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RESULTS OF FLIGHT TESTS OF A TWIN ENGINE C-45 BEECH AIRCRAFT MODIFIED WITH AN INVERTING FLAP WHICH INCREASES THE WING AREA

A COURTESY TRANSLATION BASED ON A
FANASA REPORT ACF-5 ENTITLED

RESULTADOS DE VUELOS DE PRUEBAS DE UN AVION BIMOTOR BEECHCRAFT MODIFICADO CON UNA ALETA HIPERSUSTENTADORA DESDOBLABLE QUE USANDO UN EJE DE ROTACION FIJO AUMENTA EL AREA DEL ALA

ORIGINAL REPORT WRITTEN BY PROFESSOR ALBERTO ALVAREZ-CALDERON
UNIVERSIDAD NACIONAL DE INGENIERIA
LIMA - PERU

ON THE BASIS OF TEST FLIGHTS MADE BY COMMANDER (RET.) DANTE P. VARGAS, TEST PILOT FOR THE C-45 INVERTING FLAP PROGRAM.

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RESULTADOS DE VUELOS DE PRUEBAS DE UN AVION BIMOTOR BEECHCRAFT MODIFICADO CON UNA ALETA HIPERSUSTENTADORA DESDOBLABLE QUE USANDO UN EJE DE ROTACION FIJO, AUMENTA EL AREA DEL ALA.

Preparado Por

Alberto Alvarez-Calderón F.
Ingeniero Aeronaútico

En Base De Vuelos De Prueba
Ejecutados Por

Dante Vargas P.
Piloto De Pruebas

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RESULTS OF FLIGHT TESTS OF THE TWIN ENGINE C-45 BEECH AIRCRAFT MODIFIED WITH AN INVERTING FLAP WHICH INCREASES THE AREA OF THE WING

ABSTRACT

Operation of the flap:

Motion of the flap in flight does not produce any objectionable or unpleasant acceleration of the aircraft. The flap can be retracted and extended without loss of altitude. The flap has been operated over 500 times on the ground and over 140 times in flight. The flap, its mechanism of retraction and its proportional position indicator have worked very satisfactorily. In the test flight program the flap was retracted after take off after the initial climb, usually at about 800 feet. The flap has been operated in flight at under 200 feet of altitude. For landing, normal operation was to fully extend the flap in base leg using 90° deflection in the final leg and in actual landing. The flap has been operated up to 115MPH; maximum structure of speed for the flap's retraction system was 120MPH.

Stall speeds and take off and landing rolls

There has been made over 49 stalls in different configurations. The maximum reduction of stall speed due to flap power-off was from 75 with no flaps to 58 MPH at 90° flap. The increase of wing lift coefficient power off were within 5% of theoretical predictions. Power-on and gear down, with both landing and take off flaps it was possible to measure indicated speeds of 40MPH with 22" of manifold pressure and 2,000 RPM. The gross weight at this stall speed tests was approximately maximum landing weight for the aircraft.

Groundrolls for landing were of the order of 630 feet with an approach speed of 65 MPH. This distance could be shortened with good brakes which the test aircraft did not have. The take-off roll was in the 450 to 600 feet length, depending on the pilot technique used. There was noted the capability of the aircraft to climb at a very steep angle at very low speeds.

The landing flap position was 90°, and yielded the best control "feel", minimum field length, best visibility, best approach angle and lowest minimum control speed. This position also permits reserve altitude for a go-around on landing, and the greatest "reach" to the landing field in the event of engine failure in approach, by moving the flap back to its take off position to decrease drag rapidly.

The wind in the landing and take off roll measurements was under 3 knots at 30° to the runway.

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Maneuvers

Sinking rate with 90° flaps were over 2,000 FPM at 90MPH and well over 1,000 FPM at under 65MPH, giving considerable advantage for steep approach, for intentional loss of altitude in updrafts, and for rapid descends when in poor visibility.

Under equal conditions there was a reduction of turning radius of over 35%; the reduction of turning diameter was over 1,800 feet at 30° bank. This is useful for the approach and/or exit of a landing field having difficult access.

Minimum control speed in single engine flight

The minimum control speed in single engine flight V_{mc} was greatly reduced because the asymmetric forces of the operative engine were partially absorbed by the flaps and cancelled efficiently by the ailerones, leaving a smaller asymmetric forces to be cancelled by the rudders. The minimum control speeds were reduced from 88 MPH with no flaps to 58 MPH with take off flaps and 52 MPH with landing flaps. This considerable improvement of minimum control speeds permit the utilization of this low speed attainable with a new flap, while remaining above V_{mc}.

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1. Description of the inverting flap

A description of the inverting flap, as well as the mechanical, structural, and aerodynamic aspects of its installation on a C-45 aircraft are the subject of a separate report. Fig. 1 of the present report shows a sketch of the flap on a typical wing section; Fig. 2 shows a picture of the test aircraft in flight.

2. Test aircraft

The test aircraft on which test flights were made was a Beech C-45 model F of Peruvian Registry No. 504. The conditions of the basic aircraft are known to the Maintenance Department of the Peruvian Air Force (SEMAN).

3. Test objectives

3.1 Determination, on a test aircraft, of the principal aerodynamic, structural, and mechanical characteristics of an inverting flap.

3.2 Determination of the take off, landing, and slow speed characteristics of a twin engine Beechcraft C-45 aircraft modified with the inverting flaps.

The flaps were installed such that with flaps retracted no significant change in the wing's characteristic occurred.

The information of this report is principally related

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to objective 3.2 above.

4. Instrumentation

4.1 Aircraft instrumentation: The instruments available during test flights were those normally installed in aircraft 504, duly calibrated at the instruments laboratory of the Peruvian Air Force (SEMAN). Additionally, however, a separate independent speed indicator with a separate pitot was installed at the front end of the fuselage with its pitot head about 1 yard below the nose of the aircraft; the climb indicator was changed during the test program; There was installed an angle of attack indicator on the aircraft of elementary construction using a pendulum.

4.2 Flap instrumentation: Lights were used to indicate the fully opened take off position and the fully closed flap position. There was also installed in the instrument panel a proportional flap position indicator comprising an airfoil section and a needle which moved relative to that section as the inverting flap moves relative to the wing. A convex mirror was installed on the left cowl to permit the pilot to visually inspect by looking below the wing the positions of the flaps; each flap was provided with projecting rod which permitted the pilot to observe also the position of the flaps in the zero to 90° range by looking on top of the wing.

The variable speed flap retraction system using variable resistors for the flap's electric motor, as well as the strain gage for the flap's cable were not installed due to various limitations of the program.

5. Speed measurements

The speed indicator and pitot with which the speeds indicated in this report were measured is the principal one on the aircraft. The indicator is on the left side of the panel, its pitot entry is located approximately 30" below the fuselage approximately at the location of the rudder pedals. It was calibrated originally by the Instrument Department of the Peruvian Air Force Laboratories in the presente of Prof. A. Alvarez Calderon, the calibration indicated that variation no greater than one mile per hour from the standard. It is considered that the location of the pitot is subject to such pressure gradients and speed gradients as may be induced by the fuselage and by the propeller slipstreams.

A second independent pitot was installed on the aircraft and tested with various instruments including a helicopter speed indicator, and one calibrated at Aeronautica S.A. shop at the International Airport (CALLAO). In all cases this second indicator gave lower speed readings than the principal indicator. Consequently the measurements of the principal indicator have been used in this report.

It is considered that the speeds indicated in this report which were taken with the principal and original speed indicator of aircraft 504 calibrated in the Peruvian Air Force Laboratory has the greatest possible accuracy attainable with the instrument and pitot location; it is conservative in that it read the highest speed measured by the speed indicators available on the

aircraft, and it is considered representative of the speeds that could be measured on a C-45 and Beech 18 Aircraft with similarly located pitots and with speed indicators calibrated at the Peruvian Air Force Laboratory (SEMAN).

A sketch of the positions of the pitots in the test aircraft is shown in Fig. 3.

6. Weights

The weight of the aircraft has been determined according to its manual, that is, to its basic weight there has been added additional weight on the aircraft and crew. In each flight for stall speed tests, the calculated weight at take-off was 7637 lbs; stalls were initiated 20 minutes after take-off. In the take-off and landing tests the calculated weight at their initiation was 7777 lb. The maximum landing weight is 7850 lb. In the remaining maneuvers the calculated weight at their initiation in the test area was approximately 7600 lb.

The aircraft was not flown at gross weight because of the advanced corrosion in the wings and control system and poor condition of the landing gear, oleos, brakes, and fuel cells. The aircraft 504 was rented to fly on an experimental basis, did not have an airworthiness certificate, and the fact that it was mortaged prevented heavy investments on the frame.

7. Personnel for test flights

Test pilot: Commander (Ret.) Dante Vargas P. (Commander Vargas has over 2,000 hours of flight time in C-45 and has been chief of the C-45 squadron of the Peruvian Air Force for several years. He is rated on twin and four engine aircraft).

Test flight engineer: Professor A. Alvarez-Calderon, who flew as copilot during the first 6 test flight hours including first in-flight retraction and extension of the flap and first tests for stalls.

Test flight observer and copilot during remaining test flight hours: Enrique Leon.

Test pilot designee by the Peruvian Air Force: Commander FAP Alberto Thorndike was assigned by the Air Force to evaluate the aircraft. His test flight data is included in this report and when mentioned it is accompanied by the initial (CAT).

8. List of tests made in flight related to this report

8.1 In-flight extension and retraction of flap.

8.2 Determination of stall speeds.

8.3 Simulated take-offs at altitude.

8.4 Simulated flareouts at altitude.

8.5 Approaches power-off.

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8.6 Similated approaches, power-on, at altitude.

8.7 Approaches to the landing field.

8.8 Measurements of take-off and landing rolls.

8.9 Determination of turning radius.

8.10 Minimum control speed in single engine flight.

8.11 Single engine climb.

Results of the test flights are being reported in the following sections and in the comparative tables which constitute section 17.

9. Flap extension and retraction

The flap has been operated on the ground over 500 times.

The flap has been operated in flight over 140 times, including demonstration flights.

The flap has been operated in flight with the control wheel free.

Flap extension in flight is of short duration because airloads aid flap extension. Time of extension was measured to be of the order of 4 to 5 seconds. During extension, the aircraft gains altitude, estimated at 50 feet.

The time of retraction for the flap varies according to the speed of flight. There was measured a 7 second retraction time at 95 MPH and 9 seconds as 105 MPH.

The retraction of a flap if it is not anticipated by the pilot may produce a slight loss of altitude as is usual for any flap. Due to the increased drag during flap retraction, there is a small loss of speed during the retraction.

It is possible to gain altitude while retracting the flap by adequate use of control, if desired.

The extension and retraction of the flap has been made under 200 feet altitude without any objectionable change of altitude.

During extension and retraction of the flap, there does not appear any linear or angular acceleration which might be considered objectionable from the view point of structures, aerodynamics, passenger confort or cargo stability.

The retraction and extension mechanism worked perfectly from its initial tests.

Tests to alter the retraction speed of the flap were not

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made due to various limitations of the program.

The light position indicators, after their initial recalibration to allow for the difference of cable slack on ground calibration and inflight, worked very satisfactorily. The proportional flap position indicator was very satisfactory.

In test flights, retraction of flap after take-off was usually made after initial climb from the air field at about 800 feet elevation and at approximately 105 MPH. On many occasions, as normal operating procedure, the flaps were retracted at about 400 feet and while over the runway. Minimum retraction speed used was 95 MPH or more depending on the aircraft's weight. Maximum structural speed for retraction was 120 MPH.

Normal flap procedure for landing, established after exploring several techniques, was determined to be full extension of flaps to take-off position on base leg or prior to base leg, and 90 flap position on final leg or prior to final leg, depending on traffic, approach pattern, obstacles, etc. Maximum structural speed for flap extension is 120 MPH.

10. Determination of stall speed

By stall speed it is meant in this report the speed at which the pilot of the aircraft felt the initiation of aircraft vibrations of aerodynamic origin which were generally followed by a substantial loss of altitude: 1-G conditions in the entry to the stall was substantially achieved in the tests reported herein.

The stall speeds measure in the various configurations tested are reported as follows (Stall speeds measured by Peruvian Air Force test pilot designee, Commander A. Thorndike, are indicated with the initials (CAT):

9.1 No flaps (flaps retracted)

Gear up power-off 75 MPH
Gear down power off 78 MPH
Gear up power-on 60 MPH 20" 2000 RPM
Gear down power-on 62 MPH 20" 2000 RPM

9.2 Take-off flaps

Gear up power-off 60 MPH
Gear down power-off 58 MPH
Gear up power-on 45 MPH 20" 1850 RPM (CAT)
Gear down power-on 40 MPH 22" 2000 RPM (CAT)

9.3 Landing flaps

Gear down power-off 58 MPH
Gear up power-on 45 MPH 20" 1850 RPM (CAT)
Gear down power-on 51 MPH 19" 1500 RPM
Gear down power-on 40 MPH 22" 2000 RPM (CAT)

The total number of stalls, including those of other flap deflections, those with other power settings, and those with bank angle, are 49.

The type of stalls encountered in the stall tests, as observed from tufts in the wings, is progressive trailing edge separation and flow reversal in the inboard portions of the wing towards the nacelles. In the power-on stall tests,(power limited to maximum continuous) there was noted the initiation of flow reversals in the inboard portions of the ailerones prior to stall.

In all the stalls made there was retained very satisfactory control in pitch, yaw and roll; the stalls were gentle and were preceeded with vibrations. From observations comparing stalls of a conventional Beech 18 with the modified C-45 aircraft with the inverting flap it appears that the latter had less inclination to drop a wing compared to the former. In no case was there any loss of lateral control or drop of a wing with the inverting flap. This is explained in terms of the change of stall angle in the wing section of the flapped portion of the wing due to flap which introduces an effective aerodynamic twist or wash-out to the wing which improves the spanwise stall pattern distribution.

It should be noted that the maximum lift coefficients calculated from the power-off stall speeds are within 5% of those predicted for the wing on the basis of wing theory. The 5% difference can be easily atributed to fuselage effects and/or tail loads which were ommitted in the theoretical prediction.

The significance of the stall speeds determined with the inverting flap in relation to the landing and take-off maneuvers are discussed in sections 12 and 13 of this report; the weights for the stalls measurement are mentioned in section 6 of this report.

11. Tests for maximum sinking speed with landing flap

The tests to determine the maximum sinking speed made with gear down and at low or no power indicated a very marked effectiveness of the 90° inverting flap deflection to increase sinking speed for a given flight speed. The 90° position not only gives higher lift coefficient than the 30° position, but also permits through its high drag to efficiently dissipate the potential energy of the aircraft without increasing its kinetic energy. The angles of approach obtained of the order of 12° at very slow speeds of the order of 65 MPH exceed the steep approach capability of any other conventional aircraft or flap known to this writer, including specialized STOL aircraft.

The changes of sinking speed at 90° flap, relative to the flap's up condition, were approximately 60% at 90 MPH and 40% at 80 MPH. The angles of approach measured at speeds of the order of 90 MPH were in excess of 14°. Sinking speeds of 1350 feet per minute at 70 MPH and 1200 feet per minute at 60 MPH have been measured with 90° flap.

It is considered that the sinking speed obtained can be useful not only for landing, but for rapid loss of altitude in bad weather or when flying in poor visibility without danger of undesired gain of speed.

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Tests for simulated dive conditions were not made at speeds over 100 MPH due to the poor structural condition of the basic airframe in the test aircraft and the severe nosedown altitude which such tests would have required.

The possibility of stopping the high sinking rate established with 90° flap by moving the flap to its take-off position can be used as an emergency device in approach to increase the "reach" of the aircraft towards a landing field in the case of an emergency in an approach, or to use available additional altitude for a go around for any given distance to the air field.

12. Techniques of short take-off and tests for short take-off

A short take-off in which the slipstream of propellers is used to increase wing lift can be made, according to NASA TND1032 (1961) at 1.15 of the stall speed in the take-off configuration. A stall speed's measurement in the take-off configuration, that is gear-down, open-cowl and take-off flaps, but with 30" manifold pressure and 2000 RPM (instead of 37" manifold pressure) has been made at altitude under a simulated take-off climb. The aircraft stalled at 42 MPH at an approximate 12° fuselage attitude at a climb rate of approximately 450 feet per minute at the initiation of the stall vibrations. The entry towards this stall was begun at 6000 feet and vibrations begun at 7000 feet. According to the NASA TN 1032, at the same weight, the take-off speed (rotation speed) for short take-off in this configuration would be 48.3 MPH, a figure which would be conservative for take-off at sea level and with take-off power at 37" manifold pressure. In this type of take-off a very considerable proportion of the total lift would be generated by the flap portion of the wing, which is approximately 50% of the wing area and which is almost completely inmersed in the slipstream; the take-off would be accomplished by rotating the aircraft near to its stall angle at approximately 49 MPH. This rotation would be limited by the maximum ground attitude of a conventional Beech 18 to approximately 12°.

Short take-offs with moderate rotation of the order of 6° and 8° at speeds of the order of 50 MPH have yielded ground rolls of the order of 450 feet without wind. Aircraft climb out was rapid; the aircraft did not feel in any way forced; control was very satisfactory. Lateral control was good because the aileron portion of the wing can operate at relatively low effective angles of attack since the slipstream lift is large.

Take-offs in which wheel lift-off occurred with approximate horizontal fuselage altitude and without aircraft rotation occurred at approximately 58 MPH with approximately 630 feet of groundroll with 3 knot wind at 30°.

Take-off tests were made at approximately 7650 lbs, that is 200 lbs. below maximum landing weight. Flight at gross weight was avoided due to structural condition of test aircraft.

On the basis of 1-G stall speed determined on take-off con-

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figuration, but with only 22" manifold on tests made by Commander Thorndike at 2500 feet of altitude, there is indicated below a rotation speed for short take-off according to the criteria of NASA DTN 1032.

AIRCRAFT WEIGHT	STALL SPEED AT APPROX. 22" MANIFOLD 2000 RPM AND 2500' ALTITUDE	ROTATION SPEED FOR TAKE-OFFS ACCORDING TO TND 1032
C-45 aircraft at 7637 lbs. (test data)	40 MPH	46 MPH
C-45 aircraft at 8800 lbs. (calculated)	43 MPH	49.5 MPH
Beech 18 at 9500 lbs. (calculated)	44.5 MPH	51.2 MPH

13. Technique for short landings and short landing tests

The short landing technique utilizes engine horsepower to develop slipstream lift; according to NASA TN-D 1032 an approach speed of 1.15 times the stall speed in the landing configuration can be used in approach.

In order to determine the optimum flap position for landing, several exploratory approaches and landings were made with a flap in various positions intermediate between the take-off and the fully closed position. From these exploratory tests, the pilot concluded that the flap deflection that gave the best handling characteristics during approach and landing was 90° flap. This position also gives the steepest approach, minimum field length over an obstacle, minimum ground roll, best directional control if there is a failure of one engine, improved visibility, and reserve altitude during approach for go-around.

The recommended landing configuration selected from these tests is 90° flaps, gear down and with an appropriate power setting depending on the type of approach and flare-out desired. Before discussing these matters further it is well to review the flare-out techniques investigated with the new flap. While these were investigated and are reviewed one independent from the others, it is not implied at the moment that any one technique is recommended. These techniques were tested at altitude of about 5000 feet; then are reviewed separately solely for engineering information.

One method tested utilizes an addition of power to produce a flare-out at fixed aircraft angle of attack and fixed flap deflection. Tests were made at 61 MPH steady speed, in which a uniform sinking rate of 500 FPM with 20" manifold pressure and 2000 RPM can be flared-out by increasing power setting to 30 inches manifold pressure to a new sink rate of 50 FPM.

Another method of flare out utilizes variations of lift-drag ratio by motion of the flap only. There was determined that a sinking rate of 500 FPM existing at 61 MPH flight speed with 90° flaps with 20 inches manifold pressure and 2000 RPM, can be flared-out at constant power setting and fixed an-

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gle of attack of the aircraft by moving the flap to its take-off position; the resulting sinking rate is 50 FPM. This type of flare out is due only to the increase of speed for a fixed angle of attack and power setting and is therefore not desirable for short landings. This method nevertheless illustrates a possibility of increasing the safety margin in an approach in which the pilot is falling short of the landing field and at the same time has an engine failure: by moving back the flap from 90° to take-off position he can increase his lift-drag ratio without running the risk of a stall; it is not believed that it would be necessary to utilize in such a case the full power of the remaining engine. The time of extension from 90° flaps to take-off flaps is approximately less than 2 seconds.

A third method of flare-out from a steep approach uses a constant low power setting, high pitch of the propeller, fixed 90° flap, and approach speeds of about 65 MPH with a sinking rate of about 500 FPM. The aircraft can be flared-out easily by increasing the wing's angle of attack with elevator motion, without changing power setting or flap deflection.

The types of flare-outs reviewed above are not to be thought as a rigid criteria for optimum short landings. Rather they are engineering comments of exploratory methods for one particular aircraft-flap combination. The actual technique used by the pilot must take into account obstacles, wind conditions, field length, altitude, and other factors. It is felt from the tests done that best short landings results could be obtained using fixed 90° flap and angle of attack increment for flare-out with power setting related to approach angle and abruptness of flare out.

We have discussed the criteria for short landings and reviewed some flare-out techniques. In the landing configuration, that is gear down, 90° flap and some power, there has been measured a stall speed of 40 MPH at 2000 RPM and 32 inches of manifold pressure at 2500 feet altitude; at the initiation of stall vibrations there was a sinking rate of 200 FPM. According to the criteria of NASA TN-D 1032 an approach speed of 46 MPH could be considered using 22 inches of manifold pressure in the approach, corrected to take into account altitude. As a reserve for flare-out power could be increased considerably; as a reserve for go-arounds power can be increased and flap can be moved to its take-off position without risk of stalling.

Due to the relatively short time during which the aircraft was available for test purposes, as well as due to the poor condition of the aircraft, the steep approach capability has not been fully explored in flight. The usual approach speeds used were between 60 and 70 MPH. With an approach speed of 68 MPH and 90° flap setting with low power, ground rolls of approximately 630 feet were measured at 95% of maximum gross weight of 7850 lbs. Due to poor wheel brakes it is considered the ground roll can be improved; good brakes on a tricycle gear should produce extraordinarily short rolls of the order of 450 feet.

14. Determination of turning radius

One important characteristic of a short take-off and landing

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aircraft is its low-speed turning radius, since this determines the capability of the aircraft to use fields of difficult access.

To obtain minimum turning radius it is advantageous to fly the aircraft in a high-lift low-drag configuration. The test aircraft was therefore flown with no flaps, and with take-off flap, at the same percent of speed above the power-off stall speed for the configuration in question and with a 30° bank in both cases.

The reduction of turning radius under these conditions was 1120 feet, which is 40% of the turning radius of the aircraft with no flaps. The reduction of turning diameter is therefore 2240 feet.

No attempt was made to measure the minimum turning radius of the aircraft in slow speed flight. It should be considerably lower if flown over 35° bank, at slower speed and with more power.

15. <u>Tests to determine minimum control speed in single engine flight</u>

By minimum control speed in this report it is understood the minimum speed at which the aircraft, flown with maximum continuous power on the left engine, and with an idle right engine with its propeller not feathered, can be flown with adequate control in pitch, roll, and yaw.

Comparative tests were made at 5000 feet altitude. With flaps retracted the aircraft showed impending loss of directional control at 88 MPH at which speed there was also a tendency to drop the right wing as well as the presence of stall vibrations. A strong pressure was required on the left pedal in this test.

With the flap in take-off position, at 58 MPH there first appeared the initiation of stall vibrations together with impending loss of directional control and a drop in he right wing. The pressure on the left pedal was greatly decreased.

With the landing flap position of 90° it was possible to fly the aircraft down to 52 MPH with a tendency to drop the right wing which was controllable; directional control was satisfactory with little pressure on the left pedal; no indications of stalls were detected.

It should be noted that the enormous gain in minimum control speed has been obtained without adding tail surfaces. This is because a large portion of the asymmetric power is absorbed by the flaps and cancelled out efficiently by the ailerons, with only a small remaining portion of asymmetrical power being left over to be cancelled by the rudders. Part of the improvement on the pedal forces originates in the lower critical speeds. These excellent results permit to fly the aircraft as an efficient short take-off and landing vehicle at speeds above minimum control speed, a most unusual and advantageous feature for a twin engine aircraft of any type.

FLIGHT T TS RESULTS OF INVER. G FLA. O. U.S.
PATENT 3,126,173 INSTALLED ON A TWIN BEECH

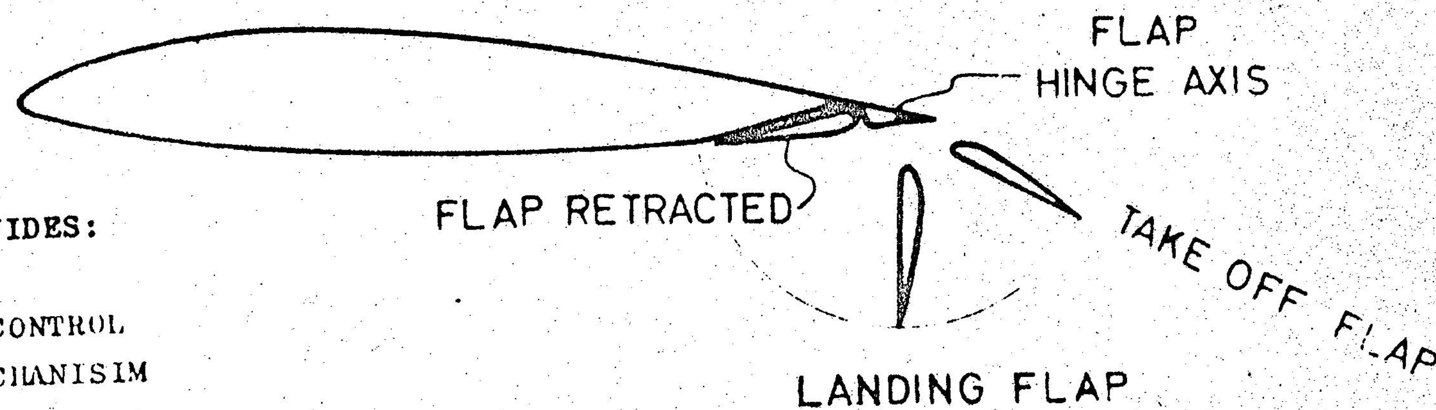
..OTE: Most deflected flap data expressed in % of flaps-up data; most test data taken within 5% of maximum landing weight

	STALLS			GROUND ROLLS		SINGLE ENGINE DATA		STALL MANEUVERS	
Inverting Flap Position	Stall Speed Idle Power Gear Down MPH @ LBS	Airplane max lift coefficient idle power gear down	Stall speeds partial power gear down MPH @ LBS	Ground roll take off and landing.	Remarks	Vmc MPH	Remarks at Vmc.	Rate decent in steep approach gear down idle power	Turning radius at 1.3 Vstall 30° bank
Flaps up	100% 75 @ 7650 83 @ 9500	100% 1.3	100% 60 @ 7650 67 @ 9500	——	——	100% 88	critical in yaw; stalls	100% at 90 MPH	100%
Take off Flaps 30°	80% 60 @ 7650 67 @ 9500	151% 1.9	66.6% 40 @ 7650 45 @ 9500	600 feet → 450 feet →	3 knot wind no rotation no wind 8° rotation	66% 58	Yaw under control; marginal in roll; stall vibrations	——	65%
Landing Flaps 90°	77.5% of no flap stall speed 59 @ 7650 66 @ 9500	167% 2.0	66.6% 40 @ 7650 45 @ 9500	600 feet	90° flap approach poor brakes.	59% 52	critical in roll; no stall no yaw problems	162% at 90 MPH; over 1000 FPM at under 65 MPH	——
Remarks Additional Notes:	All stalls occured with level wings and warning; lateral control retained Note: Stall speed flap down with partial power is 53.3% of stall speed flaps up idle power. All comparative data taken at same gross weight.			Very satisfactory control and visibility; approach and take-off angles excellent. Data taken within 5% of max. landing weight		Single engine test at 5000 feet; left engine max. continuous; right engine idle as prop would not unfeather.		Steady smooth decent; excellent control visibility; approach angles over 14° available.	Confortable slow speed turns.

In flight flap motion has been done with hands-off controls without objectionable or unpleasent aircraft motions. Trim changes due to flap are very mild since 90° and take-off setting have much smaller pitching moments than say those of a fowler flap in its landing position.
In flight complete flap motion has been conducted under 200 feet altitude.
Test flights show definite advantages in aborted flight regimes to continue flight with flap fully extended as this improves angle of climb, margin above Vmc, and reduces fuselage drag both in single and twin engine operation.
Maximum flap loads occur near take-off flap position and not at or near 90° deflection; flap support and linckage system is estimated to weight and cost approximately 80% less than a Fowler's

THE INVERTING FLAP

FIG. 1: TYPICAL AIRFOIL SECTION WITH INVERTING FLAP



THE INVERTING FLAP PROVIDES:

1) MORE LIFT
2) AND GREATER DRAG CONTROL
3) WITH A SIMPLER MECHANISIM
4) **OF LESS WEIGHT**
5) **AND OF LOWER COST**

THAN ANY OTHER FLAP.

AN ALVAREZ-CALDERON DEVELOPMENT

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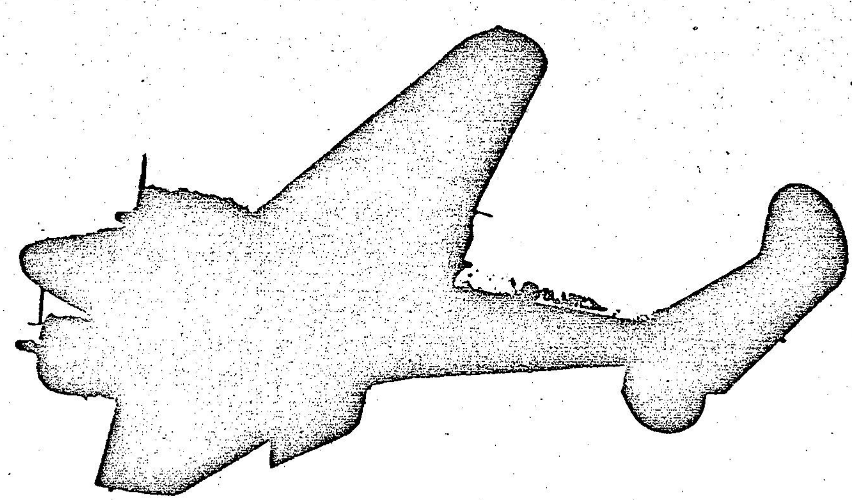
FIG 2

INVERTING FLAP PROJECT

STOL TWIN BEECH



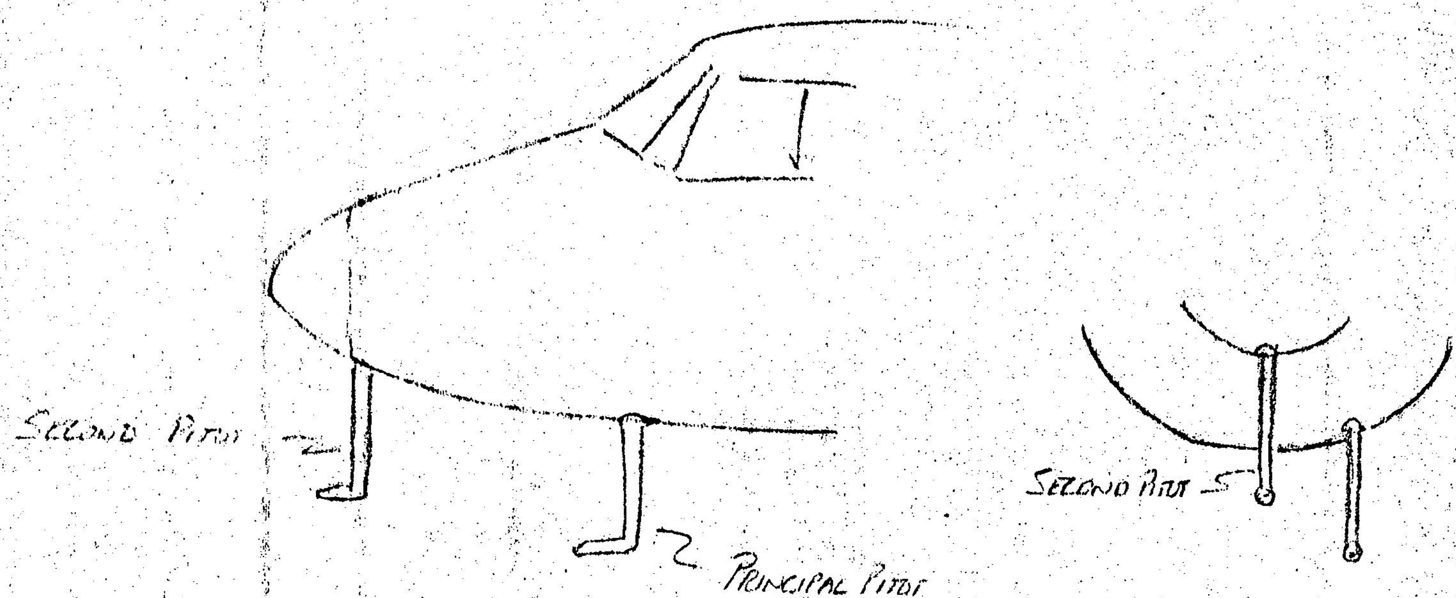
Photograph above shows Twin Beech C-45 with inverting flap in its **area-increasing** landing position: a high-lift, high-drag low-moment **flap** deflection of excellent aerodynamic characteristics.

To move the flap to its cruise position, it is rotated forwardly about a fixed hinge axis contiguous to the trailing edge of wing by about 90° to a fully retracted position in which the aircraft's characteristics are not altered.

To move the flap to its landing position, it is rotated rearwardly about its hinge axis by about 70° to an area-augmenting high lift low-drag low-moment deflection having excellent characteristics, and shown in other photographs of this report.

Test flights have shown that complete flap motion is smoothly performed. There is no undesirable aircraft motion during flap extension and retraction, and there is no buffeting at any time.

FIG 3 SKETCH OF LOCATION OF PITOTS ON TEST AIRCRAFT



EMBASSY
OF THE
UNITED STATES OF AMERICA

Lima, March 4, 1965.

Mr. Alberto Alvarez Calderón,
Avenida Salaverry 2365,
San Isidro, Lima.

Chief Advisor F.A.A. Lima-Per...

Dear Alberto:

Enclosed is a letter Harry Taber sent to me in regard to the flight we made together to observe and take pictures of the D-18 on which you had your forward-folding flap installed.

I was greatly impressed with the performance we observed from the Musketeer, and only wish we had been in an airplane with a lower stalling speed so we could have maintained our position relative to the D-18 better; I am afraid that the movies we took were not good because we could not fly slow enough.

In addition to the very low slow-flight and stalling speeds which we observed, I was impressed with the apparent stability of the D-18 when flaps were extended and retracted. I think that everyone who knows about your flap had anticipated that there would be pronounced forward pitching as the flap reached the ninety-degree position and that there might be buffeting. The only reaction of the airplane apparent to me when the flaps were extended in flight was normal ballooning of fifty to sixty feet. I would like to feel the controls when the flaps are operated, but I suppose now that you are having the installation made on a military aircraft that will be impossible.

Sincerely,

John P. Irish

Enc.- As stated

NOTE: Mr. Irish is civilian Attache in Lima's U.S. Embassy; and formerly with the FAA. He was flying the Musketeer.

March 1, 1965

Mr. John P. Irish
Civil Air Attaché
U.S. Embassy
Lima, Peru

Dear Mr. Irish:

It is the purpose of this letter to record the observations made by me on February 10, 1965 in connection with the twin-engine Beechcraft equipped with the Alvarez-Calderon flap.

Prior to flight the flap, hinged at the wing's trailing edge, was observed to operate smoothly from the faired, full-forward position to the 90° (landing) position and then to an approximate 15° (aft takeoff) position. There seemed to be complete freedom of movement during the positioning operation.

The takeoff, which did not in any way appear to have been forced, seemed extremely short for a D-18 Beechcraft; however, it must be pointed out that there was no proper comparison to be made. Our own takeoff, a short time later in a Musketeer with three normal-sized persons aboard, was observed to require a considerably greater runway length.

In flight and from our aircraft the flap extensions to various settings did not appear to cause any buffeting. There was, however, a definite "balloon" of an estimated 60 to 80 feet. The longitudinal axis was not seen to pitch abnormally during these operations.

It is judged that the landing we observed from the side of the runway was unusually short for this aircraft but, again, there was no way to make comparisons. Touchdown and roll-out were to al appearances completely normal.

Very truly yours,

ORIGINAL SIGNED BY

H. W. Taber
Chief Advisor

HARRY W. TABER
CHIEF ADVISOR
FEDERAL AVIATION AGENCY
LIMA, PERU