system.

Sec 12 - PROPELLERS

General

116 The aircraft was fitted with Hamilton Standard two-bladed, fully feathering hydromatic propellers. The propellers utilized engine oil pressure and centrifugal twisting moment of the blades to decrease propeller pitch, and governor oil pressure to increase pitch. Oil pressure for feathering and unfeathering the propeller was supplied by an electrically driven feathering pump in each wheel-well. The propellers operated normally under all conditions encountered during the test season. Feathering system tests are described in Sec 13.

Damage to Propeller Blade

117 On one occasion during the engine run-up prior to take-off a blade of the port propeller was slightly damaged by a stone that was picked up from the gravel runway by the propeller blast. The stone made a nick in the leading edge of the blade approximately 13 inches from the tip. The nick was three-eighths inch by one-sixteenth inch and one-eighths inch deep. The damaged area was reworked as specified in EO 05-45B-2, para 108. All subsequent engine run-ups were carried out on the snow-covered areas of the tarmac while at Fort Churchill. No further damage to the propeller blades occurred.

Rust in Propeller Dome

118 When the starboard propeller dome was removed on 4 Mar 54 to check for metal particles, as described in par 114, rust was observed on the distributor valve, rotating cams, and the lip on the inside of the propeller dome. The port propeller was also checked but no rust was present. The rust was removed by polishing the affected areas with crocus cloth.

119 It could not be determined if the rust had formed during the winter test season or had formed before the aircraft was accepted by the detachment. When the propellers were removed on 1 Apr 54 no further rust formation was found.

Sec 13 - PROPELLER FEATHERING SYSTEM

General

120 A training requirement called for unfeathering the propeller after 20 minutes of single-engine flight in cold weather. Reports were received that during cold weather, the propeller failed to unfeather on a number of occasions, which occasionally resulted in total electrical failure.

121 An investigation was conducted by the Beech Aircraft Corp. As a result of the recommendations in Beech Engineering Report 876 dated 18 Jan 52, a modified feathering system was incorporated in Expeditor aircraft 1511, that included oil dilution and oil bleed systems in the feathering lines. Tests were conducted by the detachment on the modified feathering system under the authority of AMTS Directive 11-52. The initial tests were made between May 1952 and September 1952. During this period the detachment incorporated a high pressure feathering dilution pump to increase the percentage dilution. These tests were the subject of CEPE Report AC9-52. Tests were continued through the 1952-53 winter season and CEPE Report 1002 was issued on the basis of these winter tests.

122 It was found that the modified system, with the high pressure dilution pump included, enabled the feathering system to operate satisfactorily down to an OAT of -24°C, the coldest temperature at which it was tested. It was thought to be adequate for unfeathering at OAT's down to -40°C. However, it was doubted that the engine could be continually restarted without damage, after 20 minutes single-engine flight at 40°C, unless the engine oil was diluted before the engine was

stopped. It was recommended that the Beech feathering system modification, with the addition of a Plessey Mk III pressure pump incorporated, be installed in all Expeditor 3 aircraft, and that no feathering line bleed system be used.

123 Under the authority of AMC EP 53/130-4 dated 23 Sep 53, the project on the modified feathering system was to be continued through the winter of 1953-54. Expeditor aircraft 2316 was supplied to the detachment after MacDonald Bros Aircraft Ltd (MBA) had installed the modified feathering system.

124 The feathering system in the test aircraft did not have a bleed system incorporated, and a Plessey Mk VII pump that included a fuel filter, was installed instead of a Plessey Mk III pump. The pump supplied dilution to either system during propeller feathering and unfeathering. A schematic diagram of the feathering system appears in Fig 28 in conjunction with the engine oil system. A complete list of feathering system components appears in Appendix "F". The electrical wiring diagram for the modified feathering system, and a general description of the system is included in CEPE Report 1002.

125 MBA advised AMC in October 1953, that difficulty had been encountered during propeller unfeathering when the dilution system was incorporated in the feathering system. MBA had encountered one instance when a propeller would not unfeather in flight. Further tests that resulted in unfeathering difficulties were ground tests. On the basis of these tests, it was believed that at relatively mild OAT's, the amount of dilution added during the early part of feathering cycle, reduced the viscosity of the oil to the point were the feathering pump was unable to build up the necessary pressure to complete the unfeathering cycle.

126 The purpose of the tests conducted on the modified feathering system during the 1953-54 test program was as follows:

(a) to determine the lowest temperature at which it would be possible to unfeather the propeller after 20 minutes of single-engine flight;

(b) to determine if diluted oil would adversely affect the operation of the feathering pump in warm weather;

(c) to obtain data on the temperature in the feathering system oil line during cruising flight to verify the statement made in CEPE Report 1002, that the feathering system bleed lines were not necessary; and

(d) to conduct functional tests on the feathering system to determine if it would operate correctly under all conditions likely to be encountered.

127 The lowest temperature experienced during propeller unfeathering after 20 minutes of single-engine flight during the 1953-54 tests was -21°C. The propeller unfeathered normally and the only difficulty that arose was overloading of the generator circuit. Ground feathering and unfeathering tests revealed that the system operated normally with diluted oil in the feathering pump having a viscosity of 60 Saybolt Universal Seconds (SUS). This was the lowest oil viscosity that could be obtained on the aircraft during test. From data obtained on the temperature of the oil in the feathering lines, it was determined that the diluted oil in the feathering lines would not congeal during cruising flight in cold weather and it was concluded that the bleed system previously used, was definitely not necessary.

128 A total of 59 feathering and unfeathering operations were conducted between 9 Jan 54 and 4 May 54 at OAT's ranging from -21°C to 1°C. In no instance did a propeller fail to feather or unfeather. However, it was found that there were several dependent and independent variables that affected propeller feathering and unfeathering, so that it was not possible to prove conclusively that the system would function effectively under all conditions.

129 It is recommended that further tests be conducted at OAT's above 0°C and below -20°C. It is also recommended that a re-assessment be made of the training requirement since the feathering system is an emergency system designed to ensure that the propeller will feather when engine failure occurs. It is felt that continual unfeathering after single-engine flight for 20 minutes at extreme OAT's will have a harmful effect on the engine and on the feathering system.

Feathering System - Flow Rates

130 Ground checks were made at the beginning of the test program to determine the delivery rate of the Plessey Mk VII pump. The rate of flow at the pump outlet was 2150 cc per minute, based on an average of four flow checks of 40 to 60 seconds duration. The pump static pressure was 80 psi which was the maximum setting

obtainable. Rates of flow measured at the inlet to the feathering oil line averaged 1850 cc per minute on the port side and 1950 cc per minute on the starboard side.

131 A check was also made to determine the rate of flow of bleed-back oil through the feathering pump during engine ground operation as it was believed there would be some flow even though no bleed system was incorporated. The port engine was run at 1000 rpm. When the engine oil temperature reached 65°C, two flow checks of one minute duration were made at the feathering pump inlet line. No measureable quantity of oil was collected.

Percentage Dilution Obtained During Feathering

132 Four single-engine landings were made during the test season to determine the percentage dilution obtainedduring in-flight propeller feathering. Oil samples were obtained from the feathering line at the nose position from the drain cock shown in Fig 36. The percentage of dilution varied from 13% to 21%. However, the rate of dilution was found to be 2.6% per second of propeller feathering time based on oil samples taken after the four single-engine landings. Data appear in Appendix "G". It was concluded that the percentage dilution obtained during propeller feathering was a direct function of the time required to feather. It is believed that percentage dilution obtained during unfeathering would also be a direct function of the time required to unfeather but the rate, in percentage dilution per second, was not determined by test.

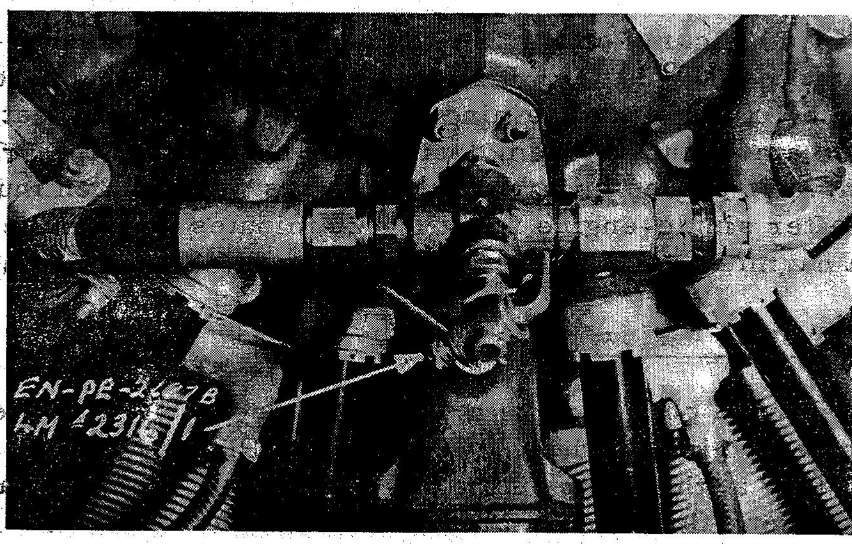

Fig 36 - Feathering Oil Line Sampling Cock and Temperature Bulb

Twenty Minutes Single-Engine Flight

133 When feathering trials were conducted in conjunction with 20 minutes of single-engine flight, normal electrical services were switched on prior to take-off. These were the VHF, MHF, radio compass, isolation amplifier, inverter and pitot heaters. The aircraft was flown at a pressure altitude of 5000 feet for approximately 30 minutes at cruising power before the propeller was feathered. One engine was stopped by moving the mixture control to the idle cut-out position, the throttle and pitch moved to the aft position, and the feathering button was pressed. The cowl flap and oil shutter of the dead engine were left in the closed position and carburettor heat was selected "HOT". The oil by-pass was placed in the "BY-PASS" position. After 20 minutes of single-engine flight the dead engine was restarted and warmed up at a power setting of 20 inches of manifold pressure and 1500 rpm.

134 Nine flights of this type were made. On all but one flight the port propeller was feathered since the port feathering system was more completely instrumented. Propeller feathering and unfeathering data obtained during these tests appear in Appendix "H".

135 The time required for the propeller to feather varied from five to ten seconds. The steady electrical current in the feathering motor circuit was between 185 and 210 amperes during feathering at OAT's between -10°C and -21°C. The peak load, which occurred at the instant the feathering button was pressed was generally greater than 250 amperes. On several occasions, a full scale deflection of the needle was observed, indicating a peak load in excess of 300 amperes. However, no electrical difficulties were encountered during propeller feathering.

136 During single-engine flight, the temperatures in the feathering line were recorded at frequent intervals. The positions of the temperature bulbs in the port feathering line are shown in Fig 28. The bulbs at the nose and adapter positions were located in the oil line while the other bulbs were attached to the surface of the lines. The temperature bulb installation at the nose position is shown in Fig 36.

137 The graph in Fig 37 shows the change in oil temperature at the nose and adapter positions during a 20 minute single-engine flight at an OAT of -21°C. The graph in Fig 38 shows the temperatures recorded from temperature bulbs positioned on the surface of the feathering pump inlet and outlet lines and also the free air

temperature in the wheel-well at a position approximately 12 inches below the pump. The free air temperature recorded does not represent the average wheel-well temperature because of the proximity of the engine exhaust to the temperature bulb.

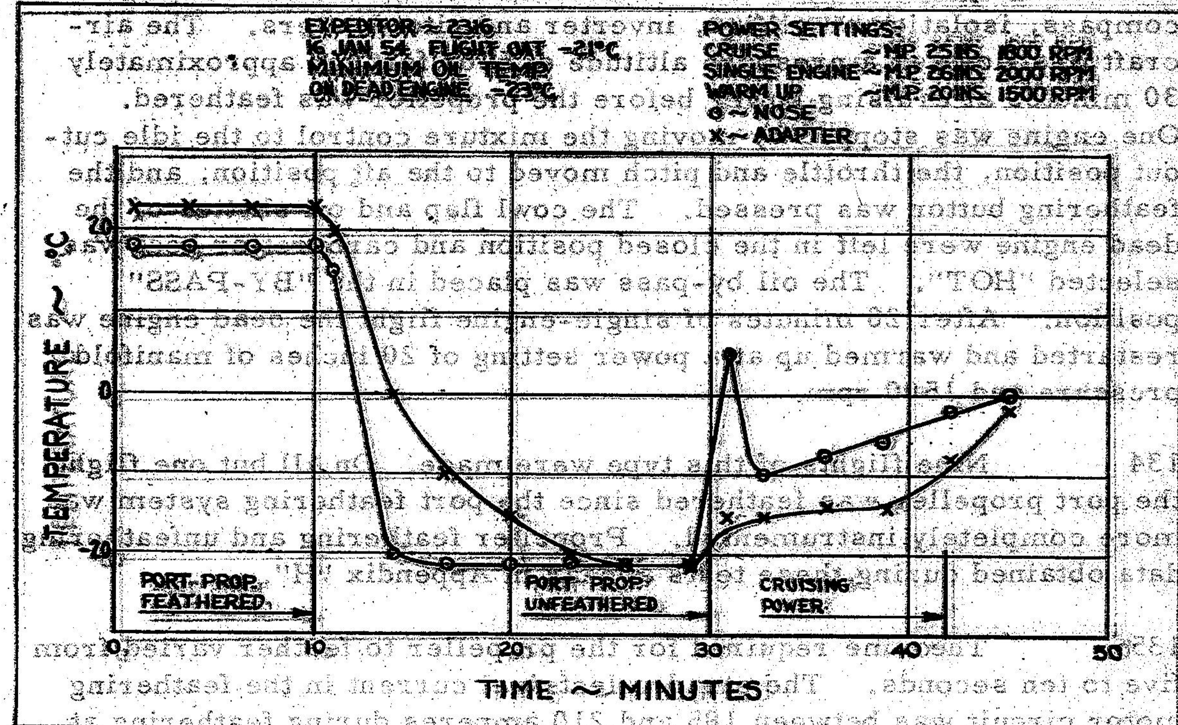

Fig 37 - Feathering Line Oil Temperatures During Single-Engine Flight

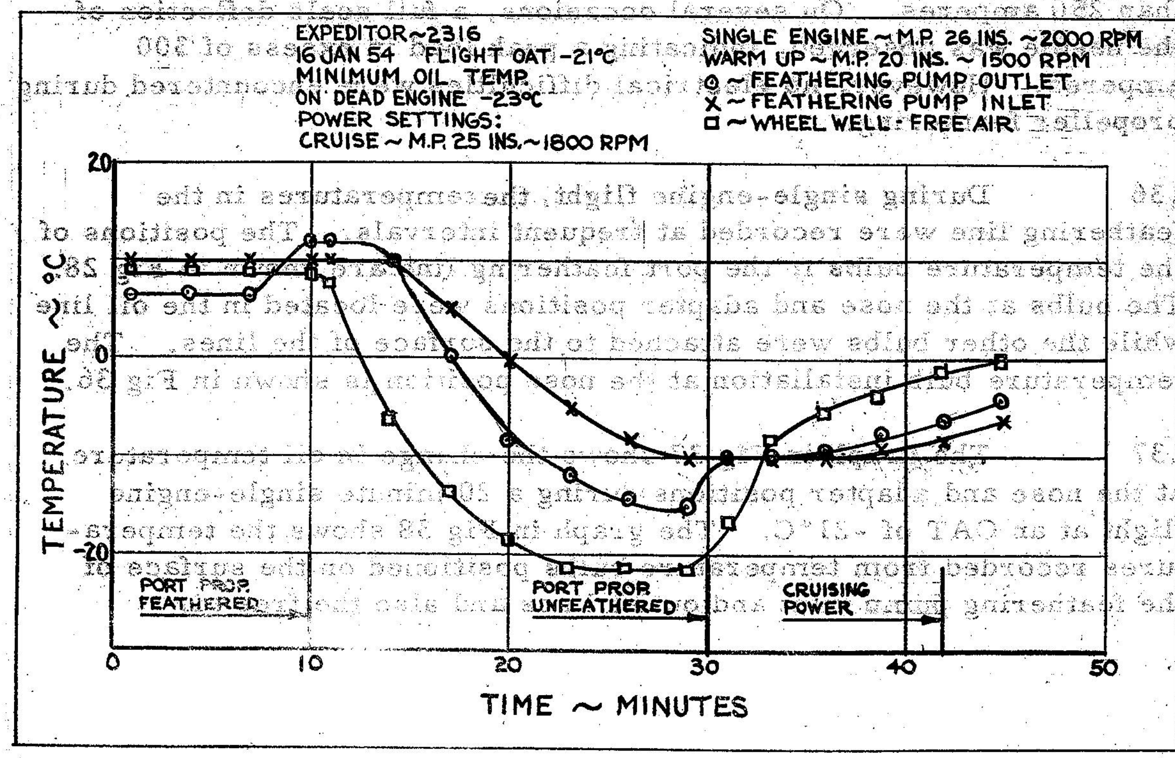

Fig 38 - Feathering Line and Free Air Temperature During Single-Engine Flight

138 The oil in the feathering line from the adapter forward to the dome cooled more rapidly than between the adapter and feathering pump and reached ambient temperature during the 20 minutes of single-engine flight. The temperature of the oil in the front of the dome was not recorded. However, it is expected that cooling at this position would be fairly rapid due to the large surface area of the dome.

140 The time required to feather the propeller during the test conducted at an OAT OF -21°C was seven seconds. At an expected rate of dilution of 2.6% per second the percentage dilution in the feathering system would be 18%. From the Standard Viscosity Chart of Appendix "J", it can be seen that oil diluted to this percentage would have a viscosity of 8000 SUS when cooled to a temperature of -21°C.

141 The graph in Fig 39 shows the change in cylinder head temperature during single-engine flight. The temperature was recorded from the aircraft cylinder head temperature gauge that did not register below 0°C. However, from the rate of decrease of temperature, it was obvious that the temperature reached approximately the ambient temperature within seven minutes after the engine was stopped. At a temperature of -21°C, the viscosity of undiluted oil between the pistons and cylinder walls would be 300,000 SUS.

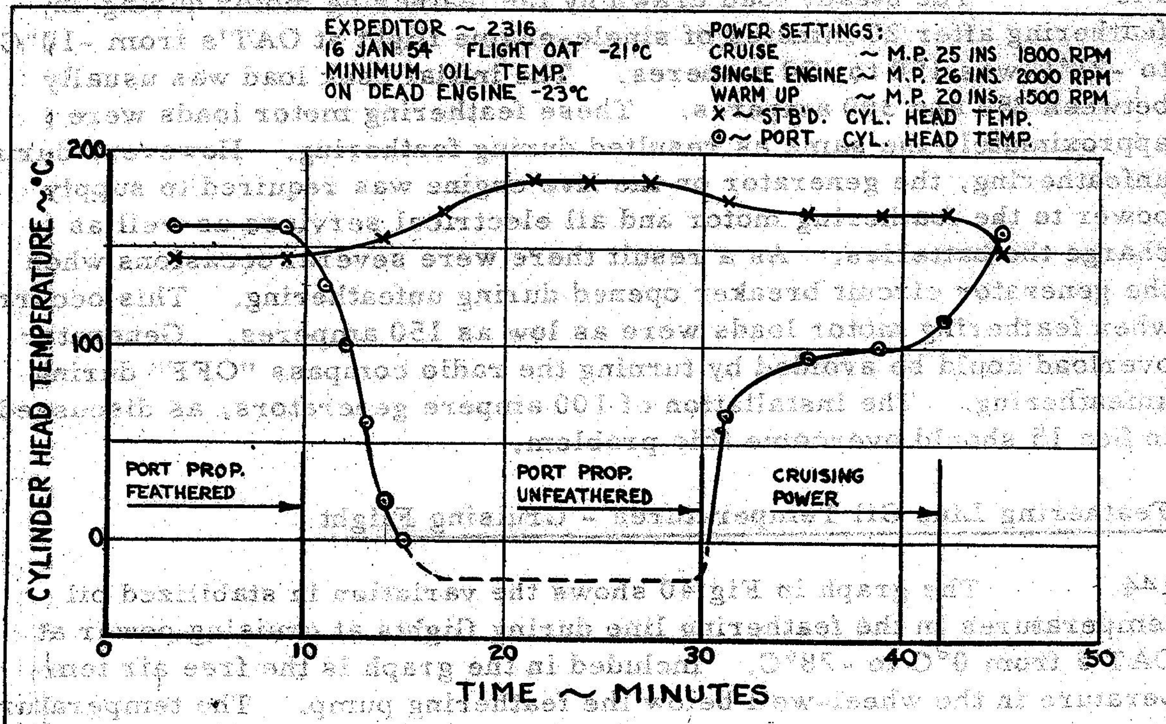

Fig 39 - Cylinder Head Temperatures During Single-Engine Flight

142 The average time required to unfeather the propeller after 20 minutes single-engine flight was ten seconds. Although the normal procedure is to hold the feathering button in until 800 rpm is obtained, this was not found to be practical. On several occasions during unfeathering, after 20 minutes single-engine flight in cold weather, it was found that rpm would increase steadily until a stabilized rpm of between 500 and 800 was reached. It appeared that the stabilized rpm was reached when maximum windmilling speed was obtained, and that no further rpm increase would occur until an engine start was obtained. On three occasions at OAT's of approximately -20°C, heavy backfiring occurred after unfeathering when pitch and throttle were adjusted to give 1500 rpm and 20 inches of manifold pressure. The conditions were similar to those encountered during engine cold start discussed in para 103. The procedure used during winter tests was to hold the feathering button until the rpm stabilized providing the stabilized engine speed was above 500 rpm. In no instance did the propeller recycle to the feathered position when this procedure was used. During unfeathering the airspeed was always between 90 and 110 knots (IAS) but the airspeed was not recorded during each unfeathering operation. Towards the completion of the test program it was proven that airspeed affected the time required to unfeather the propeller. Data obtained on the effect of airspeed on unfeathering time is discussed later in this section.

143 The steady load drawn by the feathering motor during unfeathering after 20 minutes of single-engine flight at OAT's from -10°C to -21°C was 150 to 190 amperes. The initial peak load was usually between 250 and 300 amperes. These feathering motor loads were approximately the same as resulted during feathering. However, during unfeathering, the generator on the live engine was required to supply power to the feathering motor and all electrical services as well as charge the batteries. As a result there were several occasions when the generator circuit breaker opened during unfeathering. This occurred when feathering motor loads were as low as 150 amperes. Generator overload could be avoided by turning the radio compass "OFF" during unfeathering. The installation of 100 ampere generators, as discussed in Sec 15 should overcome this problem.

Feathering Line Oil Temperatures - Cruising Flight

144 The graph in Fig 40 shows the variation in stabilized oil temperatures in the feathering line during flights at cruising power at OAT's from 0°C to -28°C. Included in the graph is the free air temperature in the wheel-well below the feathering pump. The temperature

of the oil at the nose and adapter positions was found to vary considerably since there was a flow through the line whenever the propellor pitch changed during constant speeding or when engine rpm was changed by moving the pitch control. On each flight, data were recorded after the aircraft had flown for approximately 30 minutes at cruising power in straight and level flight.

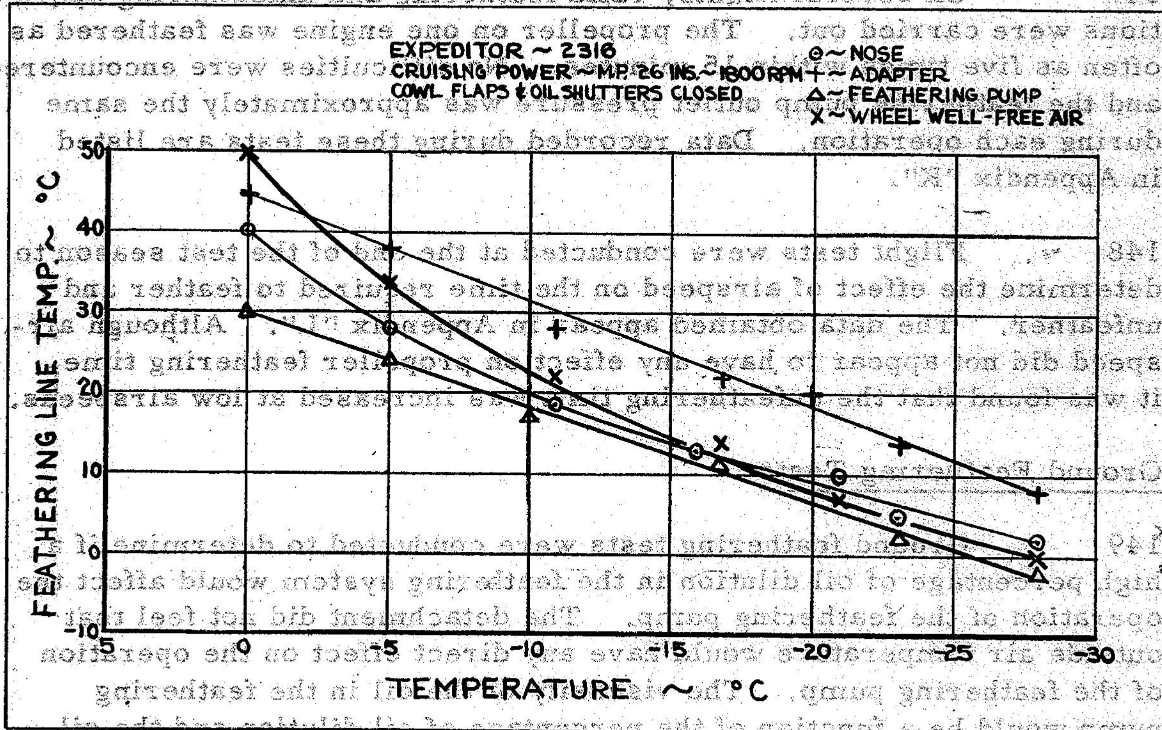

Fig 40 - Feathering Line Oil Temperatures in Cruising Flight vs OAT

145 From the graph it can be seen that the oil temperatures in the feathering system would probably stabilize between 0°C and -20°C during curising flight at an OAT of -40°C. On one occasion a propellor was successfully feathered at an OAT of -28°C, five minutes after take-off. Temperatures in the feathering line had not stabilized. The temperature at the nose position just before feathering was -20°C while the feathering pump inlet and outlet lines were at -15°C and -10°C respectively. From these tests it was concluded that no difficulty should arise during feathering at an OAT of -40°C if the aircraft had been flown at cruising power for 30 minutes prior to feathering. Difficulty is not liable to be encountered during feathering immediately after take-off at an OAT of -40°C if the propellers are partially feathered and unfeathered during the pre-take-off check.

146 It was concluded that the feathering line bleed system, previously used, was not necessary, and since it would remove diluted oil from the line between the adapter and the feathering pump, it was not considered desirable.

Functional Feathering Tests

147 On several flights, rapid feathering and unfeathering operations were carried out. The propeller on one engine was feathered as often as five times within 15 minutes. No difficulties were encountered and the feathering pump outlet pressure was approximately the same during each operation. Data recorded during these tests are listed in Appendix "K".

148 Flight tests were conducted at the end of the test season to determine the effect of airspeed on the time required to feather and unfeather. The data obtained appear in Appendix "L". Although airspeed did not appear to have any effect on propeller feathering time, it was found that the unfeathering time was increased at low airspeeds.

Ground Feathering Tests

149 Ground feathering tests were conducted to determine if a high percentage of oil dilution in the feathering system would affect the operation of the feathering pump. The detachment did not feel that outside air temperature would have any direct effect on the operation of the feathering pump. The viscosity of the oil in the feathering pump would be a function of the percentage of oil dilution and the oil temperature.

150 Laboratory tests were conducted in December 1953, at the detachment but the results were inconclusive. Initial tests were done with the feathering pump inlet attached to a header tank containing diluted oil. The pump outlet was blocked and the static pressure measured during pump operation. Because there was no return flow the pump heated rapidly during operation. The temperature of the diluted oil in the pump could not be measured so that viscosities could not be computed accurately. However, the pump was operated for periods up to 45 seconds, on grade 100 oil diluted to 50%. The temperature in the header tank was 12°C. The pump maintained the relief valve pressure of 800 psi for 30 seconds and 750 psi for the remaining 15 seconds of pumping operation. The oil viscosity based on the header tank temperature was 60 SUS. When the oil was diluted to 75%

the pump maintained a pressure of 750 psi for the first two seconds of operation, after which the pressure dropped to 600 psi within the next five seconds of operation, then the rpm of the pump began to increase and the pressure fluctuated. The viscosify in this case was very low (in the order of 15 SUS).

151 A return flow system was set up and a relief valve was put in the pump outlet line and adjusted to a setting 650 psi. The system functioned normally, but the delivery of the pump was only 25% of the delivery that would occur during feathering operations. The pump motor drew only 30 amperes as compared with 150 to 200 amperes obtained during in-flight feathering tests. Since these tests did not reproduce conditions in the feathering system, the tests were discontinued.

152 Aircraft ground feathering tests were conducted and the data obtained appears in Appendix "M". With the engine to be feathered operating at 1500 rpm and 22 inches of manifold pressure and the other engine operating at 1800 rpm in fine pitch, the feathering button was pressed. When the propeller feathered the feathering button popped out and the engine would continue to run at 400 to 500 rpm. After an interval of 30 seconds to two minutes, the feathering button was then held in until 800 rpm was reached. This procedure was repeated up to six times to determine if a series of rapid feathering operations would increase the percentage of dilution of the oil in the tank sufficiently to affect feathering pump operation.

153 Similar tests had been conducted in flight with no malfunctions resulting, so the ground tests were conducted with the engine oil diluted. Oil samples from the engine sump and "Y" drain showed 30% dilution before test and 15% and 25% respectively, after test. Samples from the bottom of the tank, adjacent to the feathering line outlet, were only 8% before test and 10% after test. As a result of the low percentage dilution at the bottom of the tank, the percentage dilution measured in the feathering system was only 24%. The oil temperature was 68°C giving a viscosity of approximately 60 SUS. During this test, six feathering and unfeathering cycles were completed in a total time of six minutes. The system operated normally throughout the test. The feathering pump outlet pressure was 200 psi during each feathering cycle. A pressure of 700 psi was recorded during the first two unfeathering cycles and 685 psi for the next four cycles.

154 It was not possible to determine at what oil viscosity the pump would fail to operate effectivey. However, if the feathering system, and feathering dilution system are operating correctly, no difficulty should be experienced during normal use.

Discussion

155 Although the propeller was successfully unfeathered after 20 minutes of single-engine flight at an OAT of -21°C it would be impossible to extrapolate the data obtained and conclude that unfeathering could be accomplished at appreciably lower temperatures. The most important factor governing the unfeathering operation is the viscosity of the oil in the feathering system and in the engine. The temperature of the oil in the forward part of the feathering line, and the oil between the pistons and cylinder walls will be cooled to ambient temperature during 20 minutes of single-engine flight. The oil in the front of the propeller dome will cool rapidly because of the large suface area of the dome and although no data are available, it isbelieved that the oil will cool to ambient temperature.

156 At an OAT of -40°C the viscosity of the oil between the pistons and cylinder walls would be 10,000,000 SUS, as compared with 3000,000 SUS at an OAT of -21°C. No data are available on the static torquerequired to turn the crankshaft under these conditions. Since the percentage of oil dilution depends on the time required to feather, the dilution in the feathering lines could be as low as 12% if the propeller feathered in five seconds. At an OAT of -40°C, the viscosity of the oil in the feathering line under these conditions would be 300,000 SUS during unfeathering as compared with a viscosity of 8000SUS which was the highest viscosity encountered during the test programs.

157 It is believed that the feathering dilution system will ensure propeller feathering at the lowest temperatures likely to be encountered. However, the system does not provide a fixed percentage of dilution because the time required to feather varies considerably depending on conditions of flight and engine temperatures. It is also thought that the time to feather will vary considerably for different propellers since the Hamilton Standard Maintenance Manual - Publication Number 144 quotes a blade torque of 35 $\pm$ 10 foot/pounds as being within limits. It is possible that there would be considerable difference in time to feather between a propeller with a blade torque of 25 foot/pounds and one with a blade torque of 45 foot/pounds. Unless a method can be devised to ensure adequate dilution regardless of propeller feathering time, unfeathering after prolonged single-engine flight at low temperatures cannot be assured. It may also be necessary to dilute the engine oil prior to feathering so that an adequate windmill cranking rate will be obtained during feathering. Extensive tests are necessary if this training requirement is to remain unchanged.

Sec 14 - INSTRUMENTS

General

158 The carburettor mixture temperature gauge, oil temperature gauges, fuel quantity gauge, and the pilot's turn-and-bank indicator used in the Expeditor, operated on direct current electrical power. The pilot's gyro-horizon, and the magnesyn compass operated on alternating current. All other gyro instruments were vacuum operated. The tachometer and cylinder head temperature gauge operated from systems that employed self-generated electrical power. The fuel pressure, oil pressure, and suction gauges employed the bourdon-tube principle. Difficulties encountered with aircraft instrumentation are discussed in the remaining paragraphs of this section.

Oil Pressure Gauges

159 Each engine oil pressure gauge was incorporated in a Unit Engine Gauge (RCAF Ref 6A/932), which also included oil temperature and fuel pressure indicators. The oil pressure gauge was the direct-reading type employing the bourdon-tube principle. From previous experience it was known that this type of pressure gauge is not reliable at low temperatures because oil congealed in the line between the engine and the gauge. At the beginning of the test season the pressure line from the engine to the starboard gauge was primed with varsol and the line to the port gauge was left unprimed for comparison. Electric pressure gauges (RCAF Ref 6A/1314) were also installed so the accuracy of the standard gauges could be checked. The method of installation of the electric transmitter type gauges is described in para 163. The standard gauge, connected to the starboard engine by a line primed with varsol, operated normally throughout the test season at OAT's down to -34°C, which was the lowest temperature encountered during engine operation. The gauge recorded oil pressure within a few seconds after engine start and the readings were practically identical to those shown on the electric transmitter type gauge. The standard gauge, connected to the port engine by a line containing engine oil, was very sluggish in operation during engine cold start and warm-up at OAT's below -10°C and showed a lower oil pressure than that of the corresponding electric gauge for from five to 55 minutes after engine start. The oil pressures recorded from the two types of pressure gauge during engine warm-up at an OAT of -30°C are shown in graphical form in Figs 34 and 35. On this occasion, the standard gauge, with oil in the line between the gauge and the port engine, gave no pressure indication for the first 12 minutes after engine start and did not show the correct pressure until approximately 55 minutes after engine start.

160 It was concluded that the pressure line to each oil pressure gauge must be primed with varsol at the beginning of winter operations to ensure proper operation of the gauges during cold weather. It is recommended that this procedure be adopted by all units operating Expeditor 3 aircraft.

Electric Trun-and-Bank Indicator

161 The electric turn-and-bank indicator (RCAF Ref 6A/1190) became unserviceable early in the test season. Frozen condensate was observed on the inside of the glass. It was found that the pointer mechanism would not operate at OAT's below -20°C even when cockpit temperatues reached 20°C although the gyro and driving motor continued to operate normally. When the gasket between the glass and the instrument assembly was removed, there was evidence that the gasket had not been providing a proper seal. A new instrument was installed and no further difficulty was experienced. It was considered that the unserviceability was an isolated case caused by the failure of the gasket to provide a proper seal.

Electric Gyro-Horizon

162 The H-5 Gyro-Horizon (RCAF Ref 6A/1165) became inoperative during the ferry flight to Fort Churchill on 11 Jan 54. The fast erection system would not erect the gyro. The OAT during the flight varied between -6°c and -11°C. On inspection if was found that both the Gyro Power Control Unit (RCAF Ref 6A/1166) and the 115-volt inverter (RCAF Ref 5U/1867) were unserviceable. The failure of the inverter is described in Sec 15. Because structural damage had occurred in the inverter, it was assumed that the initial failure was in the inverter and that damage to the power control unit and gyro erection system followed. A new inverter, power control unit, and gyro-horizon were installed and no further difficulties were encountered. The failure was not considered to be the result of cold weather operation.

Test Instrumentation

163 Electric pressure gauges (RCAF Ref 6A/1314) were installed on the test aircraft to measure engine oil pressure. The instruments were mounted on a bracket and attached to the right side of the instrument panel cowl assembly as shown in Fig 41. The gauges were wired to electric pressure transmitters (RCAF Ref 6A/1311) installed on the aft side of each engine inner cowl. Power was supplied from an inverter (RCAF Ref 5U/1877) which was mounted under the first navigator's table. An oil pressure line six inches in length extended from each transmitter to the pressure line from the engine to the standard oil pressure gauge and was connected to this line by a "T"

fitting 12 inches from the engine connection. The line in the port system operated on engine oil. The line in the starboard system was filled with varsol at the beginning of the test season. Both gauges operated normally throughout the test season and recorded engine oil pressure within a few seconds after engine start at the lowest temperature encountered.

Fig 41 - Electric Oil Pressure Gauges

164 An electro-hydraulic pressure gauge (RCAF Ref 6A/1122) was mounted on the first navigator's table as shown as item (1) of Fig 42. The gauge recorded the oil pressure at the feathering pump outlet on the port engine during feathering and unfeathering operations. The gauge was wired to an electro-hydraulic pressure transmitter (RCAF Ref 6A/1121) which was installed in the port-wheel-well above the feathering pump. Power was supplied by the inverter mounted under the first navigator's table.

165 Five resistance temperature bulbs were installed to measure the temperature of the oil in the feathering system of the port engine. One temperature bulb was installed to measure the free air temperature in the port-wheel-well in the vicinity of the feathering pump. These bulbs were wired through a six-position rotary selector

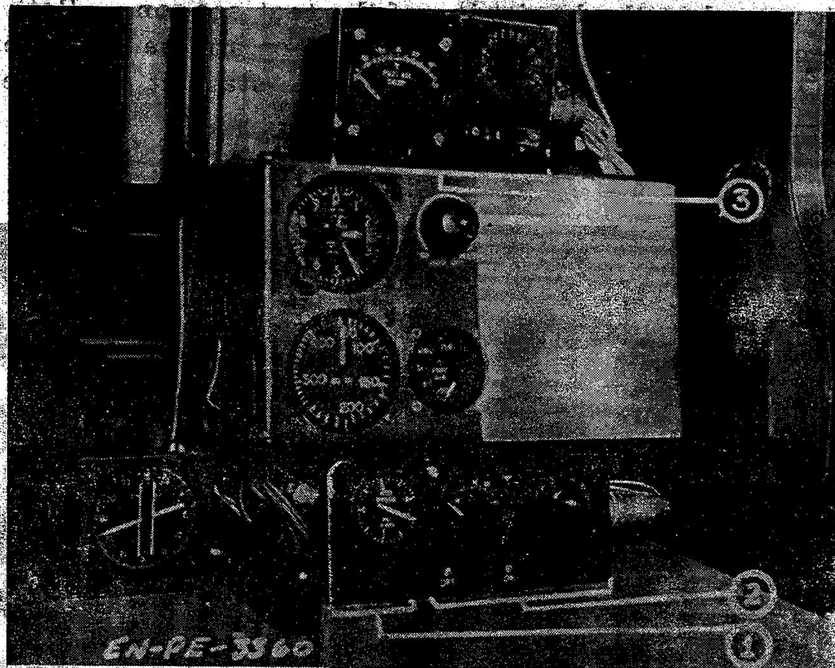

Fig 42 - Test Instrumentation on Navigator's Table

to a single temperature gauge. The selector switch and gauge were mounted on the table below the first navigator's instrument panel as shown as item (2) of Fig 42.

166 Fourteen resistance temperature bulbs were installed to measure temperatures in the cockpit and cabin. These bulbs were wired through a 14-position rotary selector switch to a single temperature gauge. Figure 42, item (3) shows the selector and gauge which were mounted above the first navigator's instrument panel.

167 An ammeter was installed on the left cockpit wall beside the main instrument panel as shown in Fig 43. This instrument measured the amperage in the feathering motor circuit during feathering and unfeathering operations. A two-position switch, mounted on the bottom of the ammeter bracket, permitted the amperage of the port or starboard feathering motor to be measured.

Fig 43 - Ammeter to Record Feathering Motor Amperage

Sec 15 - ELECTRICAL

General

168 The basic electrical system in the aircraft was a 28-volt direct-current, single-wire, ground-return system. Power was supplied by two engine-driven generators (RCAF Ref 5U/836) with a normal maximum output of 50 amperes each, and two 12-volt batteries, connected in series. A rotary inverter (RCAF Ref 5U/1867) provided three-phase alternating current of 400 cycles per second at 115 volts. A second inverter (RCAF Ref 5U/1877) provided single-phase alternating current of 400 cycles per second at 26 volts.

169 Since the aircraft systems were almost entirely electrically operated, a comparatively high load was placed on the 50 ampere generators on occasions. Generator overloads occurred during propeller feathering and unfeathering operations, and during unfeathering after 20 minutes of single-engine flight in cold weather the generator circuit breaker would open unless some of the essential electrical services were turned off. Generator overload during propeller feathering operations is discussed in Sec 13.

170 The generator drive gears provided a 1.5:1 ratio between generator speed and engine crankshaft speed which was insufficient to provide generator output during normal ground operation. This subject is discussed in paras 20 to 22 of CEPE Report AC9-52. By following the procedure recommended in para 22 of the reference report during all ground operations, reverse current was minimized, and no unserviceabilities were caused from discharged batteries during the test season.

171 AMC letter 1038 JU-3 (SACO/ARC2-1) dated 15 Mar 54 advised that 2:1 generator drive gears and 100-ampere generators have been ordered to replace the 1.5:1 drive and the 50-ampere generators. It is felt that these changes will eliminate the problems encountered with the electrical power supply.

172 The electrical system was operated at OAT's down to -34°C on the ground, and for extended periods at an OAT of -28°C in flight. Difficulties encountered are discussed in the following paragraph of this section.

Adjustment of Voltage Regulator

173 A voltage regulator was located in front of each battery in the wing battery compartments. To adjust the regulators in cold weather when heavy clothing was worn, it was first necessary to remove the batteries to allow sufficient space to work. The adjustment was carried out by a technician lying on the wing directly behind the propellor while the engine was operated at 1800 rpm. This procedure was definitely not acceptable in cold weather. It is considered that modification to provide for the adjustment of the regulators from inside the aircraft is a cold weather operating requirement. This problem was referred to in the letter mentioned in par 171. A modification to provide adjustment of the regulators from inside the aircraft is being processed through AMC.

Inverter Failure

174 On investigation of the cause of the failure of the pilot's gyro-horizon as discussed in par 162, it was found that the inverter (RCAF Ref 5U/1867) was supplying an output voltage of only 19 volts. Examination revealed that the leaf-spring on the frequency speed control governor was broken into three pieces. The centre contact of the spring showed signs of wear. It was believed that the centre contact of the spring had not been in proper alignment with the carbon-pile contact, which probably resulted in a vibration that caused the leaf-spring to fail. This was considered to be an isolated case of a technical

failure that had no bearing on cold weather operation. An Unsatisfactory Condition Report was submitted on the failure. It is believed that the defect caused the failure of the electric gyro-horizon and gyro-power control unit. A new inverter, gyro-horizon, and gyro-power control unit were installed and no further difficulty was encountered throughout the test season.

Sec 16 - TELECOMMUNICATIONS

General

175 The telecommunications equipment fitted to the test aircraft when it arrived at the detachment was as follows:

(a) AF/ICA-67 - VHF Installation

(b) SCR-274-N - HF Command

(c) AN/ARN-7 - Radio Compass

(d) AN/ARN-5 - Instrument Landing System

(e) MN-53-B - Marker Beacon Receiver

(f) BC-347-C - Interphone Amplifier

AF/ICA-67 - VHF

176 The AF/ICA-67 VHF installation functioned satisfactorily throughout the test season. Channel change time had not appreciably increased at -33°C, the lowest temperature at which it was tested on the ground, and no problems were encountered with the lubrication of the channel change slides and dynamotor bearings. Lubrication was maintained in accordance with instructions contained in EO 35AA-51CA56-2. No failure occurred during the period of test.

SCR-274-N - HF Command

177 The operational performance of the HF Command installation was entirely satisfactory and no unserviceabilities occurred. The remote receiver tuning flexible drives remained free at all temperatures encountered.

AN/ARN-7 - Radio Compass

178 At temperatures in the region of -30°C considerable difficulty was experienced in operating the flexible drive to the receiver of the AN/ARN-7 Radio Compass. The tuning control became very stiff and was inclined to spring back a few degrees after setting. Investigation showed that the routing of the flexible drive involved a number of very sharp turns. These were close to the pilot's control unit, and aft of the rear bulkhead close to the receiver but the sharpest turn was at the navigator's control close to the "T" splice. The grease in the flexible drive became very stiff at low temperatures. The type of grease that had been used could not be identified. Poor routing and improper lubrication of the unusually long flexible drive were considered to be responsible for the unsatisfactory operation. Cabin heat was sufficient under all conditions encountered to restore flexibility to the control and no difficulties were experienced in flight, but it is recommended that the drive be rerouted to avoid sharp turns and that graphite powder or low temperature grease (RCAF Ref 34A/192) be used for lubrication.

179 Below a temperature of approximately -20°C the compass indicators were found to be sluggish. By local application of heat from an electric heater gun (RCAF Ref 2T/562), the difficulty was traced to the pilot's indicator. It was also observed that normal cabin heat restored freedom of movement to the indicators in flight within 15 minutes from the time of take-off.

180 At the conclusion of the test program at Fort Churchill, the pilot's indicator, (type I-81-A, serial number 7633), manufactured by Sparks-Withington Co, was removed from the aircraft for cold chamber test at Namao to determine the torque required to initiate movement of the pointer at various temperatures between 15°C and -40°C. The pointer was exposed by removing the glass and the instrument was placed in the cold chamber and allowed to cold soak for one hour at each temperature investigated. It was not believed that removing the glass would affect the operation of the instrument since the instrument was not hermetically sealed. At the conclusion of each one hour test period the instrument was removed from the cold chamber and a 0.50 gram weight was attached to the pointer by means of a hook so that the weight could be positioned at any distance along the pointer. The weight was slid along the pointer until the pointer moved and the moment arm was measured. The instrument was cold soaked with the pointer set at various positions in relation to the dial and the torque was measured in both clockwise and anti-clockwise directions. The resultant torques were averaged for each temperature tested and appear in the graph of Fig 44. A more detailed investigation into this malfunction could not be conducted because of the lack of facilities at Namao but

it was concluded that the rapid change in torque in the -20°C to -26°C region was due to differential contraction of the moving parts and that the reduction below -26°C may be due to a reduction in brush friction.

181 From all other aspects the radio compass installation was entirely satisfactory and no unserviceabilities occurred during the period of test.

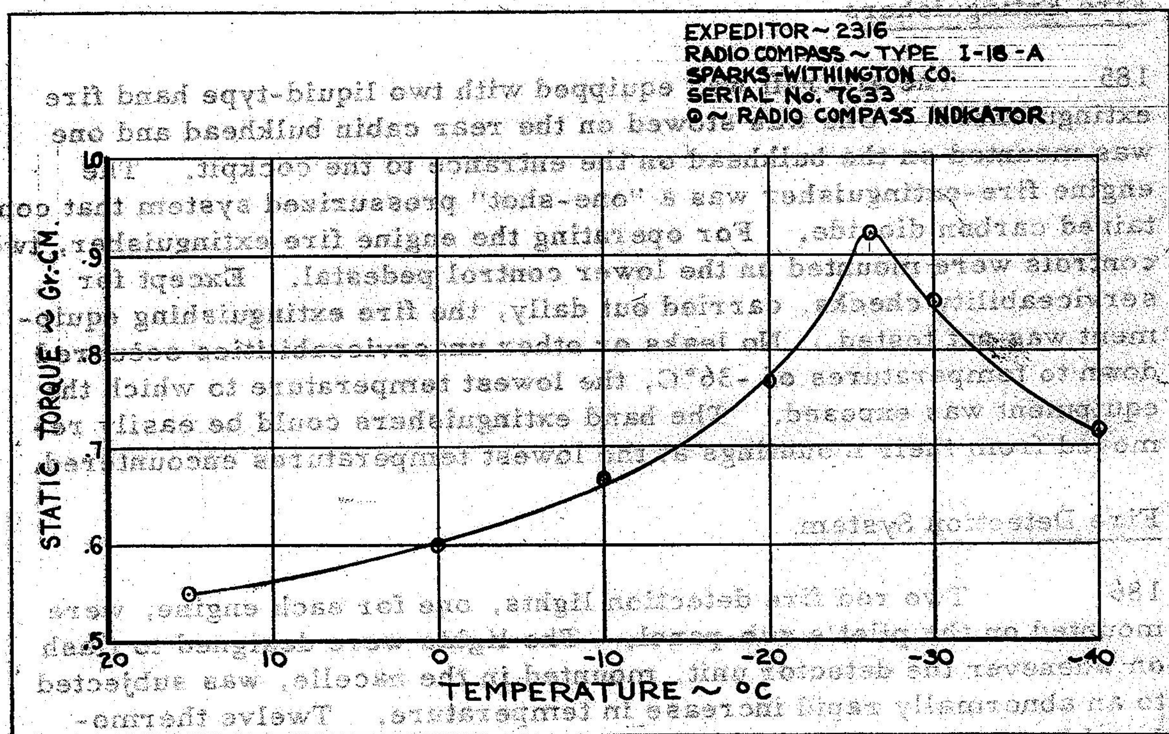

Fig 44 - Torque to Move Radio Compass Pointer Vs Temperature

AN/ARN-5 Instrument Landing System

182 No tests were conducted on the ILS equipment as the aircraft was under test at Fort Churchill and Namao, where no ILS ground facilities existed. The installation was operated in the air on several occasions and appeared to be functioning correctly.

MN-53-B - Marker Beacon Receiver

183 The marker beacon functioned satisfactorily at all times throughout the test season and no unserviceabilities were recorded.

BC-347-C - Interphone Amplifier

184 The intercommunication facility was satisfactory at all times and apart from cleaning the dynamotor commutator, no repairs or adjustments were necessary.

Sec 17 - EMERGENCY EQUIPMENT

Fire Extinguishers

185 The aircraft was equipped with two liquid-type hand fire extinguishers. One was stowed on the rear cabin bulkhead and one was mounted on the bulkhead on the entrance to the cockpit. The engine fire-extinguisher was a "one-shot" pressurized system that contained carbon dioxide. For operating the engine fire extinguisher, two controls were mounted on the lower control pedestal. Except for serviceability checks, carried out daily, the fire extinguishing equipment was not tested. No leaks or other unserviceabilities occurred down to temperatures of -36°C, the lowest temperature to which the equipment was exposed. The hand extinguishers could be easily removed from their mountings at the lowest temperatures encountered.

Fire Detection System

186 Two red fire detection lights, one for each engine, were mounted on the pilot's sub-panel. The lights were designed to flash on whenever the detector unit, mounted in the nacelle, was subjected to an abnormally rapid increase in temperature. Twelve thermocouples were mounted in each nacelle, seven of these were in front of the firewall and five in the wheel-well. A switch for testing the circuit was located next to the lights. On one occasion, during engine warm-up at an OAT of -20°C, the port fire detection light flashed on. A visual check was made before the engine was stopped but there was no evidence of fire. The false indication of fire was attributed to poor positioning of the thermocouples. Modifications EO 05-45B-6A/37 dated 6 Nov 53 regarding the repositioning of thermocouples was not received at the detachment until 10 Mar 54 and was incorporated when the aircraft returned to Namao at the end of the test season.

Safety Equipment Stowed

187 Safety equipment was carried in the aircraft in quantities conforming to the scale of issue in CAP 650. The total weight of the safety equipment was 265 pounds. Most of the equipment was stowed

on the floor at the front of the cabin as shown in Fig 45. Two sleeping bags were stowed behind the second navigator's seat, while snow shoes were stowed in the aft compartment. The type and quantity of safety equipment was considered adequate but it was believed that the total weight of the equipment was excessive and could be decreased considerably by redesign of the containers. It is recommended that the Institute of Aviation Medicine be requested to develop a more compact and lighter weight survival kit for Expeditor aircraft.

Fig 45 - Emergency Equipment Stowage

Sec 18 - MAINTENANCE AND GROUND HANDLING

Engine and Airframe

188 The total flying time since overhaul on the aircraft at the beginning of the test season was 7:00 hours. The first minor inspection was not carried out until after the test program had been completed.

Little difficulty was encountered with either the engine or the airframe during the test season. On several occasions the aircraft was moved into the hangar to install local modifications to the heating and defrosting system. On these occasions most of the required maintenance was carried out. As a result, very little maintenance, other than general servicing and daily inspections, was done on the aircraft while it was dispersed. The only major components removed during the test period were the propeller domes and the port tire. This work was done in the hangar.

Daily Inspections

189 Daily inspections were completed outdoors by a five man crew at temperatures down to -36°C in approximately 45 minutes. This time includes the time required to remove engine covers and blanking plugs but not the time required to remove heavy frost or snow accumulation.

Servicing

190 No difficulty was encountered with refuelling the aircraft or adding oil. The aircraft ladder, normally used as an entrance step to the main door, was very useful for reaching the nose tank and wing main tanks when they were being refuelled. The ladder was also used when checking or replenishing the engine oil tanks. All access panels were of reasonable size and components could be reached readily by personnel wearing winter clothing.

Dispersal

191 The aircraft was dispersed with chocks in front of and behind the main wheels and with the tail wheel locked. Ropes were fastened to the tie-down lugs under each wing and anchored to 45-gallon oil drums. The drums were filled with water at the beginning of the test season and frozen into the ground at positions which would allow the aircraft to be headed into the prevailing wind. Aileron, rudder and elevator controls were held in position by the normal control lock assembly. Blanking plugs and engine covers were used at all times during dispersal. The aircraft could be secured for dispersal in approximately 45 minutes. This time included the time required to install the engine covers. On one occasion, when the aircraft was dispersed, the wind gusted to 90 mph. To ensure security, a rope was lashed to the tail-wheel assembly and anchored to a 45-gallon oil drum which was placed under the horizontal stabilizer.

Frost and Snow Removal

192 Light frost was encountered on three occasions during the test period. In each case the frost was removed in one hour by two men using corn brooms and brush brooms. Aircraft stands were not necessary since all upper surfaces of the aircraft could be reached by a man standing on the aircraft ladder. Because of the windy conditions and generally light snowfall that occurred at Fort Churchill, it was seldom necessary to remove snow from the aircraft surfaces. Snow accumulation along the hinge lines of the control surfaces was easily removed by hand or with a broom. The ingress of snow to the engine accessory and crankcase sections, discussed in Sec 5, could be removed by first removing the wrapper assemblies on either side of the lower nacelle of each engine.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

193 It was concluded that the Expeditor 3NM aircraft was not suitable for cold weather operations because it did not meet RCAF low temperature requirements. Difficulties were encountered with several of the aircraft systems during the winter test season which will necessitate further testing as recommended specifically in para 195.

194 It was concluded specifically that:

(a) The paint on the RCAF roundels on the fuselage and under surface of the wings had scaled when the aircraft was exposed to temperatures down to -36°C because of insufficient preparation of the metal surfaces before painting, para 7.

(b) The leatherette on the cabin walls split, presumably because of excessive shrinkage at low temperatures, para 8.

(c) The following aircraft covers were not suitable as detailed below:

(i) The cockpit cover did not fit properly around the antennae at the top of the aircraft nor along the sides of the cockpit, para 13. The cover did not prevent the ingress of snow through the cockpit side windows during dispersal in blowing snow, para 14. The nylon material of which the cover was made froze to the aircraft when subjected to freezing rain conditions, para 15.

(ii) The wing and wheel covers were not necessary under the weather conditions encountered during the tests. The covers did not extend right up the wing-root and were not tailored properly over the inboard wing section between the nacelle and fuselage. No provision was made for access to the tie-down lugs on the undersurface of the wings, para 16. The nylon material of which the covers were made, froze to the upper surface of the wing when freezing rain was encountered, para 17.

(iii) The tail cover was not necessary under the weather conditions encountered during the tests. The covers froze to the aircraft when freezing rain occurred, para 19.

(iv) The engine covers did not prevent snow accumulation around the front of the lower cylinders and in the crankcase and accessory sections during blizzard conditions with the wind strength more than 40 mph. Snow entered through the overlap at the front of the cover immediately below the propeller dome, and through the rear of the cover and into the accessory and crankcase sections through the space between the lower nacelle and wrapper assemblies, and the space between the lower cowls and the wrappers, para 21. It was impossible to remove all of the snow when the aircraft was outside and difficulty arose during engine warm-up from the snow melting and freezing on the landing gear, para 22. Stiff throttle control operation that occurred during flight was also attributed to snow entry that occurred during dispersal, para 48.

(d) The cockpit sliding windows could be operated without difficulty under all conditions encountered but did not fit tightly enough to prevent snow entry during dispersal in blizzard conditions, para 31.

(e) At temperatures below -25°C there was sufficient slack in the rudder trim control system as a result of differential contraction to cause the cable to slip on the drive pulley, para 34.

(f) The silicone rubber grommets supplied to replace the neoprene grommets in the carburettor heat and cowl flaps control systems were more pliable than the neoprene grommets at low temperatures, para 38. However, because of the extremely high operating forces encountered in these systems, it was not possible to determine if control forces would be appreciably lower at extreme temperatures if silicone grommets were used instead of neoprene grommets, para 39.

(g) The cleaning and lubricating adapter (RCAF Ref 4G/1764) could not be used successfully on the engine controls of the aircraft. When fluid was forced from the adapter the fluid leaked through the spiral wound covering. The adapter was used successfully to clean and lubricate a cable with a laquered fabric covering.

(h) Frozen engine controls were caused by frozen condensate between the telescoping assemblies of the engine control cable end fittings. The moisture that resulted in the frozen condensate was normally caused by snow entry into the engine during engine ground running in blowing snow conditions, para 47. On one occasion, moisture formed on the end fitting of the throttle control from the snow that entered during dispersal and resulted in extremely stiff throttle lever operation in flight when the moisture froze because of a reduction in temperature in the engine bay during a rapid descent at reduced power, para 49.

(j) The use of low temperature grease (RCAF Ref 34A/192) for lubrication of the telescoping assemblies of the engine controls will prevent, or reduce the frequency of frozen controls during cold weather operation, para 52.

(k) The high cowl flap operating forces encountered resulted mainly from friction between the flap segments. Operating forces were reduced considerably by adjusting the cowl flap assemblies and lubricating the overlapping flap segments with low temperature grease. However the control operating forces were excessive at OAT's below -15°C, para 55.

(l) The effectiveness of the "heater-muff" modification in preventing the formation of ice in the air scoop assembly during flight could not be assessed during winter tests because airframe icing conditions were not encountered, para 57.

(m) The carburettor hot air valve froze on 12 occasions when the engine cooled after engine ground operation in blowing snow conditions. The water resulting from snow entry during ground running formed a film between the valve and the sides of the air scoop assembly. When the assembly cooled during dispersal, the water formed a film of ice or frozen condensate between the valve and assembly, para 59.

(n) The layout of the rudder pedals made operation of the brakes difficult, and was not considered acceptable when winter flying clothing and flying boots were worn. Because the feet had to be repositioned on the pedals so that brakes could be applied effectively, there was a transition period during take-off and landing when neither the brakes or the rudder could be applied effectively, which resulted in a flying hazard during the two most critical periods of aircraft operation. The fault could be overcome by providing a rudder pedal that would be two inches closer to the floor, and inclined forward at an angle of 15 degrees to the vertical so that the top of the pedal would be forward of the present position. The pedal could be redesigned so that no major change to the rudder pedal assembly or brake rod assembly would be necessary, para.66.

(o) A blow-out that occurred to the port main tire while the aircraft was in the hangar was caused by damage to the inside of the tire which had occurred during landing on the gravel runway at Fort Churchill, para 68.

(p) None of the heating and defrosting components supplied by the Beech Aircraft Corp were considered acceptable because of the difficulties that were encountered during installation on the test aircraft, para 72.

(q) The defrosting system on the test aircraft was not acceptable because of an insufficient air flow from the windscreen defroster outlets and the poor flow pattern over the windscreens. Although it could not be determined whether the modified components for the defrosting system supplied by the Beech Aircraft Corp improved windscreen defrosting, it was established that the defrosting was far from adequate on the test aircraft in which they were installed, para 78.

(r) Cabin temperatures were not considered acceptable in cruising flights at OAT's below -25°C, para 80.

(s) The fuel leaks that occurred at the fuel gauge transmitter units of both auxilliary wing tanks were isolated cases caused by the installation of non-standard gaskets and using an improper sealing material that did not provide a proper seal at low temperatures, para 88.

(t) The recommended oil dilution times quoted in EO 05-45B-1 were adequate, although the detachment recommends that dilution rates normally be from 7% to 10% per minute, para 97.

(u) When normal operating procedures were followed as laid down in EO 05-45B-1, no additional ground running was necessary to allow time for diluent boil-off, para 98.

(v) Consistent cold starts could be accomplished at temperatures down to -30°C using the procedure given in EO 05-45B-1 amended as detailed in para 104 of this report.

(w) It was almost a physical impossibility for an operator sitting in the pilot's seat, to cold start the engines unassisted because of the poor layout of the engine starting controls, para 105.

(x) The flow of bleed-back oil in the feathering system between the adapter and feathering pump was negligible, para 131.

(y) The percentage of oil dilution obtained in the feathering system oil line during in-flight feathering varied in direct proportion to the time required for the propeller to feather, and was determined to be 2.6% per second of propeller feathering time, para 132.

(z) Generator overload occurred during unfeathering after 20 minutes of single engine flight when all normal electrical services were on but could be avoided by turning the radio compass "OFF" prior to unfeathering. The installation of 100-ampere generators should overcome this problem, para 143.

(aa) No difficulty should arise during feathering at an OAT of -40°C if the aircraft has been flying at cruising power for 30 minutes prior to feathering. Difficulty is not liable to be encountered during feathering immediately after take-off at an OAT of -40°C if the propellers are partially feathered and unfeathered during pre-take-off check, para 145.

(bb) The feathering line bleed system, previously used, was not necessary, and since it would remove diluted oil from the line between the adapter and the feathering pump, it was not considered desirable, para 146.

(cc) The time required to unfeather the propeller was increased at low airspeeds, para 148.

(dd) Although it was not possible to determine at what oil viscosity the feathering pump would fail to operate effectively, it did operate normally at viscosities as low as 60 SUS, para 153. The feathering pump maintained a pressure of 600 psi during laboratory tests at a viscosity in the order of 15 SUS, para 150.

(ee) The propeller was unfeathered successfully at -21°C after 20 minutes of single-engine flight but it was impossible to extrapolate the results at lower temperatures, para 155.

(ff) Extensive tests are necessary if the training requirements for 20 minutes of single-engine flight at low temperature is to remain unchanged, para 157.

(gg) The pressure lines to each oil pressure gauge should be filled with varsol at the beginning of winter operations to ensure proper operation of the gauges and prevent congealing of the lines in cold weather, para 160.

(hh) The failure of the electric turn-and-bank indicator was an isolated case caused by the failure of the gasket between the glass and the instrument assembly to provide a proper seal, para 161.

(jj) The failure of the electric gyro-horizon and gyro-power control unit were isolated cases that were not the result of cold weather operation, para 162.

(kk) Modifications to provide for the adjustment of the voltage regulators from the inside of the aircraft is a cold weather operating requirement, para 173.

(ll) The failure of the inverter (RCAF Ref 5U/1867) was and isolated case caused by structural failure that was not a result of cold weather operation, para 174.

(mm) Stiffness of the flexible tuning drive to the receiver of the AN/ARN-7 Radio Compass was caused by poor routing of the drive and improper lubrication, para 178.

(nn) At OAT's below -20°C the radio compass indicators were sluggish, presumably because of differential contraction in the pilot's indicator, para 179.

(oo) The false indication of the fire detection system that resulted during the engine warm-up at an OAT of -20°C was caused by poor positioning of the thermo-couples, para 186.

(pp) The type and quantity of safety equipment issued for use in Expeditor aircraft was considered adequate but the total weight of the equipment was excessive and could be decreased considerably by redesign of the containers, para 187.

Recommendations

195 It is recommended that Expeditor aircraft 2316 be retained at the detachment for further cold weather tests. Problems encountered with aircraft covers, engine "Teleflex" control cables, carburettor hot air valve, windscreen defrosting, cabin heating, engine cold starting, nose fuel tank vent line, crankcase breather vent lines, propeller feathering, and the AN/ARN Radio Compass, require further testing before the aircraft can be considered acceptable for cold weather operations.

196 It is recommended that RCAF approved modifications presently being processed for installation on all Expeditor aircraft be embodied on Expeditor 2316 as soon as possible so that they can be cold weather tested during the 1954-55 test season. These modifications include the provision of 100 ampere generators incorporating a 2:1 drive gear ratio, repositioning of the voltage regulators, new type master brake cylinders, and modified rudder trim tab indicator,

197 It is recommended that the aircraft and/or its associated equipment be modified as follows:

(a) Cabin wall upholstery should be installed more loosely to prevent splitting due to excessive shrinkage at low temperatures, para 8.

(b) The cockpit cover should be redesigned to provide a closer fit around the cockpit windows and should be made of a material that will not freeze to the aircraft in conditions of wet snow and freezing rain, para 15.

(c) The wing and wheel covers and the tail cover should be dispensed with, as they are not necessary during cold weather operations and in freezing rain conditions they freeze to the aircraft, para 17.

(d) Engine covers should be modified as described in para 23, and para 24.

(e) Carburettor air inlet covers similar to those used during the test should be used when the aircraft is dispersed without engine covers if precipitation is expected near zero temperatures, para 25.

(f) The blanking plugs for the ventilating air inlets should be left in place during flight in cold weather until a suitable valve is supplied to replace the present ventilating air valve which does not shut off the cold air completely, para 27. Oil cooler inlet blanking plugs of the type developed by the detachment should be used during dispersal of the aircraft if snow or freezing rain is anticipated, para 28.

(g) Neoprene rubber grommets for the carburettor heat and cowl flap control system should not be replaced by silicone grommets at the present time, but when replacement becomes necessary due to deterioration or wear, it would be adviseable to use silicone grommets, para 39.

(h) Low temperatuce grease (RCAF Ref 34A/192) should be used to lubricate the telescoping end fittings of all engine controls on Expeditor aircraft to prevent the occurence of frozen controls, para 52.

(j) Low temperature grease (RCAF Ref 34A/192) should be used as the lubricant between cowl flap segments to reduce the operating force in cold weather, para 55.

(k) The "heater-muff" modification should not be installed on Expeditor aircraft until further tests have been carried out in airframe icing conditions, para 62.

(l) A modified rudder pedal should be developed to overcome the difficulty encountered when operating the brakes when flying clothing and flying boots are worn by the pilot, para 66.

(m) The modified defroster outlet ducts and modified cockpit air valve developed by the Beech Aircraft Corporation should not be installed on Expeditor aircraft since windscreen defrosting was far from adequate on the test aircraft to which they were fitted, para 78.

(n) One of the following changes should be made to improve the defrosting system, para 78:

(i) install defroster outlets that will provide an adequate flow pattern over the windscreens and incorporate a small blower to increase the volume of air through these outlets;

(ii) provide an emergency ground and flight blower that could be used to defrost the windscreens, cockpit windows, and astrodome; or

(iii) replace the curved windscreen panels in front of the pilot and co-pilot positions with duo-pane panels.

(o) The heating system should be modified so that all the heat available from the exhaust intensifier tubes can be directed to the windscreen defrosters, and frost shields should be provided to all units operating Expeditor aircraft for use on the cockpit side windows during winter operation, para 78.

(p) Consideration should be given to redesigning the intensifier tubes or provision made for a gasoline heater of 20,000 to 30,000 BTU/hr capacity to supplement the heating system, para 81.

(q) The cockpit air valve should be redesigned so that the amount of hot air entering the cockpit can be reduced without allowing cold air to enter, para 81.

(r) Relief holes, as described in para 92, should be embodied in the crankcase breather vent lines of all Expeditor aircraft, para 93.

(s) Further tests should be conducted to obtain a rate of engine oil dilution of between 7% and 10% per minute, para 97.

(t) A change in the cold weather starting technique should be incorporated in EO 05-45B-1, Pt 2, para 47; para 104.

(u) The starting and booster coil switches should be moved to the left instrument sub-panel in front of the pilot to facilitate starting during cold weather, para 105.

(v) Electrically driven fuel pumps should be embodied to replace the wobble pump, para 105.

(w) Further tests should be conducted on the feathering system at OAT's above 0°C and below -20°C, para 129.

(x) A re-assessment should be made of the training requirement since the feathering system is an emergency system designed to ensure that the propeller will feather when engine failure occurs. Continual unfeathering after single-engine flight for 20 minutes at extreme OAT's will have a harmful effect on the engine and on the feathering system, para 129.

(y) The pressure line between each engine and the oil pressure gauges should be primed with varsol at the beginning of winter operations to ensure proper operation of the gauges and prevent oil from congealing in the lines and gauges, para 160.

(z) The tuning control flexible drive to the receiver of the AN/ARN-7 Radio Compass should be re-routed to avoid sharp turns and graphite lubrication should be used instead of grease lubrication, para 178.

(aa) A more detailed investigation should be conducted to determine the cause of sluggishness of the Radio Compass indicator at low temperature, para 180.

APPENDIX "A"

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EXPOSURE DATA, SERVICEABILITY STATE, GROUND RUNNING AND FLYING TIMES

DATE	OVERNIGHT LOCATION	TEMP. ~ °C OVER-NIGHT MINIMUM	AT ENGINE START	AT A/F INSP.	GROUND RUNNING HRS : MIN	FLYING TIME HRS : MIN	S OR U/S AT 0830	SERVICEABILITY STATE
24 Nov 53	Hangar Namao					7:00	S	Received at Namao from MacDonald Bros. Winnipeg.
25 Nov 53 to [illegible] Dec 53	Hangar Namao						U/S	Acceptance Check. Installation CEPE Local Modifications. A/F Greasing in Accordance with EO 05-45B-7A Sec 1.
23 Dec 53 to 27 Dec 53	Outside Namao						U/S	All Engine and Airframe Covers Installed.
28 Dec 53 to 30 Dec 53	Hangar Namao						U/S	Installation of CEPE Local Modifica-tions.
31 Dec 53 to 3 Jan 54	Outside Namao						U/S	All Engine and Airframe Covers Installed.
4 Jan 54 to 8 Jan 54	Hangar Namao				1:00		U/S	Installation of CEPE Local Modifica-tions. Engine Run-up and servicea-bility checks.
9 Jan 54	Hangar Namao	-24			:30	1:30	S	Acceptance Check Flight.
10 Jan 54	Hangar Namao	-28					S	
11 Jan 54	Hangar Namao		-8	-8	:15	5:25	S	Ferry Flight ; Namao to Fort Churchill.
12 Jan 54	Outside Churchill	-30					S	
13 Jan 54	Outside Churchill	-36	-35	-35	:30		S	
14 Jan 54	Outside Churchill	-34	-30	-30	:40		U/S	Rear Fuel Tanks Leaking at Fuel-Quantity Tranmitter Mounting.

EXPOSURE DATA, SERVICEABILITY STATE, GROUND RUNNING AND FLYING TIMES

DATE	OVERNIGHT LOCATION	TEMP ~ °C OVER-NIGHT MINIMUM	AT ENGINE START	AT A/F INSP.	GROUND RUNNING HRS : MIN.	FLYING TIME HRS : MIN.	S OR U/S AT 0830	SERVICEABILITY STATE
15 Jan 54	Hangar Churchill						U/S	Repair Fuel Leak at Rear Fuel Tank Liquidometer.
16 Jan 54	Outside Churchill	-34	-30	-30	:20	2:25	S	Inverter Installed For Autosyn Oil Pressure Gauges
17 Jan 54	Outside Churchill	-31					S	
18 Jan 54	Outside Churchill	-30	-33	-38	:40		S	
19 Jan 54	Outside Churchill	-30	-28	-28			S	
20 Jan 54 to 24 Jan 54	Hangar Churchill						U/S	Nose Fuel Tank System Leaking.
25 Jan 54	Hangar Churchill			-28	:10	:45	S	Serviceable - 25 to 28 Jan Inclusive.
26 " "	"			-28	:10	1:10	"	A/C in Hangar Over Night and no engine
27 " "	"			-28	:10	1:05	"	oil dilution used. Feathering system
28 " "	"			-29	:10	1:45	"	dilution tests conducted.
29 Jan 54	Hangar Churchill						U/S	Windscreen Defrost Blower Installed. Wiring and circuit breaker installed.
30 Jan 54	Outside Churchill	-34	-25		:15		U/S	Completed Windscreen Defrost Blower. Installation.
1 Feb 54	Outside Churchill	-17	-15	-15	1:10	1:45	S	
2 Feb 54	Outside Churchill	-23	-22	-25	:55		S	
3 Feb 54	Outside Churchill	-28					S	
4 Feb 54	Outside Churchill	-20	-18	-18	1:10		S	

EXPOSURE DATA, SERVICEABILITY STATE, GROUND RUNNING AND FLYING TIMES

DATE	OVERNIGHT [illegible]	TEMP ~ °C OVER-NIGHT MINIMUM	AT ENGINE START	AT A/F INSP.	GROUND RUNNING HRS: MIN.	FLYING TIME HRS: MIN.	S OR U/S AT 0830	SERVICEABILITY STATE
5 Feb 54	Outside Churchill	-26	-20	-20			U/S	Engine Controls Frozen.
6 Feb 54	Outside Churchill	-22					U/S	Heater Duct Modifications.
7 Feb 54	Outside Churchill	-14					S	
8 Feb 54	Outside Churchill	-23	-20	-20	:30	1:15	S	
9 Feb 54	Outside Churchill	-25	-20	-20	:40	1:45	S	
10 Feb 54	Outside Churchill	-30	-32	-32	1:00		S	Excessive snow in cowlings and engine accessory section.
11 Feb 54	Outside Churchill	-29					U/S	Batteries required recharging. Cowling fastener broken.
12 Feb 54	Outside Churchill	-27	-25	-25	:50	2:00	S	
13 Feb 54	Outside Churchill	-33	-34	-34	:40	1:20	S	Heat required on start.
14 Feb 54	Hangar Churchill						U/S	
15 Feb 54	Hangar Churchill						U/S	Starboard generator circuit breaker.
16 Feb 54	Hangar Churchill						U/S	Engine oil filters, port and starboard checked.
17 Feb 54	Hangar Churchill						U/S	Artificial horizon power control unit.
18 Feb 54	Hangar Churchill						U/S	Electrical turn and bank indicator.
19 Feb 54	Hangar Churchill						U/S	Tire blowout.

EXPOSURE DATA, SERVICEABILITY STATE, GROUND RUNNING AND FLYING TIMES

DATE	OVERNIGHT LOCATION	TEMP. ~ °C OVER-NIGHT MINIMUM	AT ENGINE START	AT A/F INSP.	GROUND RUNNING HRS : MIN.	FLYING TIME HRS : MIN	S OR U/S AT 0830	SERVICEABILITY STATE
2[illegible]	Hangar Churchill						U/S	Rear fuel tank transmitter.
21 Feb 54	Hangar Churchill						U/S	Installation of electric blower for defroster Modification.
22 Feb 54	Hangar Churchill						U/S	Installation of electric wiring for defroster blower.
23 Feb 54	Outside Churchill	-22	-18	-18	:30	4:25	S	
24 Feb 54	Outside Churchill	-27	-20	-20	:40	1:40	S	
25 Feb 54	Outside Churchill	-29	-20	-25	1:00	3:10	S	
26 Feb 54	Outside Churchill	-28		-23			S	
27 Feb 54	Outside Churchill	-32	-25	-25	:40	1:40	S	
28 Feb 54	Outside Churchill	-27					S	
1 Mar 54	Outside Churchill	-30	-30	-30	:50		S	Carburettor heat control frozen after engine run-up.
2 Mar 54	Outside Churchill	-31	-30	-30	:30	3:30	S	
3 Mar 54	Outside Churchill	-31		-30			S	
4 Mar 54	Hangar Churchill	-31	-25	-29	1:15		U/S	Metal particles in Starboard engine oil filter. Starboard generator output intermittent.

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EXPOSURE DATA, SERVICEABILITY STATE, GROUND RUNNING AND FLYING TIMES

DATE	OVERNIGHT LOCATION	TEMP. ~ °C OVER-NIGHT MINIMUM	AT ENGINE START	AT A/F INSP.	GROUND RUNNING HRS:MIN.	FLYING TIME HRS:MIN.	S OR U/S AT 0830	SERVICEABILITY STATE
5 Mar 54 to 7 Mar 54	Hangar Churchill						U/S	Check of Starboard oil filter. Rust on propeller distributor valve and inside dome.
8 Mar 54	Hangar Churchill						U/S	Installation of propellor dome.
9 Mar 54	Hangar Churchill	-18	-18		:20		U/S	Starboard generator circuit.
10 Mar 54	Hangar Churchill	-21	-21		:30		U/S	Starboard generator circuit.
11 Mar 54	Hangar Churchill	-17	-17		:20	1:10	S	
12 Mar 54	Hangar Churchill						S	
13 Mar 54	Outside Churchill	-23	-7	-7	:20	7:05	S	Ferry flight from Churchill Manitoba to Namao Alberta.

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PUBLICATIONS AND ENGINEERING DRAWINGS

1 The following publications and drawings were available during the test period:

RCAF EO 05-45B-1 to 8 inclusive

RCAF EO 10A/10AA-1, 2, 3, 6A and 6B

RCAF EO 15-30AB-4

RCAF EO 15-10BAA-2

RCAF CAP 665

CEPE Report AC-9-52

CEPE Report 1002

Hamilton Standard Publication Number 144

Hamilton Standard Service Bulletin Number 89

Beech Aircraft Corporation Engineering Report 876

MacDonald Bros. Aircraft Ltd. Engineering Memorandum 11328

Beech Aircraft drawings: A53272, 404-185503, 404-185500, 516025, 404-183950.

MacDonald Bros. Aircraft Ltd. drawings: 5MBA-13497, 644-189011, 2MBA-13513, 6691, 6692, and 6693.

MODIFICATION STATE, AIRCRAFT 2316

1 **RCAF Special Inspection**

Completed prior to receipt of aircraft:

EO 05-45B-5/1, /2, /3, /4, /5, /6, /7, /8, /9, /10, /11, /12, /13, /14, /15, /16, /17, /18, /19, /20, /21, /23, /24, /25, /27, /28, /29, /30, /32, /33, /34, /35, /36, /37, /38, /39, /40, /41, /42, /45.

EO 10A-10AA-5/1, /2

Completed during test season:

EO 05-45B-5/46	**Airspeed Indicator Range Markings**	**23 Feb 54**
EO 05-45B-5/48	**Cockpit Windscreen for Leaks**	**7 Jan 54**

2 **RCAF Modifications**

Completed prior to receipt of aircraft:

EO 05-45B-6A/1, /2, /3, /5, /9, /11, /14, /15, /18, /21, /22, /27, /29, /30, /31, /33, /34.

EO 10A-10AA-6B/1, /2, /3, /4, /5.

Completed during the test season:

EO 05-45B-6A/35 Introduction of AN Connectors for Driftmeter Installation 9 Dec 53

3 **CEPE Local Modifications**

2316/1	Propeller Feathering System Sample Points	6 Jan 54
2316/2	Ammeter for Feathering Load	6 Jan 54
2316/3	Modification to MBA Crankcase Breather	7 Dec 53
2316/4	Carburettor Heat Warm Air Supply (Starboard)	7 Dec 53
2316/5	Windshield Defrosting and Cabin Heat	7 Jan 54
2316/6	Engine Controls Sticking	6 Jan 54
2316/7	Oil Sump Sample Point and Access Door	6 Jan 54
2316/8	Nose Fuel Tank Vent	Not Embodied
2316/9	Installation of Oil Pressure Transmitter and Gauges for Feathering System (Port)	31 Dec 53
2316/10	Installation of Cabin Temperature Recorder	31 Dec 53
2316/11	Installation of Port Engine Temperature Recorder for Feathering System	31 Dec 53
2316/12	Installation of Oil Pressure Gauges	8 Jan 54

APPENDIX "D"

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INSTALLATION OF HEATING, DEFROSTING AND VENTILATING SYSTEM MODIFICATIONS

General

1 Modified components for the heating, defrosting and ventilating systems were supplied to the RCAF by the Beech Aircraft Corp for installation on the test aircraft. The components were fitted to Expeditor 2316 under the authority of AMC EP 53/130.

2 The drawings which accompanied the parts, with the exception of drawing 404-185500, were for the standard aircraft systems and did not indicate the procedure to be followed nor the placement of parts different from the standard installation. The drawings were not applicable to the parts which they accompanied.

Cockpit and Air Valve Assembly

3 The modified cockpit air valve assemblies (part number 404-183998-1 and 404-183998-2) were to replace the standard cockpit air valve assemblies (part number 404-183948 and 404-183948-1). Fig 46 shows the standard valve on the left, and on the right is the modified valve. Both valves shown are for installation on the port side of the aircraft.

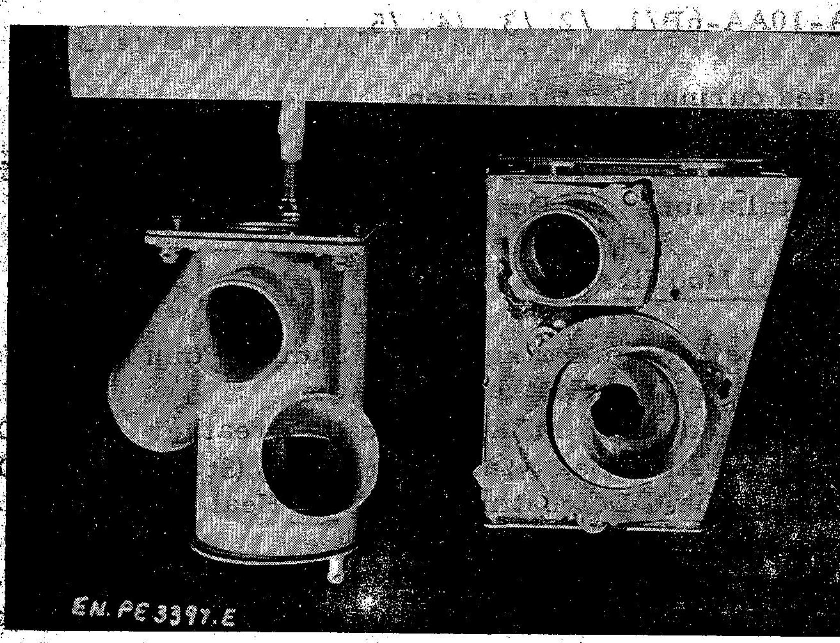

Fig 46 - Standard and Modified Cockpit Air Valve Assemblies

INSTALLATION OF HEATING, DEFROSTING AND VENTILATING SYSTEM MODIFICATIONS

4 Because the new valve assembly was 1 5/8 inches wider than the standard valve assembly it was necessary to position the new assembly approximately three inches aft of the position of the standard assembly to prevent interference with the rudder pedal cross-shaft yoke assemblies (part number 404-187818 and 404-187818-2) and the bundle of wires running longitudinally along the aircraft below the valve assembly at the side of the fuselage. The arrow in Fig 47 shows the position of the hole cut in the cockpit floor to accommodate the Cap Assembly Outlet (part number 183921) of the modified valve assembly.

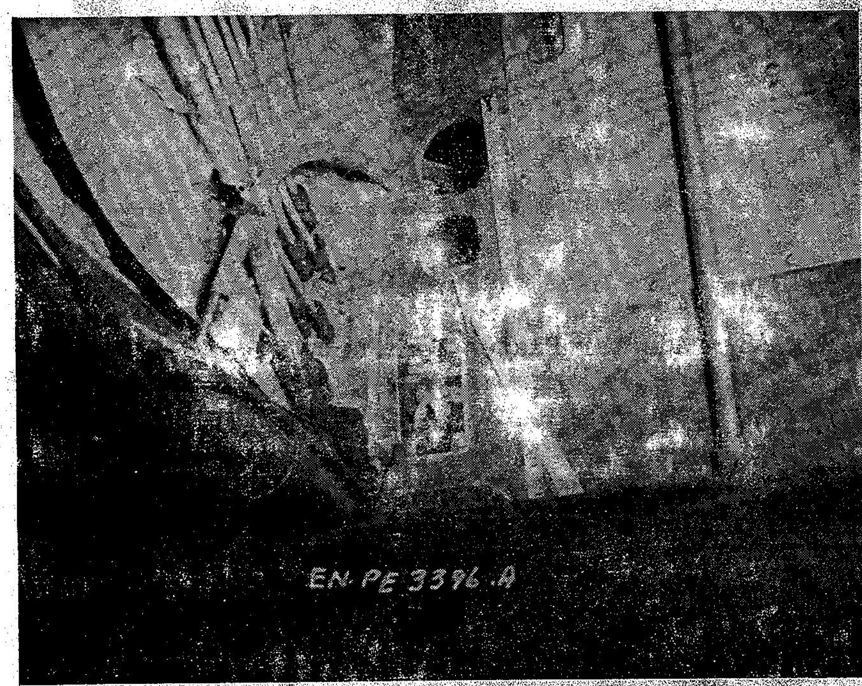

Fig 47 - Repositioned Air Outlet on Port Cockpit Floor

5 Adapter plates were made locally to block off the air outlet of the standard valve assembly. One plate was fitted below the floor and the other above the floor. The adapter plates for the port installation are shown in Fig 48. Fig 49 shows the top adapter plate in position on the port cockpit floor. The same installation procedure was used on the starboard valve assembly.

INSTALLATION OF HEATING, DEFROSTING AND VENTILATING SYSTEM MODIFICATIONS

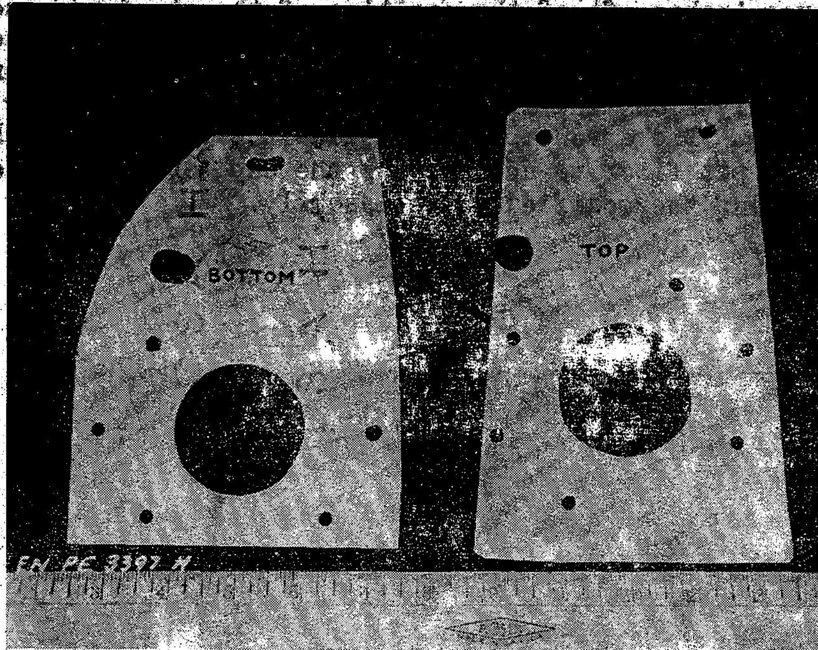

Fig 48 - Adapter Plates for Port Valve Assembly

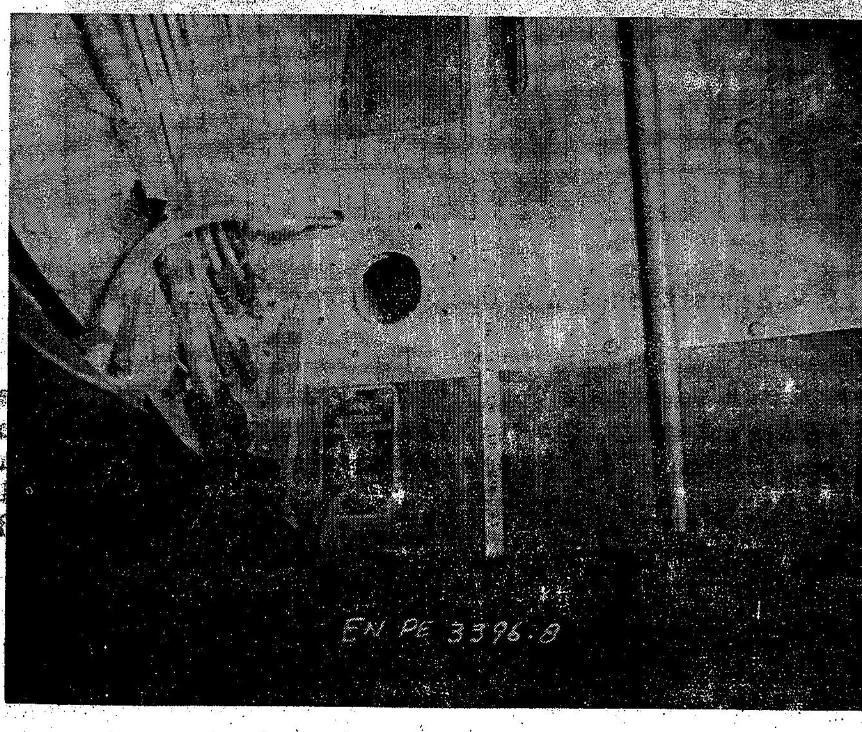

Fig 49 - Position of Adapter Plate on Port Cockpit Floor

INSTALLATION OF HEATING, DEFROSTING AND VENTILATING SYSTEM MODIFICATIONS

6 The proximity of the valve assembly to the side of the fuselage made it necessary to install the iris shutter (part number 404-183944) with the shutter actuating arm on the inboard side. However, in this position the arm interfered with one of the rudder control cables and the bundle of wires running longitudinally along the fuselage under the inboard side of the valve assembly. To prevent this interference 5/16 of an inch was cut off the arm. The arrow in Fig 50 indicates the proximity of the arm to the wire bundle with the iris closed after the 5/16 of an inch had been cut off the arm.

Fig 50 - Installation of Modified Valve Assembly - Showing Proximity of Iris Actuating Arm to Wire Bundle.

7 To provide a clear path for the iris shutter control cable (part number 404-183958-8) it was necessary to manufacture a ring adapter and secure it to the operating lever as shown in Fig 51.

INSTALLATION OF HEATING, DEFROSTING AND VENTILATING SYSTEM MODIFICATIONS

Fig 51 - Ring Adapter Fitted to Iris Shutter Assembly

The control cable was attached at (A) by a locally manufacturedfitting, and was routed up through the adapter plates, behind the upholstered panels, and out to a bracket behind the pilot's seat. The bracket and control knob behind the pilot's seat is shown in Fig 52.

Fig 52 - Iris Shutter Control and Bracket Installed Behind

INSTALLATION OF HEATING, DEFROSTING AND VENTILATING SYSTEM MODIFICATIONS

The same method of installation was used in providing a control for the starboard iris shutter. The control knob was positioned behind the co-pilot's seat.

8 The iris shutter control cable was enclosed in a one-half inch aluminum tube and secured to prevent chafing of the cable against the adapter plates and the instrument tubing on the fuselage wall. The tubing can be seen in Figs 47 and 49.

Windscreen Defroster Outlets

9 The standard windscreen defroster outlets (part number 894-183981 and 894-183981-1) were removed and were replaced by modified defroster outlets (part number 404-183932-1 and 404-183932-2). The standard defroster outlets are shown in Fig 53. Fig 54 shows one of the modified defroster outlets.

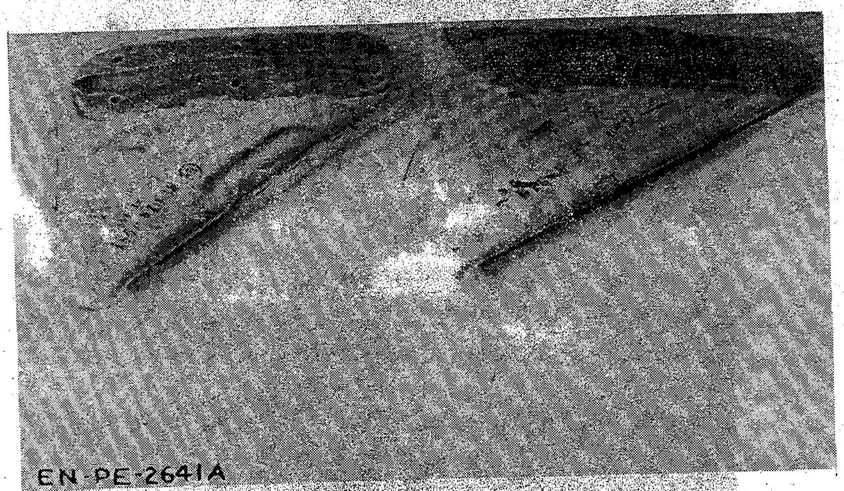

Fig 53 - Standard Defroster Outlets

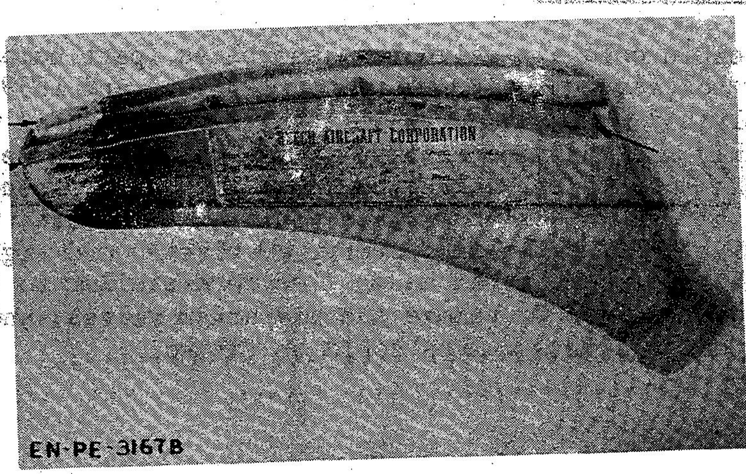

Fig 54 - Modified Defroster Outlet

INSTALLATION OF HEATING, DEFROSTING AND VENTILATING SYSTEM MODIFICATIONS

The arrows in Fig 54 show the positions on the duct that had to be modified so that the duct would fit the curvature of the cowl assembly.

10 The replacement units were approximately 4 ¾ inches longer and three-eighths of an inch wider than the original units, which necessitated an increase in the size of the openings in the instrument panel cowl assembly (part number 404-185503). A pneumatic drill (RCAF Ref 2T/456) was used to drill a series of holes outlining the desired shape of the proposed opening in the cowl assembly. A file was used to finish the surface of the opening. Protective screening and a locally made gasket were fitted in place and the defroster outlet was secured by four AN526-632-8 screws with four AN-364-632A nuts. The completed duct opening is shown in Fig 55 with the original duct opening indicated by the dotted line.

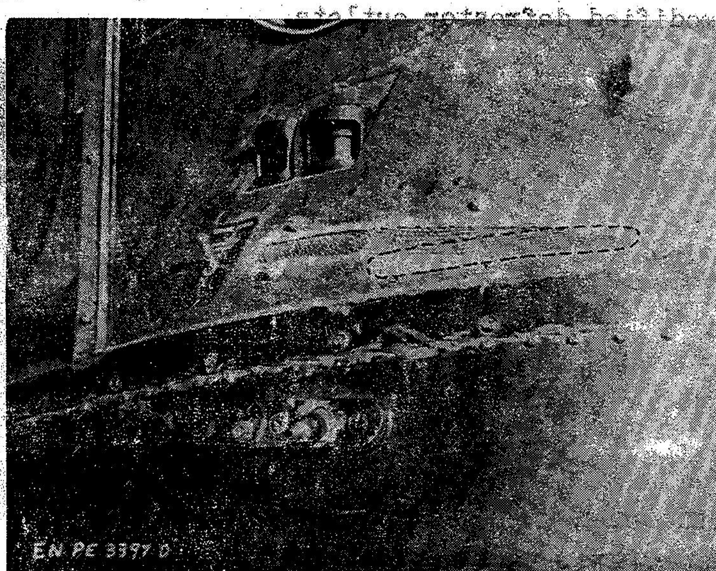

Fig 55 - Windscreen Defroster Duct Opening

Cabin Ventilating Air Valve

11 The cabin cold air valve box assemblies (part number 183979) were to be replaced by box assemblies (part number 183979-1 and 183979-2). The standard box assembly had a diaphragm type air valve incorporated while the new type box assembly was modified so that an iris shutter valve, of the same type used on the cockpit air valve, could be fitted. To remove either of the cabin cold air valve box assemblies would have required the removal of a front main wing tank, cabin upholstery, 29 rivets, and eight screws and nuts. Since the replacement box assemblies were similar to the standard assemblies it was decided to remove the diaphragm valves, and adapt the assemblies so that the iris valves could be fitted.

INSTALLATION OF HEATING, DEFROSTING AND VENTILATING SYSTEM MODIFICATIONS

12 The six screws securing the diaphragm type valve were removed and a locally made adapter was secured to the box assembly by six AN-515-8-10 screws. The replacement iris valve and the body cold air valve duct (part number 309911) were then secured to the adapter by three AN515-8-16 screws and three AN 365-632 nuts. Fig 56 shows the modified components on the starboard side as viewed through the battery compartment access panel. Item (A) is the standard box assembly, (B) the locally manufactured adapter, (C) the iris valve, and (D) the body cold air valve duct. The installation on the port side of the aircraft was similar. In order to expedite the modification program, a control system to operate the iris shutter was not developed and the ventilating air inlet ducts in the leading edge of each wing were blocked off with plugs.

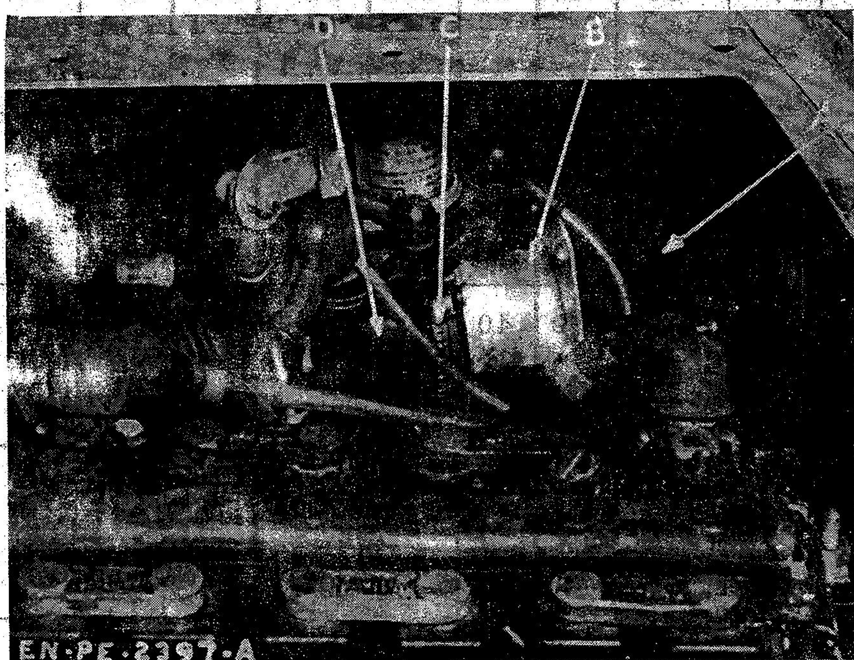

Fig 56 - Modified Components of Starboard Ventilating Air System

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ENGINE COLD START DATA - (Cont'd on next page)

Temp - °C		Sump Oil Dilution - %		Cranking RPM of Prop		Crank Time Seconds		Prime Before Start		Prime During Start	
At Start	Pre 12 Hr Low	Port	Stb'd	Port	Stb'd	Port	Stb'd	Port	Stb'd	Port	Stb'd
-34	-36	28	34	36 36 55	50 36 30 40 55 55 50	40 70 90	40 90 45 75 30 19 4	7 5	7 5 3 5 5 0 0	19 21 22	19 10 0 17 47 42 6
-25	-32	19	24	48	48	60	30	10	10	26	17
-22	-23	28	34	44	60	27	35	5	5	7	8
-20	-29	20	28	40	40	45	35	10	10	12	14
-20	-27	23	28	48	40	25	30	10	10	5	9
-20	-25	24	28	55	55	20 15	25	10 4	10	2 6	3
-18	-20	10	10	30 45	21 45	45 45	60 45	7 4	5 2	7 7	21 15
-15	-17	31	29	60	60	27	12	6	6	12	0

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ENGINE COLD START DATA

Prime After Start		Force at tip to Move Prop lbs		
Port	Stb'd	Port	Stb'd	Remarks
0 0 12	0 0 0 0 0 8 42	20	16	Battery cart 22 volts. Port engine started on 3rd attempt. Starboard engine started on the 7th attempt. During 3rd attempt on port engine, 1/2 carburettor heat used during start, and selected "HOT" 30 seconds after start. Heavy backfiring occurred during attempts to start starboard engine. On the 6th attempt the starboard engine ran for 19 seconds.
17	27	NR	NR	Battery cart 28 volts. Heavy backfiring in starboard engine after start was minimized by priming and retarding throttle, letting engine run roughly at 400-600 rpm.
15	22	12	16	Battery cart voltage not recorded. Normal starts but starboard engine backfired for 3 minutes after start whenever attempt made to advance throttle.
18	17	14	13	Battery cart 28 volts. Normal starts. Carburettor heat used after start on both engines accomplished smooth running on port but did not help starboard.
19	10	8	14	Battery cart 28 volts. Normal starts except that backfiring occurred for 3 minutes after start on starboard engine whenever thortle advanced.
15 12	15	12	8	Battery cart 26 volts. Normal cold starts. Port fire detector flashed 2 minutes after start. Visual check before engine shut down did not reveal presence of fire but engine stopped for thorough check and then restarted.
0 30	0 17	10	9	Battery cart 28 volts. First attempts failed due to low cranking rate caused by low dilution. Second attempts gave normal starts.
0	10	15	14	Battery cart voltage not recorded. Normal starts.

EQUIPMENT STATUS, AIRCRAFT 2316

1 **Engines**

Pratt and Whitney R985-AN14B
Part Serial No 20777
Starboard Serial No JP 211610

2 **Engine Accessories**

Part	Manufacturer	RCAF Ref	Part or Type No
Starter, Direct Cranking	Eclipse	5U/1923	94-32282
Generator	"	5U/836	95-32361
Magnetos	Bendix-Scintilla	37A/1141	SB-9RN
Carburettor	Stromberg	37C/3	NAR-9B-19
Fuel Pump, Engine Driven	Pesco	37J/65	TF-900-1
Vacuum Pump	"	37J/133	3P-207-JA
Generator Tachometer	General Electric	6A/1074	AN-5531-2
Spark Plugs	Champion	37S/22	C26 S

3 **Propeller and Feathering System Accessories**

Part	Manufacturer	RCAF Ref	Part or Type No
Propeller, Hydromatic	Hamilton Standard	25A/305	22D30-201
Governor, Constant Speed	"	25A/306	4B2-P8
Adapter Assembly	"	25AA/	HSP-59484-6
Pump, Propeller Feathering (RH)	"	37J/85	66094-1
Pump, Propeller Feathering (LH)	"	37J/85	1E-521-DC
Pump, Fuel Electric Driven	Plessey and Co.	37J/	FP3 Mark VII
Valve Solenoid	United A/C Products	27VA/550	37D-6210

4 **Airframe Accessories**

Part	Manufacturer	RCAF Ref	Part or Type No
Primer, Engine Fuel	Parker	37J/3	401-2A
Pump Wobble	Romec	37J/69	RXD 1563
Strainer Fuel	Aero-Supply Mfg.	27B/125	C2A
Valve Assembly Suction Cross Feed		26JU/	404-189669
Valve Fuel	Thompson Products		TCB-15200-4
Valve Check	Wittek Mfg. Co.	27VA/668	W1500-5/8D
Pump Assembly Anti-Icing	Adel		AN-6100-1
Battery - 12 volt	Willard	5J/123	AR-12-36
Regulator	Eclipse Pioneer	5U/1860	1042-17
Inverter	Jack and Heintz	5U/1867	AN-3432-1
Inverter	Eclipse Pioneer	5U/1877	12117-6A
Radiator Oil L.H.	G and O Mfg. Co.	27R/10	94-189850
Radiator Oil R.H.	G and O Mfg. Co.	27R/11	94-189850-1
Valve Oil By-Pass			S 80
Valve Assembly Oil Shut Off L.H.		26JU/	404-189791
Valve Assembly Oil Shut Off R.H.		26JU/	404-189791-1

Propeller Feathering and Dilution Data

Propeller Feathered		P	S	P	P
OAT	(°C)	-28	-25	-25	-4
Oil Temperature	(°C)	62	65	65	62
Oil Pressure	(psi)	80	82	75	72
Cylinder Head Temperature	(°C)	150	155	155	165
Time to Feather	(sec)	8	8	5	6
Test Amperage During Feathering		210	190	185	110
Feather Pump Pressure During Feathering	(psi)	400	-	350	300
Dilution in Feathering Line Single-Engine Landing	Sample 1 %	21	20	13	15
	Sample 2 %	19	22	13	17
Calculated Rate (%/Sec) of Dilution		2.5	2.6	2.6	2.7

Feathering and Unfeathering Data - 20 Minutes Single-Engine Flight

OAT (°C)	-21	-20	-15	-15	-11	-10	-10	-1	1
Oil Temperature (°C)	65	60	65	78	72	70	65	68	70
Oil Pressure (psi)	80	84	80	80	75	75	75	75	72
Cylinder Head Temperature (°C)	170	155	170	172	160	165	170	180	180
Time to Feather (sec)	7	6	10	8	7	6	6	7	6
Test Amperage During Feathering	190	210	190	185	210	190	190	150	150
Feathering Pump Press During Feathering (psi)	350	300	400	500	400	350	400	300	NR
Minimum Cylinder Head Temperature (°C)	--0	--0	--0	--0	--0	--0	--0	5	5
Minimum Oil Temperature (°C)	23	14	15	15	20	20	20	25	20
Amperage On Live Engine	46	41	45	40	45	35	30	30	NR
Time to Obtain Noted rpm During Unfeathering (sec)	8 to 800	10 to 800	6 to 500 12 to 650	10 to 500	10 to 500	10 to 800	9 to 800	8 to 800	9 to 800
Test Amperage During Unfeathering	190☆	190☆	150☆☆	110☆☆	160☆☆	180☆☆	170☆☆	130☆☆	120
Feather Pump Pressure During Unfeathering (psi)	800	800	800	350	800	800	800	800	NR
Time to Warm Engine (min)	15	13	8	4	5	5	5	4	3

☆ - Generator Circuit Breaker Opened During Unfeathering
☆☆ - Radio Compass Turned "OFF" During Unfeathering
NR - Not Recorded. This test was made on the Starboard System.

APPENDIX "J"

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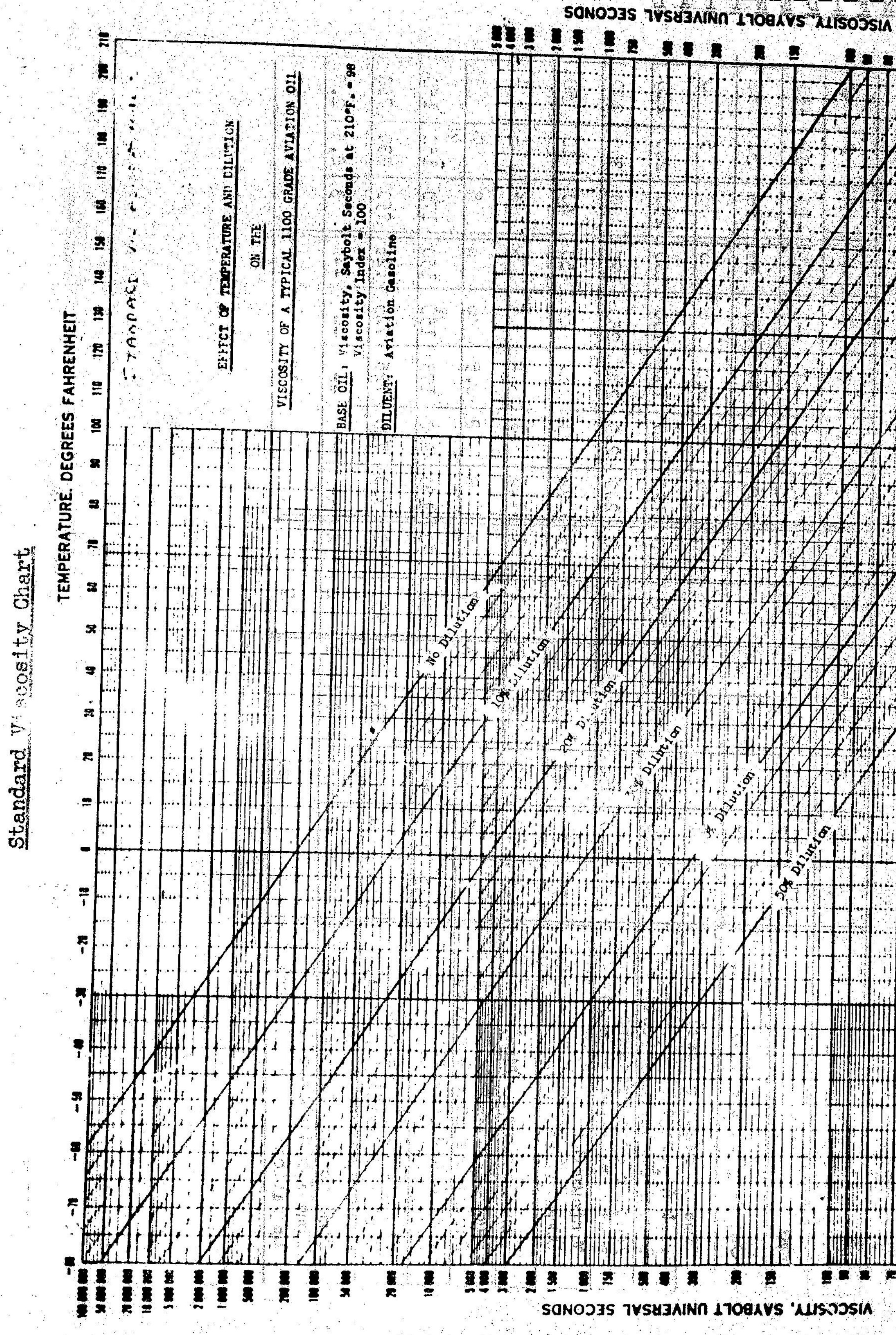

C O N F I D E N T I A L

Flight Tests - Rapid Feathering Data

Propeller Feathered	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
OAT (°C)	-11	-11	-11	-11	-11	-15	-15	-1	-1	-1	-1	-1	-10	-10	-10
Oil Temperature (°C)	65	60	55	50	48	75	50	75	60	57	50	58	58	52	52
Time to Feather (sec)	7	7	7	5	5	7	5	6	6	0.5	6	6	8	5	6
Test Amperage During Feathering (psi)	190	180	180	180	180	180	180	125	110	100	100	100	250	200	210
Feather Pump Pressure During Feathering (psi)	400	400	350	300	300	400	400	200	200	200	250	175	400	300	300
Minimum Oil Temperature (°C)	55	45	45	40	45	40	35	72	71	50	45	50	40	40	50
Time Feathered (Min)	1.5	2	2	2	2	1	1	1.5	1	1	1	1	2	1	1
Time to Reach 800 rpm During Unfeathering (sec)	7	8	8	7	7	7	7	8	9	0.5	6	6	8	7	8
Test Amperage During Unfeathering	200	180	180	180	180	200	190	190	200	175	150	150	170	150	150
Feather Pump Pressure During Unfeathering (psi)	NR	NR	NR	NR	NR	750	750	700	725	725	725	725	750	730	750
Time to Warm Engine (min)	2	2	2	2	2	2	2	--	--	--	--	--	3	2.5	2.5
Time For Complete Operation (min)	20					7		15					15		

Effect of Airspeed on Feathering Operations

Propeller Feathered	S	S	S	P	P	P	P
OAT (°C)	-12	-12	-12	-12	-12	-12	-12
Indicated Airspeed During Feathering (knots)	160	200	120	160	180	120	120
Time to Feather (sec)	6	5	6.5	5	4.5	5	5
Time Feathered (min)	2	2	1	2	2	1	3
Indicated Airspeed During Unfeathering (knots)	80	90	100	80	90	90	100
Time to Reach Noted rpm During Unfeathering (sec)	8 to 500*	7 to 700 11 to 800	8.5 to 800	10 to 800	8 to 800	9 to 800	9.5 to 800

* - No Increase in rpm after 15 seconds
Oil Temperature During Each Unfeathering Approximately 50 °C
Cylinder Head Temperature during each unfeathering approximately 80 °C

Ground Test - Rapid Feathering Data

Propeller Feathered	P	P	P	S	S	S	P	P	P	P	P	P	P	P	P	P	P	P
OAT (°C)	-2	-2	-2	-2	-2	-2	-1	-1	-1	-1	-1	-1	-5	-5	-5	-5	-5	-5
Oil Temperature (°C)	70	72	2	70	70	72	35	40	45	48	50	53	60	60	62	65	67	68
Time to Feather (sec)	7	6	6.5	7	6	6	6	5	5	5	5	5	7	6	6	6	6	6
Test Amperage During Feathering	120	95	90	100	90	90	85	80	75	75	80	80	90	90	90	85	85	85
Feather Pump Pressure During Feathering (psi)	350	200	200	NR	NR	NR	250	500	200	200	200	200	300	200	200	200	200	200
Time to Reach 800 rpm During Unfeathering (sec)	10	10	9	13	9	9	7.5	7	7	7	7.5	7.5	8	8	7	7	7	7
Test Amperage During Unfeathering	120	115	120	120	120	120	110	110	110	110	110	110	120	120	120	115	115	115
Feather Pump Pressure During Unfeathering	700	700	700	NR	NR	NR	700	700	700	700	700	690	700	700	685	685	685	685
Time to Complete Operation (min)	20						5.5						6					
Percentage Dilution in System	Oil Samples Not Taken						Before			After			Before			After		
Engine Sump							31			20			31			16		
"Y" Drain							40			24			34			19		
Oil Tank at Feathering Line Outlet							--			--			8			10		

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AOC TAC	1	16
AOC 12 Air Def Grp	1	17
AOC 14 "T" Grp	1	18
AFHQ/CK File	1	19
IAM	1	20
CEPE (R)	5	21-25
CEPE Climatic Detachment	5	26-30
SMOSO, Climatic Detachment	1	31
RCAF Staff College, Toronto	1	32
DIRECTOR, NAE, Ottawa	1	33
DRB	1	34
CJS London	1	35
MOS (TPA/TIB) through SMOSO, Cl Det	45	36-80
CJS Washington	15	81-95
Spares - AMC Technical Library	10	96-105
OC FIS	1	106
OC CFS	1	107
OC Air Navigation School, Winnipeg	1	108
USAF Air Proving Ground (Eglin AFB) through CJS Washington	1	109
WADC, Wright-Patterson AFB, Dayton	1	110