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MODEL: 309A & 319 REPORT NO. 5

**APPLICATION OF CIRCULATION CONTROL TO
AN AIRPLANE OF MILITARY LIAISON TYPE**

NONR CONTRACTS 234(00) AND 856(00)

661

Cessna Aircraft Company
Wichita, Kansas

64062

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Cessna
Aircraft Company
Wichita, Kansas

PERIODIC PROGRESS REPORT

MODEL 309A & 319: REPORT NO. 5
APPLICATION OF CIRCULATION CONTROL TO
AN AIRPLANE OF MILITARY LIAISON TYPE.
HOUR CONTRACTS 234(00) AND 856(00)

REPORT DATE: 2 March 1953
PREPARED BY: E. G. Blosser
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APPROVED BY: A. N. Petroff

OCT 21 1954

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TITLE **PERIODIC PROGRESS REPORT**

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PREPARED BY **NLS** DATE **3-2-53**

CESSNA AIRCRAFT CO.

REPORT NO **5**

CHECKED BY **JWF** DATE **3-2-53**

WICHITA, KANSAS

MODEL **309-309A-319**

FORM 484

CESSNA MODEL 309 - CONTRACT NO. 234(00)

Analysis

Report 1309-4, "Design Construction Project", Model 309A has been written and ready for distribution. It contains detail description of the present electrical D.C. system.

Design and Construction

Low efficiency of the electrical system installed in the 309A, which resulted in an excess power drain on the main power plant, brought about the need for an auxiliary source of power for system operation during take-off and landing operations. This power will be supplied by four (4) T-88 aircraft batteries mounted aft of the pilot's seat.

The electrical system is designed to charge the battery in flight, will also permit the system to operate from the generator if it is desired to use HLC for a long period of time. Ground and flight tests will be conducted with the battery installation in the near future.

The test evaluation of the hydrogen peroxide system in the 309C will necessitate installation of a new multiple manometer as part of the instrumentation for this system. This manometer has been constructed and is awaiting installation.

The following drawings have been released:

- 12309-67 Gas Generator Installation - Model 309C
- 70 Wiring Diagram - HLC System
- 71 Multiple Manometer
- 72 Battery Box Assy.
- 73 Multiple Manometer Installation

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CESSNA MODEL 319 - CONTRACT NO. 856(00)

Analysis

The project as a whole is in a stage of intensive search for a suitable air pumping system and also for an optimum aerodynamic configuration of the wing. Both of these items depend largely upon the outcome of wind tunnel tests, (conducted at the University of Wichita) which started December 27, 1952, and concluded on February 12, 1953. The quantity flow of air necessary to achieve a given lift coefficient which, in turn, affects the power required for the pumping system depends upon the efficiency of the slots and the ducts.

The quantity flow coefficient C_{Q_B} required by the Model 319 HLC system as a function of $C_{L_{max}}$ is shown by Figure 1. The values of Q were computed from wind tunnel data on .6 scale model of the wing panel by the following formula:

$$Q = C_{Q_B} S_B V = 877 \left[\frac{W}{S} \frac{C_{Q_B}^2}{C_{L_{max}}} \right]^{\frac{1}{2}} \quad (1)$$

where C_{Q_B} is based on the wing area S_B affected by the blowing slot, and related to C_{Q_S} by $\frac{C_{Q_S}}{C_{Q_B}} = 1.34$

Air horsepower required by system shown by Figure 2, was computed by the basic equation:

$$HP_A = \frac{\Delta P Q}{550} \quad (2)$$

where HP_A is defined as the rate of doing work upon air passing through the internal wing ducts. ΔP the total pressure head rise, $= q (C_{Q_B}^2 n_B + C_{Q_S}^2 n_S + C_{P_{st}})$

The values of n_B and n_S - pressure loss coefficients in the blowing and the suction ducts respectively are taken from Kruger's report (NACA Technical Memorandum No. 1167) modified by Dr. F. Wagner of University of Wichita.

$C_{P_{st}}$ - static pressure loss coefficient to account for the reversing air flow before it enters the suction duct was assumed to be 2.

Combining (2) and (3) yields the final expression for air horsepower required per panel:

$$HP_A = 1.595 Q C_{Q_B} \left[\frac{(W/S)}{C_{L_{max}}} \right]^{\frac{3}{2}} (C_{Q_B}^2 n_B + C_{Q_B}^2 n_B + C_{P_{st}}) \quad (4)$$

The wind tunnel data corrected for wall interferences is now applied to calculations of C_L for the optimum take-off. This will determine the desired C_Q and the power required for the pumping system.

Meanwhile, several manufacturers of auxiliary power units, air pumps and fans were contacted, either directly or by letters, with specifications of the pumping requirements. The table presents the possible pumping systems applicable to the Model 319.

A study of this table indicates that as soon as power required for the system is determined a decision should be made whether the system is to be designed for a continuous or intermittent operation.

By the process of elimination, it seems that the choice could be narrowed down to items 3, 4, 5 and 6 shown in the table.

For the continuous operation, (items 3 and 4) the system will consist of two axial fans pumping approximately 85 cu. ft. of air per second against the total pressure head rise of 130 lbs/sq. ft. The fans are driven either directly or hydraulically by an APU of 30 HP. This unit could be a two cycle gasoline engine located inside or outside of the fuselage.

For the intermittent operation the principle of storing energy (either electrical energy or energy in the form of compressed air) at a slow rate and releasing it, when desired at high rate is feasible.

In the first case a compound arrangement of generator (driven continuously by the main engine) and a battery will supply electrical current to the axial fan motors.

In the second case an air compressor (absorbing 4-5 HP) driven continuously by the main engine will supply air to high pressure tanks, located in the wings, of sufficient capacity to run air turbines on the axial fan shafts for 60 seconds.

The advantages and disadvantages of each case when applied to a research or a prototype airplane are now being carefully considered on the basis of take-off and landing performance.

Design and Construction

V-n diagrams for a range of wing loadings from fifteen #/sq.ft. to twenty-five #/sq.ft. was prepared to be used for the wing analysis of the 319.

To obtain the desired performance from the Model 319 it was decided to use an O-470-A Continental Engine with a Hartzell constant speed propeller. A drawing of this installation is now being prepared.

Tests on the .6 scale wing at the University of Wichita Wind Tunnel indicate that the original proposal, to use wing tip fuel tanks, has an adverse effect on stalling characteristics. In the light of this information design has been started on an internal fuel tank for the airplane.

MODEL 319
 C_{LMAX} VS. C_{D0}

BASED ON UNIVERSITY OF WISHLTA
WIND TUNNEL DATA

$C_{D0} = \frac{q}{S_0 V}$ (BLOWING WING AREA)
 $S_0 = 10.87 \text{ FT.}^2$
 $q = 2.5 \text{ IN. ALCH.}$

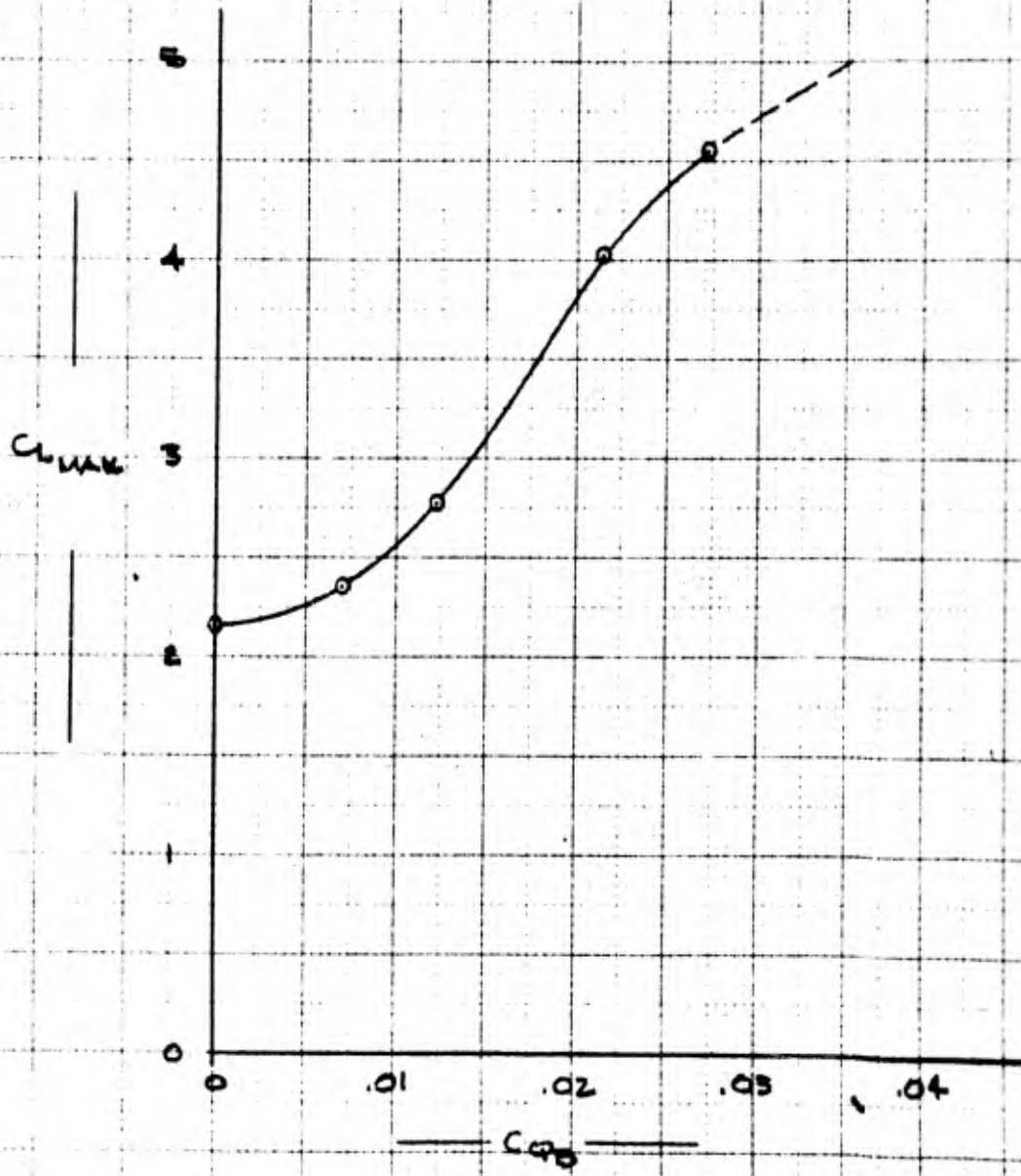


FIG. 1

3-31-53
J. J. ...

MODEL 319

AIR HORSEPOWER REQUIRED BY BLC

$$AHP/PANEL = 1.595 C_{DB} \left[\frac{W/S}{C_{LMAX}} \right]^{3/2} (n_B C_{DB}^2 + n_S C_{DB}^2 + C_{P,T})$$

VALUES GIVEN ARE COMPUTED FOR ONE WING PANEL
 & DO NOT INCLUDE PUMPING SYSTEM EFFICIENCY

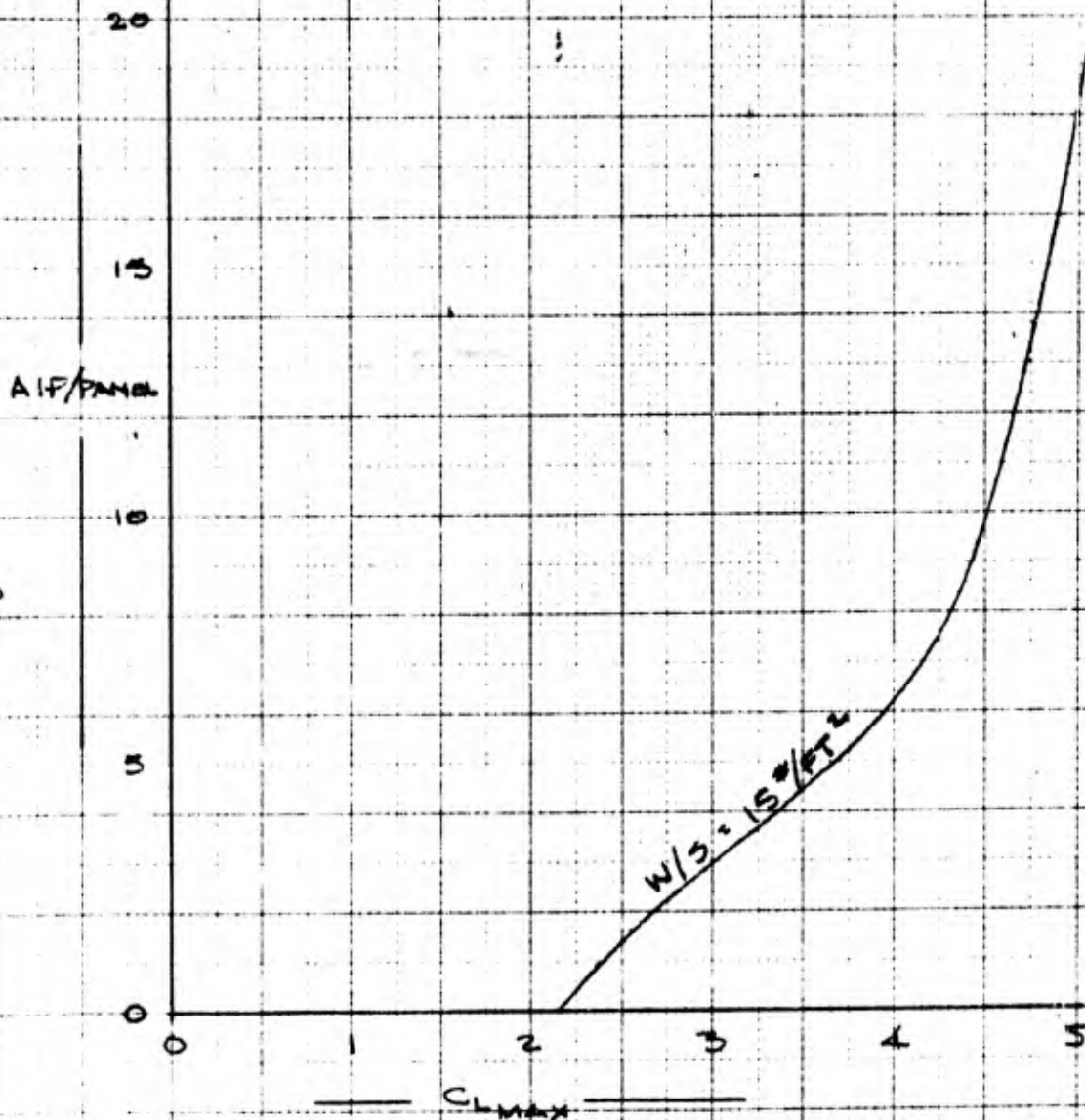


FIG. 2

2-26-53
J. H. ...

GENERAL ENGINEERING REPORT NO. 329

| No. | 1 UNIT OF 1/2 TONS | HP RATED | LOCATION | COMPONENTS OF UNIT | CONNECTIONS | DRIVES OF MACHINERY | TYPE | CONTROLS | PH. AND MEASURING M.A. |
|-----|-----------------------|-------------|----------------|------------------------------|-------------|---------------------|--------------|------------|---|
| 1 | 1 1/2 Ton Engine | 30 | --- | 1 D.C. Generator | Wires | 2 D.C. Motors | 2 Axial Fans | Continuous | None |
| 2 | " | 30 | --- | 1 A.C. Generator | " | 2 A.C. Motors | " " " | " | " |
| 3 | " | 5 | --- | 1 D.C. Generator & Supply | " | 2 D.C. Motors | " " " | 60 Sec. | Intensity C.G.L. |
| 4 | " | 5 | --- | 1 Vacuum Compressor & Supply | Air Pipes | 2 Air-Starters | " " " | " | None |
| 5 | 1 1/2 Ton Engine | 30 | Inside of | 1 Oil Pump | Wiring | Direct Drive | " " " | Continuous | Mixture of Gas & Oil |
| 6 | " | 30 | " | 2 Centrifugal Air Comp. | Oil Pipes | 2 Oil Starters | " " " | " | " |
| 7 | " | 30 | Outside of the | 1 Centrifugal Air Comp. | Air Pipes | 2 Air Starters | Direct Flow | " | " |
| 8 | " | 30 | " | 1 Piston Air Comp. | Air Pipes | 2 Air Starters | 2 Axial Fans | " | " |
| 9 | " | 30 | " | 1 D.C. Generator | Wires | 2 D.C. Motors | " " " | " | " |
| 10 | " | 30 | " | 1 A.C. Generator | " | 2 A.C. Motors | " " " | " | " |
| 11 | 1 1/2 Ton Engine | 225 | Wings | None | Wiring | Direct Drive | " " " | " | " |
| 12 | 1 1/2 Ton Engine | 5 | Inside of the | 1 D.C. Generator & Battery | Wires | 2 D.C. Motors | " " " | 60 Sec. | Mixture of Gas & Oil & Intensity C.G.L. |
| 13 | " | 5 | " | 1 Piston Air Comp. & Supply | Air Pipes | 2 Air Starters | " " " | 60 Sec. | Mixture of Gas & Oil |
| 14 | 1 1/2 Ton Engine | 30 | " | Air and Fuel | Wiring | Injection | Injection | Continuous | None |
| 15 | " | 30 | " | Centrifugal Air Comp. | " | " | Direct Flow | " | " |
| 16 | 2 1/2 Ton Engines | 225 | Wings | Air and Fuel | None | Integral Mix | " | " | " |
| 17 | 2 1/2 Ton Engines | 225 | Wings | " " " | " | " | Direct Flow | " | " |
| 18 | 2 1/2 Ton Engines | 30 | " | Superheated Steam | Wires | " | Injection | 5 Min. | 1/2 O ₂ & N ₂ |

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