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Cessna

MODEL: 309A-309C-319A REPORT NO. 6

APPLICATION OF CIRCULATION CONTROL TO AN AIRPLANE OF MILITARY LIAISON TYPE

NONR CONTRACTS 234(00) 856(00)

Cessna Aircraft Company
Wichita, Kansas

FORM 484

Cessna Aircraft Company

Wichita, Kansas

PERIODIC PROGRESS REPORT

MARCH 1 TO MAY 1, 1953

MODEL 309A-309C : REPORT NO. 6
319A

APPLICATION OF CIRCULATION CONTROL TO AN AIRPLANE OF MILITARY LIAISON TYPE

NONR CONTRACTS 234(00) 856(00)

REPORT DATE: May 1, 1953

PREPARED BY: Alex Petroff

Jack W. Fisher

Earl G. Blosser

A. OWEN HOLLIDAY

CESSNA MODEL 309A-309C - NONR CONTRACT NO. 234(00)

Analysis

The report No. 1309-4 "Design and Construction Project - Model 309A" is now complete. It will be printed, assembled and released in the near future.

Manufacturing

The battery electrical system has been designed and checked. Subsequent flight tests have shown that the batteries will quite adequately operate the fans for the time required either for take-off or landings.

Flight Test

To correct for the violent left roll condition that existed when the airplane was stalled it was decided to check and re-rig the aileron droop system. A three degree differential was found to exist between the right and left aileron in the drooped position. A slight modification of the droop mechanism corrected this condition.

Flight tests indicated the change in aileron droop improved the stall. To further improve the situation the horizontal incidence was changed from -3° to -1.25°. Flight tests after this change indicated the stall of the airplane is now normal.

Familiarization flights have been performed by Pilot Fritz Feutz in preparation for take-off and landing measurements with battery operated axial fans. Several minor changes were made to reduce stall abruptness and lateral unbalance with the BLC system operating. Re-rigging and careful adjustement of the aileron droop system definitely improved the lateral problem. A reduction of negative horizontal tail incidence improved the stall so that the most severe pitch and roll are not now objectionable.

Further flights have been performed in preparation for take-off and landing distance measurements. Specifically these tests establish break-ground, climb, and approach speeds for conditions of BLC on and off. During these flights it became apparent that there was insufficient elevator power for a three-point landing with flaps down. This was caused by a previous change in tail incidence. Elevator area was increased by the addition of a 3 inch strip of aluminum to the trailing edge. The increased area was found to provide sufficient control for a flaps-down landing with BLC system off.

Photographs of take-off and landing performance were made on April 23, 1953. They included measurements of:

1.	5 take-offs	BLC system off
2.	5 take-offs	BLC system on
3.	9 landings	BLC system off
4.	7 landings	BLC system on

Visual observation indicated definite take-off distance improvements, but it appeared that only marginal changes in landings were obtained. Photographic data is now in the process of analysis.

With the completion of these tests the airplane will now be disassembled, the electric fan system and all of its components will be removed, and the airplane will be readied for the installation of the H_2O_2 jet pump system.

Installation

Work on the 309C wings has now progressed as far as it can go pending the arrival of hydrogen peroxide gas generator and jet pumps from Reaction Motors, Inc.

CESSNA MODEL 319 and 319A - NONR CONTRACT 856(00)

Since the concept and, therefore, the purpose of the research airplane has not been clearly delineated in the contract, it led to a variety of interpretations, resulting in several possible design requirements.

The following table presents summary of salient parameters of each design variant which was under the consideration since the beginning of the project.

SUMMARY OF THE DESIGN PARAMETERS

MODEL DESIGNATION	S_w Sq.Ft.	W/S_w #/Ft.^{2}	AR	C_{Lmax} Power Off	Q Ft.^{3}/Sec.	ΔP #/Ft.^{2}	HP_a * Per Panel	HP_a Total	HP_r ** Total	REMARKS
319 Research	125	25	6.5	4.5	51.5	185	17.3	34.6	53.2	Original concept
319 Research	125	15	6.5	4.5	42.5	126	9.8	19.6	30.2	of 319 wing.
319A Research	175	13.5	7.5	4.5	57.5	123	12.8	25.6	39.4	Modified L-19 wing
319A Demon-strator	175	13.5	7.5	3.5	44.0	76	6.1	12.2	18.8	Modified L-19 wing

* Work done on air to overcome losses in slots and ducts for a given C_{Lmax}. It was computed on the basis of wind tunnel tests at the University of Wichita and presented on the graph at the end of this report.

** Total horsepower required to operate the system. It was computed assuming 90% efficiency for the hydraulic pump and motor and 80% efficiency for the axial fan.

Examination of the table reveals that horsepower required to operate the system for the research airplane is roughly double of that required for the demonstrator. The only way this power requirement could be met is by installation of an auxiliary power unit such as a two-cycle gasoline engine. This was feasible for a research type airplane, but was objectionable for the case of practical demonstrator due to unreliability of starting the system. Moreover, it was expected that design of tail surfaces for the research version, necessary to overcome high moment associated with $C_{Lmax} = 4.5$, might present difficulties which would tend to delay delivery of the airplane.

Therefore a meeting was arranged on March 30 and 31, 1953 between representatives of ONR, University of Wichita and Cessna personnel to delineate the objective of the project more precisely and to map out a more or less definite course of action.

The following personnel was present at the meeting:

Major J. Willcox, Office of Naval Research

Mr. R. Putnam, Office, Chief of Transportation Dept. of the Army

Mr. J. Beech, Office, Chief of Transportation Dept. of the Army

Mr. K. Razak, University of Wichita

Mr. Tom Salter, Cessna Aircraft Company

Mr. Jack Fisher, Cessna Aircraft Company

Mr. Alex Petroff, Cessna Aircraft Company

The concensus of the opinion was to abandon, temporarily, the original concept of the research airplane and concentrate immediate efforts on the design and manufacturing of the demonstrator airplane, so that it could be flight tested next August. The airplane, designated as Model 319A, will consist of L-19 fuselage, a new, thicker, wing to accomodate the fans, a 225 HP Continental engine and Hartzell constant speed propeller.

Axial Fan

The air pumping system will consist of two axial fans (one in each wing panel) designed to the following specifications:

$Q = 46$ cu.ft./sec. at sea level

$\Delta P = 82$ lb./sq.ft. (Total static pressure rise)

$HP_a = 6.9$

$D = 8$ in.

RPM = 12,000 - 14,000

Search for the Power Plant

The search for a suitable motive power to drive the fans presented a difficult problem of compromise between the conflicting requirements of good engineering design such as mechanical efficiency, light weight and compactness and the requirements of service in the field such as maintenance, reliability and safety.

The 18 motive power systems that were under careful study and consideration for some time were narrowed down to four, which will be bench tested and selected to satisfy the requirements mentioned above.

	Motive Power Systems	Duration	Approximate Power Taken Off Main Engine	Approx. Wt. (lbs.)
1.	Hydraulic motors driven by a hydraulic pump belted to the engine	Continuous	20	110
2.	Air turbines driven by compressed air stored in spherical tanks	2 Min.	0	160
3.	Gas turbines driven by solid or liquid propellant gas generators	2-one Min periods	0	70
4.	Electric motors driven by generator and storage battery	2 Min.	12	230

Selection of Power Plant -

At the present time the most promising source of power from the standpoint of mechanical efficiency and the availability is the engine driven variable displacement Vicker's hydraulic pump actuating two Vicker's hydraulic motors geared to the fans. Negotiations with Vicker's Company of Detroit and Joy Manufacturing Company of New Philadelphia, Ohio has been started to procure the pump-motor-fan combination. The names of other firms and establishments contacted with the intention of obtaining design information or procuring a suitable motor-fan unit are listed at the end of this report.

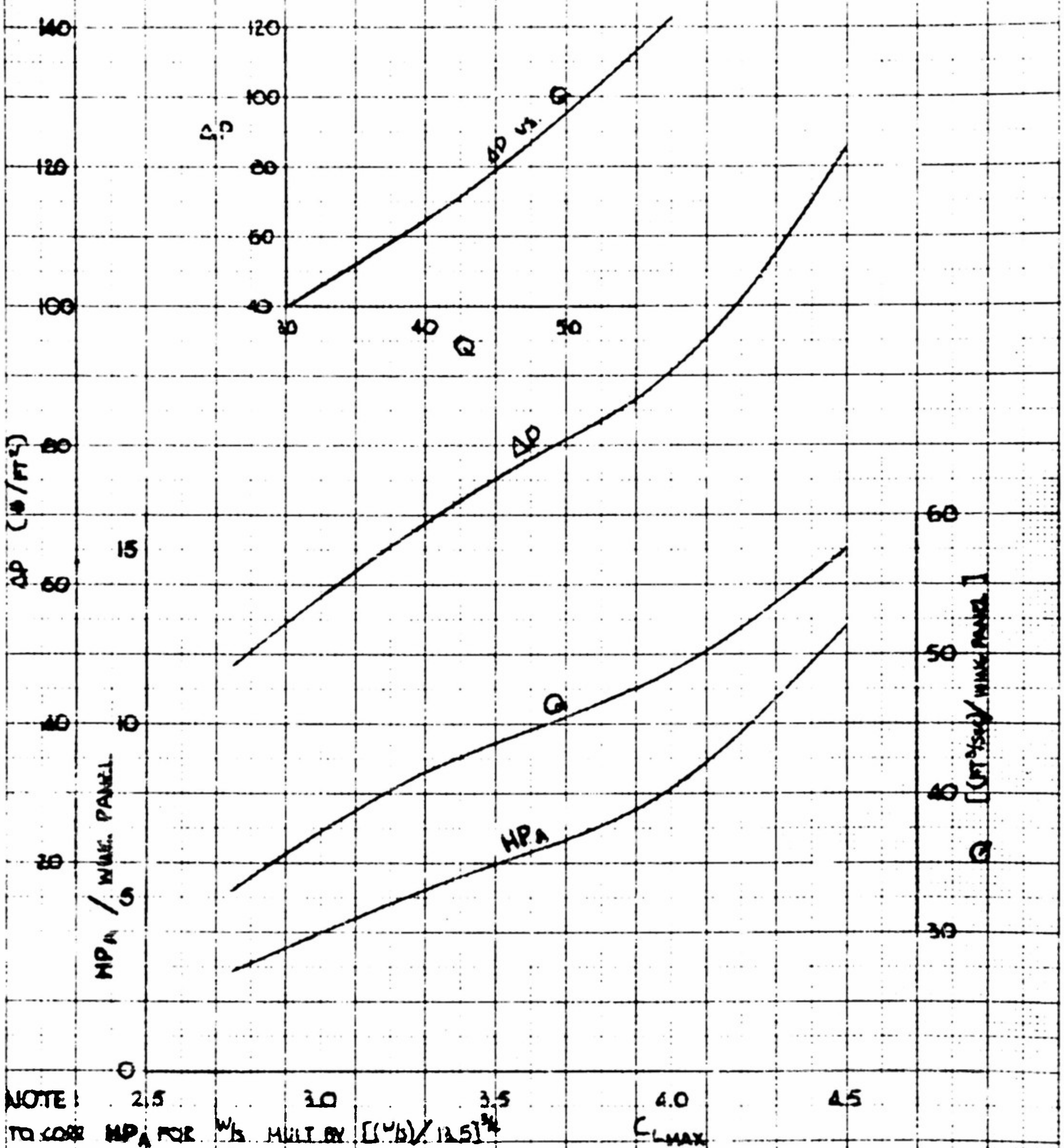
Performance of the Airplane with BLC

Calculations indicate that with the hydraulic system which draws approximately 20 HP off the main engine, it is possible to achieve 20% decrease in take-off distance over a 50 foot obstacle as compared with the distance required by the present Model L-19 airplane.

Results of the detail calculations correlated with recent flight tests of take-off and landings on Model 309 equipped with electrical-generator-storage battery system will be presented in the next periodic report.

MODEL 319A
BLC PUMP REQUIREMENTS

W/S = 13.5   GROSS WEIGHT = 2350 LBS S_b = .005 C



NOTE:
TO CORR HP_A FOR W/S MULT BY $[(W/S)/13.5]^{3/2}$
TO CORR ΔP FOR W/S MULT BY $[(W/S)/13.5]$
TO CORR Q FOR W/S MULT BY $[(W/S)/13.5]^{1/2}$

4-30-53

List of Facilities Visited in Search of Suitable Pumping System

Date	Place	Facility Visited	Persons Contacted	Subject Discussed
2-11-53	Dayton, Ohio	WADC	Mr. Liebarth, Equip. Lab.	Application of small gas turbine as an air pump for BLC
2-11-53	Dayton, Ohio	WADC	Mr. Conrad, Power Plant Lab.	Discussion of pneumatic system of BLC
2-12-53	Dayton, Ohio	WADC	Mr. J. Flatt and Mr. R. Kosin, Aircraft Lab.	Evaluation of efficiency and practicability of various pumping systems applicable to BLC
3-6-53	West Lynn, Mass.	General Electric Company	D.G. Bloomberg, H.L. Nuttall D.C. Prince, Jr., Accessories Turbine Division	Evaluation of efficiency and weight of several mono propellant gas generators as a source of power for BLC
3-9-53	Belleville, N.J.	Walter Kidde Co.	I.G. Hammill, M.E. Zeek, W.A. Orsini	Discussion of hydrogen peroxide turbine and compressed air systems.
4-6-53	Detroit, Mich.	Vickers Inc.	Wm. Main, K. Postel	Selection of suitable hydraulic pump and motor.
4-7-53	Buffalo, N.Y.	Fredric Flader	R. Krouse, R. Dalton, F. Laskowitz	Specification for the fan and invitation to bid to manufacture.
4-8-53	New Philadelphia, Ohio	Joy Mfg. Co.	C.P. Jenkins, L.J. Herrig	Specification for the fan and invitation to bid to manufacture.
3-13-53	Oshkosh, Wis.	Kiekhaefer Aeromarine Motors, Inc.	Mr. Kiekhaefer, C.B. Strang and Edgar Rose	Discussion of 2-cycle internal combustion engines as a BLC power source.