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Avro CF-100 Specification for NAE Automatic Control for Electro-thermal Wing De-Icing.

D. Fraser

12 Sept. 1952

L.O. 6147A	NATIONAL AERONAUTICAL ESTABLISHMENT OTTAWA, CANADA	NO. LT-34
FILE M4-A3-R22	LABORATORY MEMORANDUM	PAGE 1 OF 6
PREPARED BY D. Fraser		COPY NO.
CHECKED BY D. Fraser	SECTION Low Temperature Laboratory	DATE 12 Sept., 1952

SECURITY CLASSIFICATION ~~CONFIDENTIAL~~ UNCLASSIFIED

SUBJECT AVRO CF-100
SPECIFICATION FOR NAE AUTOMATIC CONTROL FOR ELECTRO-THERMAL WING DE-ICING

PREPARED BY D. Fraser

ISSUED TO
Mr. Parkin
Mr. Cleminson,
A.V. Roe Canada Ltd.
DD"A", A.F.H.Q.
Mr. Murphy
Mr. Bowler
Mr. Robertson
Mr. Milsum
Sub-Registry
Aero Library
Section

Signed ......DF.............. Author

Approved ......DF for J.L.Orr...... Laboratory Head

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AVRO CF-100

SPECIFICATION FOR NAE AUTOMATIC CONTROL FOR ELECTRO-THERMAL WING DE-ICING

1.0 INTRODUCTION

The proposed NAE automatic control system for the CF-100 electro-thermal wing de-icing system is in two parts.

(a) An anti-icing control for the parting and dividing strips. This has reached a stage of development where it can be used.

(b) A de-icing control to operate the ice-shedding. This has not been fully developed and will have to be introduced in three stages. In the first stage, the Trial Installation, manual adjustment of the Off, or icing-up period, and of the On, or shedding time, is required. In the second stage, the Preliminary Production, these two adjustments will be preset at values to be determined by flight trials on the Trial Installation. In the third stage, Final Production, the Off-period adjustment will be preset, and the On-time will be determined by a temperature-sensing device.

The requirements for the control of the electro-thermal de-icing system are as follows -

1.1 Anti-icing

Ice must not be allowed to form on the parting and dividing strips, and therefore the power to these components must be switched on immediately the aircraft enters icing conditions. Under varying icing conditions the parting and dividing strips must be supplied with only just sufficient power to prevent ice forming, as any excess of heat is detrimental to the shedding process. The temperature of the parting and dividing strips must also not be allowed to become excessive, as this would lead to a breakdown of the organic insulation. On emerging from icing conditions, the power must be switched off.

1.2 De-icing

Eight shedding zones are provided along the span of the wing and on the tail unit. Ice is allowed to form on these, and then, when sufficient ice has accreted for efficient shedding, but not before, each shedding section must be heated in turn till the ice on that section has shed. The heat on that section must then be turned off immediately, otherwise run-back will occur; and if the heat is left on too long, excessive temperatures may also be reached, which will cause break-down of the insulation. On emerging from icing, any ice on the wings must be shed, whether sufficient ice for efficient shedding has accreted or not.

2.0 CONTROL SYSTEM

2.1 Anti-icing Control

2.1.1 On receiving the first signal from an icing detector, the control will turn full heat on to the parting and dividing strips until T_1* seconds have elapsed. During this time an override will be in operation which will turn off the power if the surface temperature on a parting or dividing strip reaches the critical value of θ_1*, but will turn it on again when this temperature drops to θ_2*.

2.1.2 After the initial T_1 seconds, control is taken over by a temperature controller, probably a Westinghouse temperature control unit, which will switch on the power when the surface temperature at the parting or dividing strip falls below θ_3*, and switch it off when it rises to θ_4*.

2.1.3 The temperature controller is kept energised so long as signals from the icing detector keep arriving within a fixed period of each other. As soon as the period between signals exceeds T_2* secs., indicating that icing has ceased or is occurring at a very low rate, the control is de-energised, switching off the power to the parting and dividing strips.

2.1.4 After the control has been de-energised, the next signal from the icing detector starts the initial operation again.

2.2 De-icing Control

2.2.1 This control receives signals from the icing detector. As soon as a given number of signals, N*, has been received, showing that a certain amount of ice has accreted, shedding action is initiated.

2.2.2 Power is then applied to each shedding section in turn. Power is applied to each section until an indication is received that the surface temperature at that section has reached a value of θ_5*, or until an override time of T_4* seconds has elapsed. Power is then applied to the next shedding section.

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* See Appendix.

2.2.3 If N signals are received before the previous shedding sequence is completed, the control will continue with the shedding action, and then when it is complete, will immediately initiate the next shedding sequence. In the meantime the counter in the control will not start to recount the icing-detector signals until the fresh shedding sequence has been initiated.

This operation is for use in exceptionally heavy icing, where more than the required amount of ice can accrete during the shedding cycle.

2.2.5 When the aircraft emerges from icing and the parting and dividing strips are automatically switched off, the control will initiate a shedding sequence to clean any ice off the wings. At the same time the counter in the control will return to zero, ready to start a fresh count when icing is encountered again.

3.0 STAGES OF INSTALLATION

3.1 Anti-icing Control

The same anti-icing control will be used for the Trial Installation, Preliminary Production, and Final Production Stages.

3.2 De-icing Control

3.2.1 In the Trial Installation Stage, the number of signals, N, required to initiate shedding, will be manually selectable between any of the values shown in the Appendix. Shedding will be applied to each section for a time T_3* seconds, manually selectable between the values shown. T_3 will in effect be the same as the override time T_4.

3.2.2 In the Preliminary Production Stage the values of N and T_3 will be preset on the basis of results obtained from flight trials on the Trial Installation.

3.2.3 In the Final Production stage the value of N will be preset, and the shedding time will be determined by an indication of shedding surface temperature, with an override time T_4.

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* See Appendix.

3.2.4 It should be possible to use virtually the same control for each stage, by arranging for the override time T_4 to be manually selectable in the Trial Installation, and to be preset in the Preliminary Production, so as to give in effect the variable shedding time T_3.

4.0 COCKPIT CONTROLS AND INDICATORS

The automatic control will be energised by a circuit-breaker which will be switched on before flight. No other controls will be provided except in the Trial Installation, which will have manual selection of N and T_3.

Two indicator lights are required - -

4.1 An amber light which will come on when heat is applied to the icing detector. This light will come on and off with each cycle of the icing detector, and the frequency of its signals will be an indication of the rate-of-icing being encountered.

4.2 A green light which will come on when the parting-strip temperature controller is energised , and remain on till the controller is de-energised. This light will modulate or flicker as power is applied to each shedding section during a shedding sequence. This light will thus be on during icing, and will indicate when shedding is taking place. As it shows while the temperature controller is energised, it will not necessarily indicate that the parting strip power is on, and so will not come on and off as the heat to the parting-strip is modulated by the controller.

REFERENCE

NAE Lab. Memo. LT-32 - Specification for automatic control for NAE electro-thermal wing de-icing system - 1 Aug., 1952.

APPENDIX

It is not yet possible to assign definite values to all the constants given in this Specification. The following are tentative values.

T_1 - 20 or 30 seconds

T_2 - between 60 and 120 seconds

T_3 - the following values should be selectable: 2, 4, 6, 10, 15, 20 seconds

T_4 - about 20 seconds

θ_1 - about +100°C.

θ_2 - about +90°C.

θ_3 - about 0°C.

θ_4 - about +3°C.

θ_5 - 0°C. to +5°C.

N - the following values should be selectable: 10, 20, 30, 40, 50.