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FINAL DRAFT OF FANASA REPORT
COMPARING SINGLE AND DOUBLE SLOTTED
INVERTING FLAPS AND THEIR APPLICATION
TO BEECH 18 AIRCRAFT. PREPARED BY
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COMPARISON OF AERODYNAMIC CHARACTERISTICS OF DOUBLE SLOTTED AND SINGLE SLOTTED INVERTING FLAPS, AND COMMENTS ON ITS APPLICATION TO BEECH 18 AIRCRAFT

1. There is no wind tunnel test data for the inverting flaps. The characteristics of an airfoil section with inverting flap, however, can be estimated very accurately from published NACA data in which the flap configurations and deflections correspond substantially to those of the inverting flaps. This is possible because the flap and wing loads for a given flap deflection are independent of the method of displacement of the flap to that deflection. The geometries of the corresponding NACA flaps are shown in Figs 5 to 7.

2. The airfoil section geometries assumed for the comparative study of the single and double slotted inverting flaps are shown in their retracted positions in Figs. 1 and 2, respectively. The proportions of the flaps have been chosen to correspond to published NACA data as well as to actual design practice of inverting flaps. That this choice is possible is a fortunate coincidence. Comparing Figs. 1 and 2, the following is observed:

   2.1. An identical inverting wing rear spar location can be assumed for both flaps, in this case at 0.665C. For Beech 18 application, [illegible] spar location [illegible] flaps [illegible] maintained

   2.2. The geometric chord (but not effective aerodynamic flap chord) of the single slotted inverting flap, Fig. 1, is larger than that of the inverting flap of Fig. 2, excluding its vane, by 0.03C, a difference which is representative of actual design choice for an aircraft installation on a Beech 18 airplane.

   2.3. The overall chord, and the aerodynamically effective chord, of the double slotted inverting flap of Fig. 2, including the vane, is 0.07C larger than that of the single slotted flap, which is approximately representative of a design choice for an installation on a Beech 18 wing.

   2.4. The effective flap camber of the combined inverting flap and vane in the double slotted ~~flap in the~~ extended position (as is shown in Fig. 3), is much greater than that possible with a single slotted flap, or with a flap such as in Fig. 1 with an added fixed flap nose slot, since the flap of Fig. 1 when retracted must conform to the uncambered trailing edge of the basic airfoil. Therefore, the double slotted flap of Fig. 2 is much more effective for high lift development. [illegible] with larger camber, and independent of the [illegible] of the [illegible].

3. The actual geometry for the NACA test data from which the lift comparison of the inverting flaps is made are shown in Figs. 5 and 6, on which the following comments are made.

3.1. Fig. 5 shows a single slotted Fowler flap of NACA TR 664; it is seen to correspond in dimensions to the inverting flap of Fig. 1. The underlip wing fairing for the ~~inverting~~ single slotted inverting retracted flap, when the single slotted inverting flap is in its extended position as shown in Fig. 4, adds drag due to stagnation pressures in the underlip unrecovered by the low pressures in the slot at the rear of the lip. This is undesirable for take-off. The underlip may also cause accumulation of snow in take-off with a ski installation.

3.2. Fig. 6 shows a double slotted Fowler flap of NACA WR L-544; Shown in Fig 3 it is seen to correspond in dimensions and shape to the double slotted inverting flap very closely, except that in the inverting flap the wing slot lip is located at 0.94C whereas the wing slot lip in the flap of ~~TN 1071~~ WRL-544 is at 0.88C. Therefore, the inverting flap has more lift capability due to wing area than that of the flap of WRL-544 ~~TN 1071~~.

4. Comments on quantitative predictions of section lift characteristics for single and double slotted inverting flaps.

4.1. Predictions for the single slotted inverting flap of Fig. 1 sketched in based on data of NACA TR 664 of Fig. 5 should be fairly accurate for lift values, but the drag values of the Fowler flap should be lower than those of the inverting flap due to the wing underlip for the latter flap (see Fig. 4). Shown in Fig 4

4.2. Predictions for the double slotted inverting flap of Fig. 2 sketched in based on flap data of WRL-544 of Fig. 6 should be conservative in lift for flap deflections of 40° or more in that the wing of the double slotted inverting flap has an 0.06C greater chord. For small flap deflections up to 35°, the flap of WRL-544 does not have the full area increment which the inverting flap of Fig. 2 can provide, hence a correction would have to be introduced for area increment of the inverting flap. The lift increments of the NACA flap of reference, are shown in Fig. 8; specific comments on lift increment are made on section 6 / [illegible] specific to that figure, and on section 9 in relation to a Beech 18 aircraft installation. (this report)

[illegible] flaps ([illegible]) and single and double slotted

and predictions

and of single and double slotted inverting flaps a similar flap on an airfoil

5. Pitching moments and drag characteristics of double slotted inverting flap. For comparison of section pitching moment and drag characteristics of the double slotted inverting flap, WRL-544 is not useful since it has no pitching moments or drag data with flap deflected. Fortunately, NACA pitching moments and drag data for the double slotted NACA 65_3-118 is available in sufficient quantity in "Theory of Wing Sections" by V. Doenhoff and Abbot, to be of use for our purposes. These are used since they are the only ones available in appropriate geometry; this geometry is shown in Fig. 7. Its lift values were not used because of the small camber and leading edge radius of the basic airfoil--the NACA 65_3-118--limit the significance of that data, liftwise, for applications for NACA 23000 series airfoils, such as is had by the Beech 18 airfoil. Specific comments on pitching moments and drag values are made on sections 8 and 7, respectively, this report.

This data is

6. Comments on section lift increment due to a plain flap, a single slotted inverting flap, and a double slotted inverting flap, shown in Fig. 8.

   6.1. The increment of maximum lift due to plain flap deflection (at 50°) above the plain wing is 0.75. (Plain flap data from [illegible] based on NACA [illegible] data)

   6.2. The increment of maximum lift from the single slotted Fowler flap and for the single slotted inverting flap at 30° and 90°, is 0.65 above that of the plain flap. In other words, the single slotted Fowler and inverting flaps yield substantially the same gain above the plain flap as the plain flap yields above the basic wing.

   6.3 The increment of maximum lift coefficient that a double slotted conventional Fowler flap (wing lip 0.88C) can have above the single slotted inverting and Fowler flaps can be estimated conservatively at 0.65, that is substantially the same gain that the single slotted inverting and Fowler flap have above the plain flap.

   6.4 The double slotted inverting flap offers special gains over the double slotted Fowler flap as follows:

      6.4.1. For the 0° - 45°, unlike the Fowler, it offers full area increment for lift at very low drag (in this range of deflection a Fowler flap designed for 65° cannot provide full area increment).
      full area increment

      6.4.2. For the entire range of deflection, the double slotted inverting flap has a structurally feasible wing lip location further to the rear than that [illegible] possible for the Fowler.

double slotted at about 0.94C,

This curve is based on data of Fig 4 WRL 544 corrected for geometric difference

applies only in the 25°-45° range.

6.4.3. With the above considerations in mind, in Fig. 7, there has been predicted lift increment vs. flap deflection curves for the double slotted inverting flap. The first correction is that due to flap chord extension and appears as a curve based on WRL-544 corrected for the actual vane position shown in Fig. 3; the correction factor, strictly a geometric chord increment, has been estimated from Fig. 2 of NACA WRL 544 and our Fig. 3 at 1.08 for 30° and 1.05 for 40°. The resulting curve is identified as WRL-544 corrected for area change of inverting flap. A further correction factor is due to wing lip geometric difference, introduced as a 1.06 factor to account for a 6% difference of wing chord between the wing chord of Fig. 3 and that of WRL-544. The resulting curve is identified in Fig. 8 as "inverted double slotted with wing lip at 0.94C." These corrections were introduced, of course, to the original absolute values, and not to the changes shown in Fig. 8.

6.5. It is evident from Fig. 8 that it is possible to have a conventional double slotted full Fowler (like in the F-111) which, at deflections greater than 30°, can provide more lift than either a conventional single slotted full Fowler flap or a single slotted inverting flap.

6.6. It is also evident from Fig. 8 that a double slotted inverting flap can provide, albeit with a considerably much simpler and less expensive mechanism, considerably more lift increment than a double slotted full Fowler, particularly in the 20°-50° range of deflection. (and from single slotted flight data, at least as much lift with less pitching moments and lower lift-drag ratios at 90° range of deflection) In fact, the double slotted flap lift increment shown in Fig. 8 correspond very closely to the theoretical maximum, and to those of BLC flaps, at flap deflectives up to the order of 40o. This is no doubt due to the effect of full area increment together with two slot flows, related to a coefficient calculation based on the flaps-up wing chord. It is nevertheless considered that the double slotted inverting flap is the ultimate practical flap arrangement of an eminently practical design.

than?

7. Improvement in climb due to smaller drag of a double slotted inverting flap. Fig. 9, based on NACA TR 664 and on NACA tests for a 65118 airfoil, shows that generally, the section drag of the double slotted flap is half as large as that of the single slotted for flap deflections of the order of 10° to 35° and ~~lift~~ coefficients greater ~~than 1.~~

~~Fowler~~ Fowler Fig 7

Reported in "Theory of Wing Sections" of V. Doenhoff and Abb.

7.2 The double slotted flap makes the airfoil section drag with flap extended smaller the drag of the basic airfoil for lift coefficients greater than approximately 0.6; the single slotted makes the airfoil section drag with flap extended smaller than that of the basic airfoil flaps up only for lift coefficients greater than 1.2. Hence, for a flight regime of local C_L CL greater than 0.6, a double slotted flap ~~may have~~ considerable drag advantage. on the flapped portion of the wing, (assuming C_L smaller than that)

7.3 It is considered that the drag difference between the single slotted inverting flap, which has a high drag underlip on the wing, and the double slotted inverting flap, which has greater area increment and better drag shape than that of the flap on airfoil 65118 on Fig. 9, should be greater than the difference shown in Fig. 9 between the single slotted Fowler of TR 664 and the double slotted flap on NACA airfoil 65118.

[illegible]

7.4 Let us consider the effect of drag difference due to flap configuration on engine power available for climb on a Beech 18 airplane at a low speed value representative say, of single climb say with floats or with gear down, or of slow speed climb at a steep climb angle.

wing tip stalls [illegible] to avoid

From Fig. 9, it is evident that to avoid very high drag on the unflapped portion of the wing their local lift coefficient should be no greater than about 1.1.

outside the flap

If we assume an 80 MPH climb speed (realistic for a float plane in single engine with efficient flaps), the airplane lift coefficient would be, from Fig. 10, 1.55.

The added lift due to flap can be estimated from Dwinell's formula for wing lift coefficient C_{L_W} as follows

$$C_L = C_{l\ \text{win}} + \Delta C_{l\ \text{flap}} \left(\frac{S_f}{S}\right)$$

where $C_{l\ \text{wing}}$ is section lift coefficient, $\frac{S_f}{S}$ is [illegible]

After iteration we select 20° flap deflection, which from Fig. 8 gives a ΔC_l of 1.1 both single and double slotted. The accuracy of the choice is verified by substituting values in the above equation

NACA Fig.

$$C_L = 1.1 + 1.1\,(0.5) = 1.65$$

which is slightly greater than the assumed aircraft lift coefficient of 1.55 to allow for negative tail loads. The section lift coefficient that is generated by the flapped portion of the wing is then, on the average

$$1.1 + 1.1 = 2.2$$

The savings of section drag coefficient which could be made in the flapped portion of the wing, from Fig. 9, and 20° deflection, is 0.029.

ΔC_l [illegible]

The flapped portion of the wing has an area of 175 feet^2. The drag savings ΔD_a in pounds, at 80 MPH, which are realized between a double slotted and single slotted flap are then

$$\Delta D = \Delta C_d \, q \, S_{proper}$$

$$= -0.029\ (16.4)\ (175) = -83$$ pounds of drag, without taking into account added dynamic pressure due to slipstream.

The equivalent engine horsepower which could be released for climb by using a double slotted flap instead of the single engine climb is, assuming a 65% propeller efficiency,

$$\Delta HP = \frac{-83 \times 80\ (1.467)}{550 \times 0.65} = + 27.2 \text{ HP}$$

equivalent engine power available due to 2 slots, free stream pressure.

Actually, the dynamic pressure over the flap is higher due to slipstream. It can be estimated approximately as follows:

$$T \times V = \text{Thrust power}$$

$$\frac{T \times V}{550} = \text{BHP} \times \text{Efficiency of propeller}$$

$$T = \frac{450 \times 0.65}{80 \times 1.467} \times 550$$

$$T = 1250 \text{ pounds}$$

From VTOL theory, the added effective dynamic pressure is approximately equal to the disc loading. If the propeller radius is 4 feet, the disc area is:

$A = \pi R^2 = \pi\, 16 = 50.4$ feet^2 and the average disc loading $\frac{T}{A}$ is

$$\frac{T}{A} = \frac{1250}{50.4} = 25\ \frac{\text{LB}}{\text{feet}^2}$$

The added slipstream drag saving Δ Dss [illegible] due to two slots can be approximated $\Delta D_{\text{2 slots, ss.}} = -0.029\ (25)\ (175) = -127$ pounds the additional savings in horsepower is

$$\Delta HP_{ss} = \frac{-127 \times 80\ (1.467)}{550 \times 0.65} = 41.7 \text{ HP (two engines operative)}$$

additional
equivalent
engine power
available
due to 2 slots,
slipstream only

The total equivalent engine power released for climb with one engine operative would be 27.2 + 20.53 = 47.73 HP. This has a large payload equivalent. 20° deflection [illegible] for [illegible]

Due to time limitations, these calculations have not been repeated for velocities other than 80 MPH. The value of 80 MPH is considered of importance in view that the aircraft's rotation speed in take-off is below 60 MPH, its approach speed (and hence its initial [illegible] speed) is below 70 MPH, and its best climb speed single engine, with floats on (or gear down), and with area increasing flaps, is of the order of 80 - 90 MPH.

8. Pitching moments of the double slotted inverting flap.

The double slotted inverting flap has its effective flap knee somewhat upstream of the knee of the single slotted flap, as can be seen from Figs. 3 and 4. Thus up to 30° deflection in which both flaps have attached flap flows, the double slotted one should have somewhat smaller pitching moments.

For deflections greater than 30°, the double slotted flap which retains attached flows, should have greater pitching moments, flap but may

The pitching moments of the double slotted inverting flap can be estimated fairly accurately from those of an NACA 65_3118 airfoil test of a double slotted flap, of a geometry shown in Fig. 7 and the NACA tests are reported in "Theory of Wing Sections" by Abbot and Von Doenhoff and can be used provided these are corrected for the difference of location of the flap's knee. This correction factor is estimated as the ratio of the distance between the flap knee of the double slotted inverting flap to its aerodynamic axis (0.94 - 0.25); to the ratio of the flap knee to its aerodynamic axis of the flap of 65_3118 test (0.864-0.25). The ratio is $\frac{0.69}{0.614} = 1.12$.

A comparison of principal section pitching moment characteristics (not wing) follow:

It should be realized that, if [illegible]

The maximum section pitching moments of the Fowler type flap of TR 664 is -0.61 at 30° deflection and at a C_1 of 2.4.
(See Fig. 7)

The maximum section pitching moments for 45° deflection of the double slotted flap on the 65-110 airfoil is -0.65 at $C_L = 2.4$. Slightly larger values are had at larger flap deflections; at 55° it is -0.72 [illegible]

The maximum section pitching moments estimated for the double slotted inverting flap deflection (See Fig. 8) which gives as much lift increment over the single slotted inverting flap as the single slotted inverting flap gives over the plain flap ~~is,~~ also at 45° deflection, -0.65 (1.12) = -0.728.
The [illegible] deflection is, from Fig 8, 45°, and the section pitching mom[illegible]

The 45° double slotted deflection is accompanied by a stronger downwash than that of the 30° single slotted inverting flap. The increased downwash should considerably relieve the small added pitching moment ΔC_M between both flaps which the double slotted at 45° has over the single slotted at 30°.

It is estimated that for the double slotted inverting flap with 90° inverting flap and 20° vane deflection, the section pitching moments should be ~~of the order of~~ -0.35 to -0.40.
[illegible]

On the basis of test flight experience on a Beech C-45 with a fairly forward CG location (pilot, copilot, one main fuel tank full) this writer is of the opinion that a double slotted inverting flap can be used in Beech 18 aircraft satisfactorily.

9. Comparative change on a Beech 18 airplane of stall speed power off, and of relative change/ground rolls without taking into account beneficial effects of slipstream; with no flap, plain flap, single slotted inverting flap, and double slotted inverting flap.

Maximum wing lift coefficient can be estimated approximately, according to Dwinell, as

$$C_{L\max\,\text{wing}} = c_{l\max\,\text{airfoil}} + \Delta c_{l\,\text{flap}} \frac{\delta f}{x} \frac{S_f}{S} \qquad (1)$$

Definition of symbols [illegible] in Section 7 [illegible] (1)
~~where S is flapped area of wing.~~ For the Beech 18, the ratio $S_f/S = 0.5$. The usefulness of equation can be established by checking for a given flap deflection the predicted value against test flight values. Using the Fowler flap data of Fig. 8 at 17° deflection and test data of inverting flap at 17°, this is done as follows:

$$C_{L\max\,\text{wing}\;17^\circ\,\text{flap Fowler predicted}} = 1.6 + 1.1\,(0.5) = 2.15 \qquad (2)$$

, NACA

where 1.1 is ΔC_1 at 17° and 1.6 is maximum lift coefficient for the basic airfoil 23000 series at full Reynolds number. The measured maximum airplane lift coefficient for 17° inverting flap was 2.37. The difference is $\frac{0.22}{2.15} = +10.2\%$ of the predicted value. This inaccuracy can be attributed to favorable Reynolds number effect, and to favorable nacelle and fuselage lift which overcome effect of tail load, and the fact that the flap chord-wing chord ratio of Fig. 8 is more favorable than that of the test aircraft. The difference could be also attributed to error of speed indicator, or to error in pilot reading.

[illegible] effect, difference of flap chord of Fig. 1 and 2 and Beech [illegible] installation, speed error, etc; [illegible]

In order to make prediction of stalling speed for a Beech 18 significant in terms of Fig. 8 and in terms of equation (1) and of previous flight test data of Beech 18 type aircraft, an experimental constant is introduced to equation (1) as to make exact agreement of known flight data and predictions results of equation (1) with data of Fig. 8, as follows:

$$C_{L_{max}\ \text{aircraft}} = C_{L_{max}\ \text{airfoil}} + K_{exp}\ \Delta C_{1_{flap}}\ (S_f/S) \qquad (3)$$

A ~~where~~ $K_{exp} = 1.4$ and has been determined to exactly ~~yields~~ agreement of predicted and flight data, for flap deflection of 17°. Recalling that the data of $\Delta C_{1_{flap}}$ of Fig. 8 assumes an identical rear spar location for the single and double slotted flap, as shown in Figs. 1 and 2, then prediction based on Fig. 8 according to equation (3) can be made on a consistent and realistic basis. For the sake of completeness, the plain flap data is also introduced. [The following calculations are made; power off, using identical assumptions on the operations and previously established flap geometrics from which Fig. 8 was derived.] [illegible] comparison of flap benefits [illegible] objective [illegible]

$$C_{L_{max}\ \text{aircraft plain flap } 50^\circ} = 1.6 + \underset{\Delta K}{\boxed{1.4}}\ (0.75)\ (0.50) = 2.125$$

$$C_{L_{max}\ \text{aircraft inverting single slotted } 30^\circ \text{ (or } 90^\circ)} = 1.6 + \boxed{1.4}\ (1.4)\ (0.50) = 2.58$$

$C_{L_{max}}$ aircraft inverting double slotted, 30° $= 1.6 + 1.4\ (1.7)\ (0.50) = 2.79$

$C_{L_{max}}$ aircraft inverting double slotted at 40° or double slotted Fowler at 48° $= 1.6 + 1.4\ (2.05)\ (0.50) = 3.04$

$C_{L_{max}}$ aircraft double slotted inverting flap at 60° or 90° $= 1.6 + 1.4\ (2.35)\ (0.50) = 3.25$

The change of stalling speed, power off, can be determined for W = 9000 from Fig. 10; the ground rolls, neglecting slipstream effect, vary with the inverse of lift coefficient. Principal data is summarized below.

Flap	$C_{L_{max}}$ aircraft	Stall speed MPH	Use of flap	Drag	$\frac{C_{L_{no\ flap}}}{C_{L_{flap}}}$	Ground roll wit flap relative to ground roll no flap without taking into account ~~benefici~~ slipstrea effect for lift
No flap	1.6	79	take-off	low	1.0	100%
17° Fowler or single slotted	2.15	68.5	take-off	low	0.745	74%
30° inverting double slotted	2.79	59.8	take-off	lower	0.572	57.2%
50° plain	2.125	69	land	high	0.75	75%

	C_L MAX. AIRCRAFT	STALL SPEED MPH	USE OF FLAP	DRAG	C_L FLAP	WITH [illegible] FLAP
3 30° Fowler; 30° or 90° inverting	2.58	62.5	land	Fowler medium high; inverting 90° very high	0.62	62%
5 40° double slotted inverting or 48° double slotted Fowler	3.04	58.5	land	medium high	0.526	52.6%
6 60° or 90° double slotted inverting	3.25	56	land	60° high 90° very high	0.492	49.2%

10. Summary and conclusions.

10.1. Lift. The double slotted inverting flap gives as much increment of wing lift coefficient above the single slotted inverting flap as the single slotted inverting flap gives above the plain flap. The section value of this increment is 0.65. {Generally, the same lift improvement in stall speed and landing distances can be obtained with the double slotted inverting flap above the single slotted inverting flap as those that were obtained with the single slotted inverting flap above the plain flap.

would depend on the stall speed in take-off flaps configuration. The [illegible]

For the case of a Beech 18 airplane calculation using a lift coefficient based on power-off section data, the take-off rotation speed is reduced from 68.5 MPH with the single slotted inverting flap to 59.8 with the double slotted inverting flap, with considerable flap form drag reduction. The corresponding reduction in ground roll in take-off is estimated as 17% of the original ground roll of the aircraft with 0° plain flap.

Forlanding, based on power off section data, the reduction of stalling speed is from 62.5 MPH with the single slotted inverting flap, to 56 MPH with the double slotted inverting flap. The corresponding reduction of ground roll is 17.3% of the original ground roll of the aircraft with 50° plain flap. For purposes of comparison the reduction of stall speed due to single slotted inverting flap compared to plain flap is from 69 MPH to 62.5 MPH.

A conventional double slotted Fowler flap design with full area increment should give more lift than either a single slotted Fowler or inverting flaps; the larger area augmentation of the double slotted inverting flap makes its lift increments and drag values considerably better than those of the double Fowler, apart from structural advantages of the inverting flap. The inverting slotted flap develops lifts increments that closely approach theoretical values for flap deflection up to 45°.

The addition of slipstream has greater benefit for the double slotted than for the single slotted flap, but this calculation is beyond the scope of this paper.

10.2. Pitching moments. No trim problems are anticipated for the double slotted inverting flap installation. Section ~~pitching moment~~ (not wing) values of double slotted inverting flap at 45° deflection is -0.728 compared to -0.61 at 30° of the single slotted inverting flap. The ~~latter has been~~ flown on a C-45 aircraft. Greater downwash of double slotted flap is expected to diminish the small difference in pitching moments as far as airplane trim is concerned. The section pitching moments for the inverting flap at 90° and the vane at 20° are estimated at -0.35.

10.3. Drag and climb. For the Beech 18 the use of a double slotted inverting flap will reduce flap drag considerably, releasing engine power for climb. This engine power release is calculated as +27.2HP effective increment without taking into account slipstream, plus an additional 20.5 HP effective increment per engine taking into account slipstream flap drag.

The lower stalling speed of the double slotted inverting flap should lower considerably the required rate of climb at 5000 feet.

Both the flap drag reduction and reduction of stalling speed can be taken advantage for increasing the aircraft's legal payload.

Conclusion

10.4. Considering the results of this study, including conclusions on lift, drag and pitching moments, it is recommended that a double slotted inverting flap installation be made on a Beech 18 aircraft for certification purposes. It is considered that either the lift benefits alone, or the drag benefits alone, which the double slotted inverting flap has over the single slotted inverting flap, are sufficient reason for its use on the Beech 18, both these benefits can be used to improve the aircraft's performance as far as single engine climb is concerned. The fact that both these lift and drag benefits can be obtained simultaneously with a simple double slotted inverting flap installation point to the great advantage of the flap design.

Two more important ~~[illegible]~~ ~~[illegible]~~ advantages of the double slotted inverting flap must be considered. One is that the ground clearance and snow-~~[illegible]~~ accumulation characteristics of the double slotted inverting flap are superior to those of the single slotted flap. The other is that the use of the double slotted ~~[illegible]~~ inverting flap would definitely discourage the possible production of any competitive double slotted conventional flaps in the future.

AM Alvarez Calderón

FANASA

APT. 5599-LIMA-PERÚ

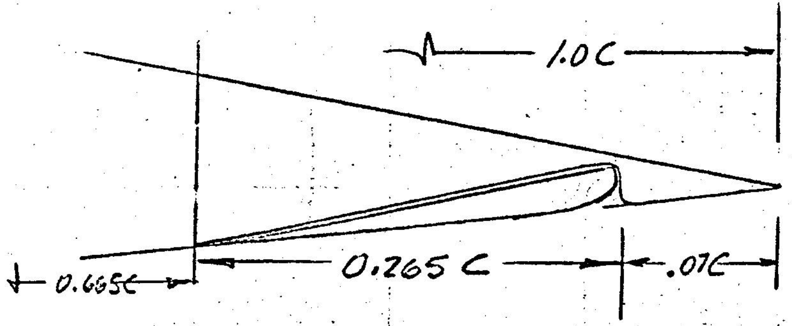

FIG 1

SINGLE SLOTTED INVERTING FLAP RETRACTED

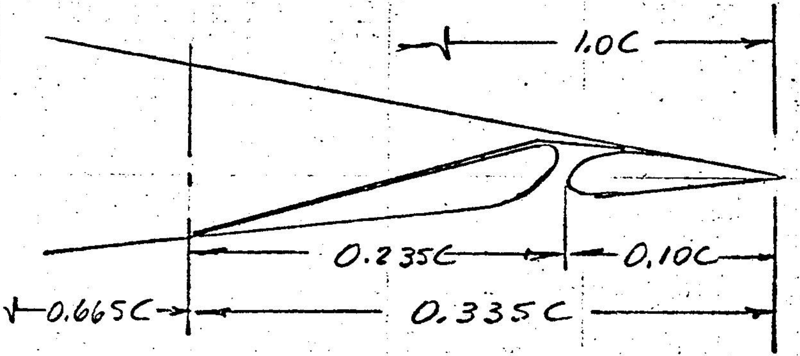

FIG 2

DOUBLE SLOTTED INVERTING FLAP RETRACTED. NOTE LARGER FLAP OVERALL CHORD FOR SAME WING AFT SPAR LOCATION AS IN FIG 1.

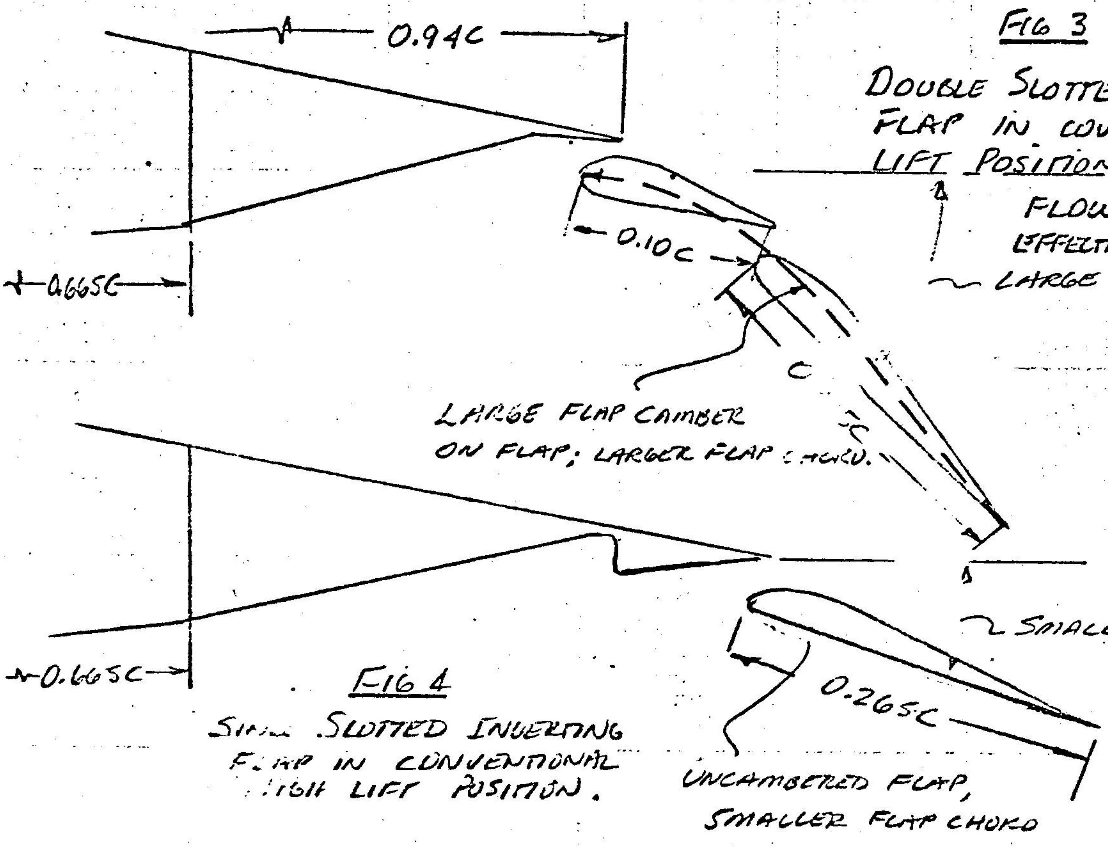

FIG 3

DOUBLE SLOTTED INVERTING FLAP IN COVENTIONAL HI
LIFT POSITION WITH ATTACHE
FLOWS: NOTE LARGE EFFECTIVE FLAP CAMBER
~ LARGE ANGLE

LARGE FLAP CAMBER ON FLAP; LARGER FLAP CHORD.

~ SMALL ANGLE

UNCAMBERED FLAP, SMALLER FLAP CHORD

FIG 4

SINGLE SLOTTED INVERTING FLAP IN CONVENTIONAL HIGH LIFT POSITION.

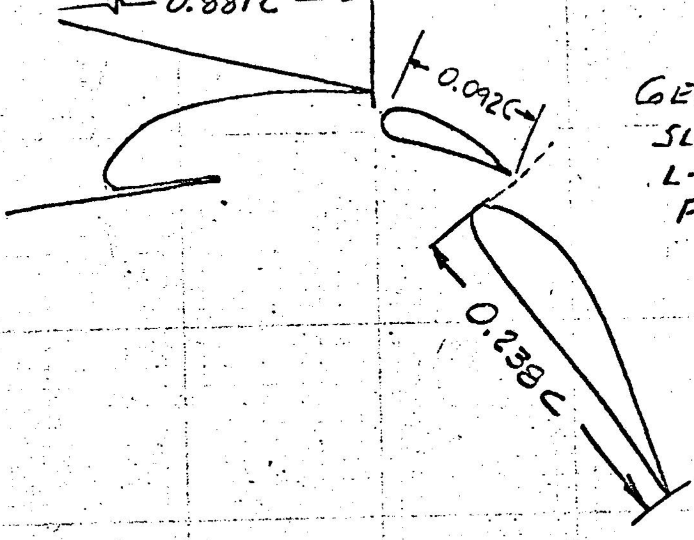

FIG 6

GEOMETRY OF DOUBLE SLOTTED "FOWLER" OF WR L-544; COMPARE TO FIG 3.
DATA ON FIG 8

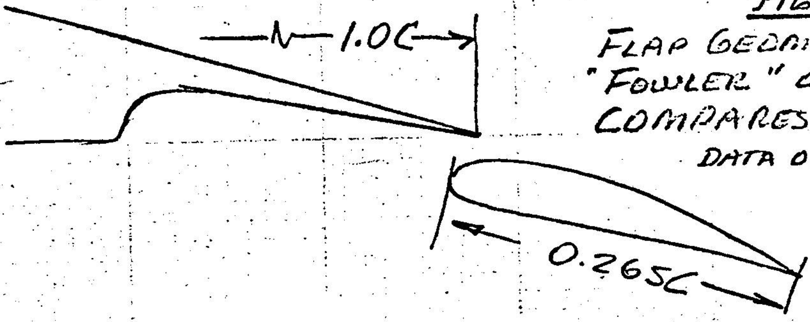

FIG 5.

FLAP GEOMETRY OF "FOWLER" OF TR 664; COMPARES TO FIG 4.
DATA ON FIG 8.

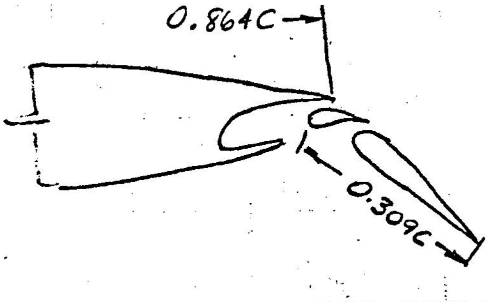

FIG 7

GEOMETRY OF DOUBLE SLOTTED PARTIAL FOWLER TESTED BY NACA ON 65 118 AIRFOIL & REPORTED ON "THEORY OF WING SECTIONS".
DATA OF FIG 8.

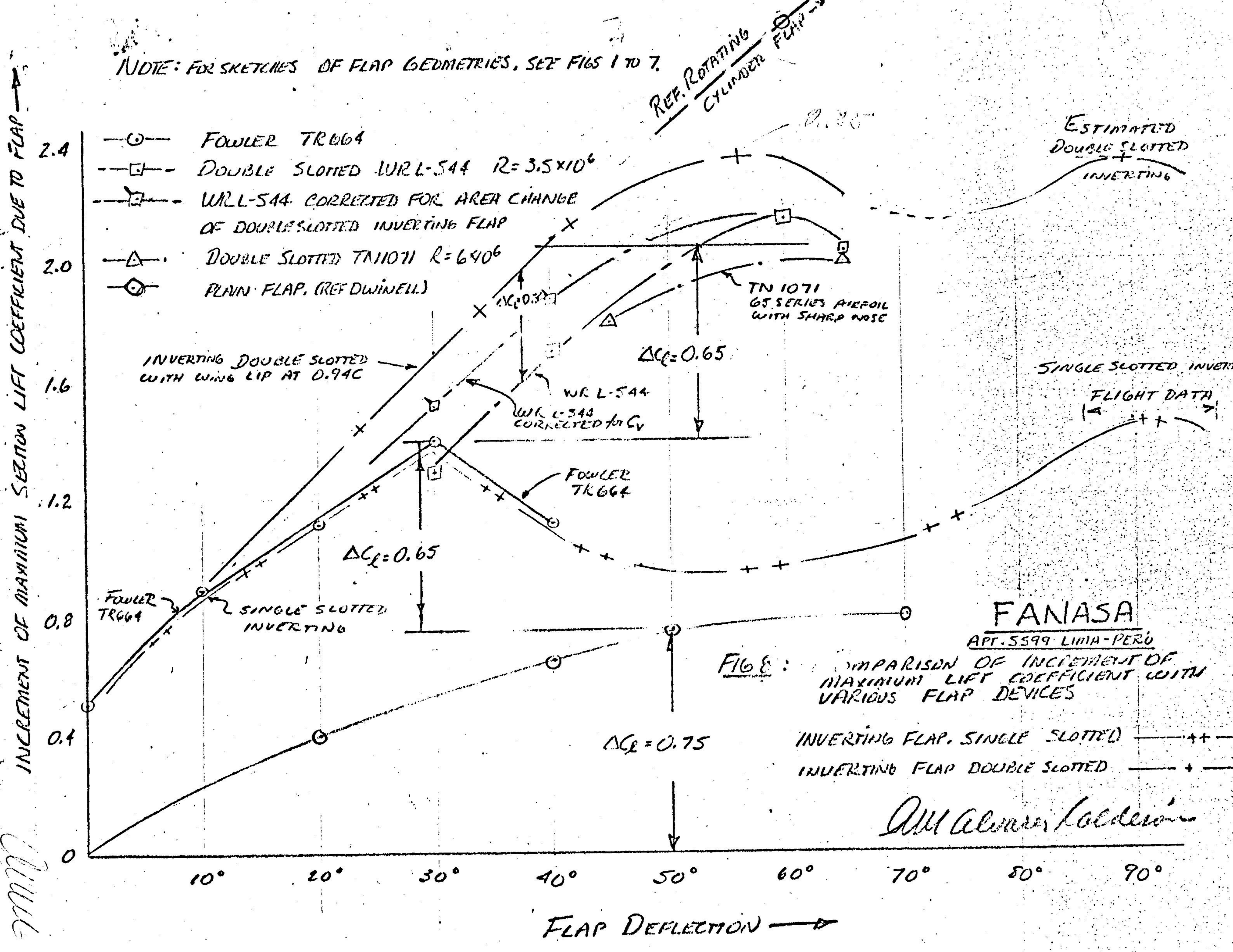

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FIG 8: COMPARISON OF INCREMENT OF MAXIMUM LIFT COEFFICIENT WITH VARIOUS FLAP DEVICES

AM Alvarez Calderón

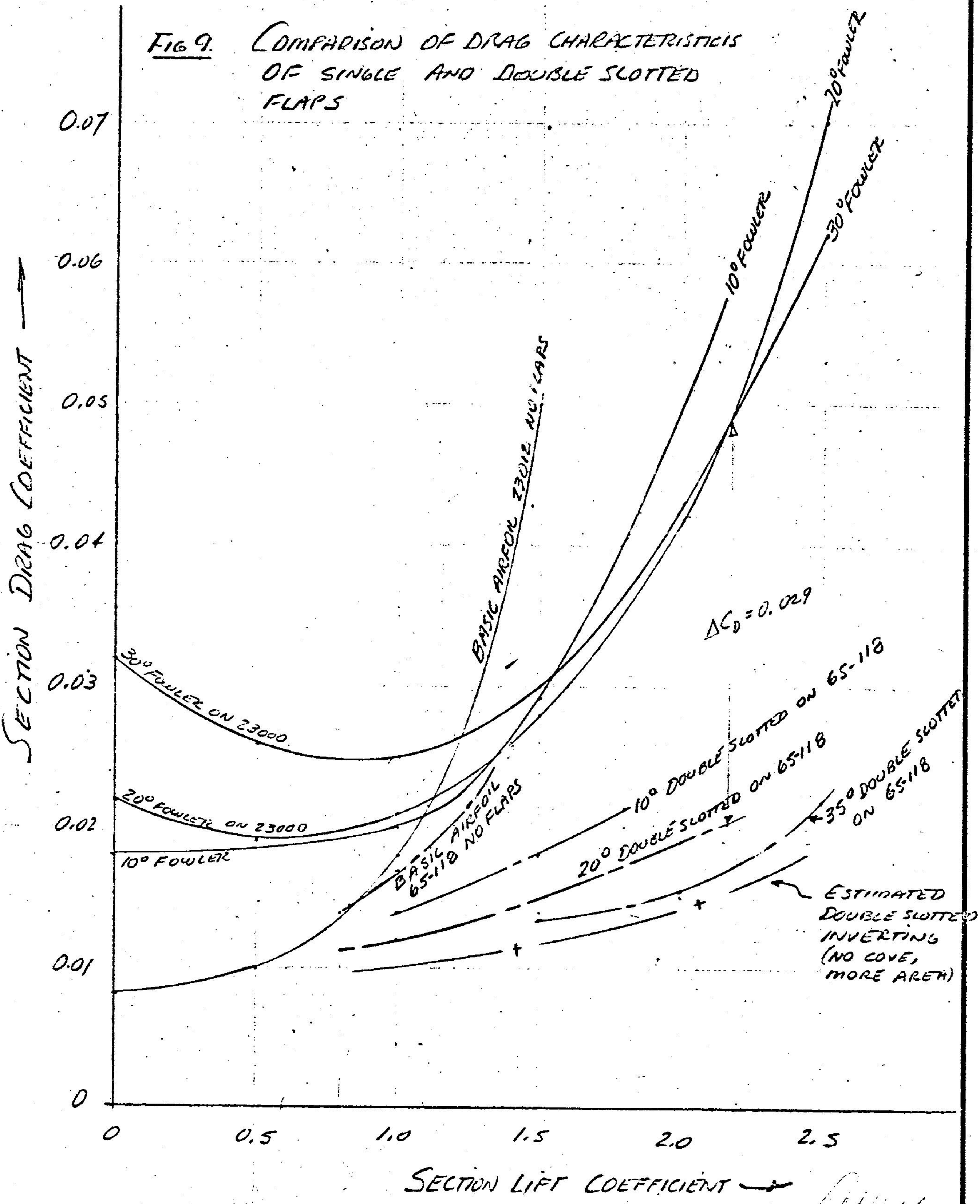

FIG 9. COMPARISON OF DRAG CHARACTERISTICS OF SINGLE AND DOUBLE SLOTTED FLAPS

A.H. Alvarez Calderón

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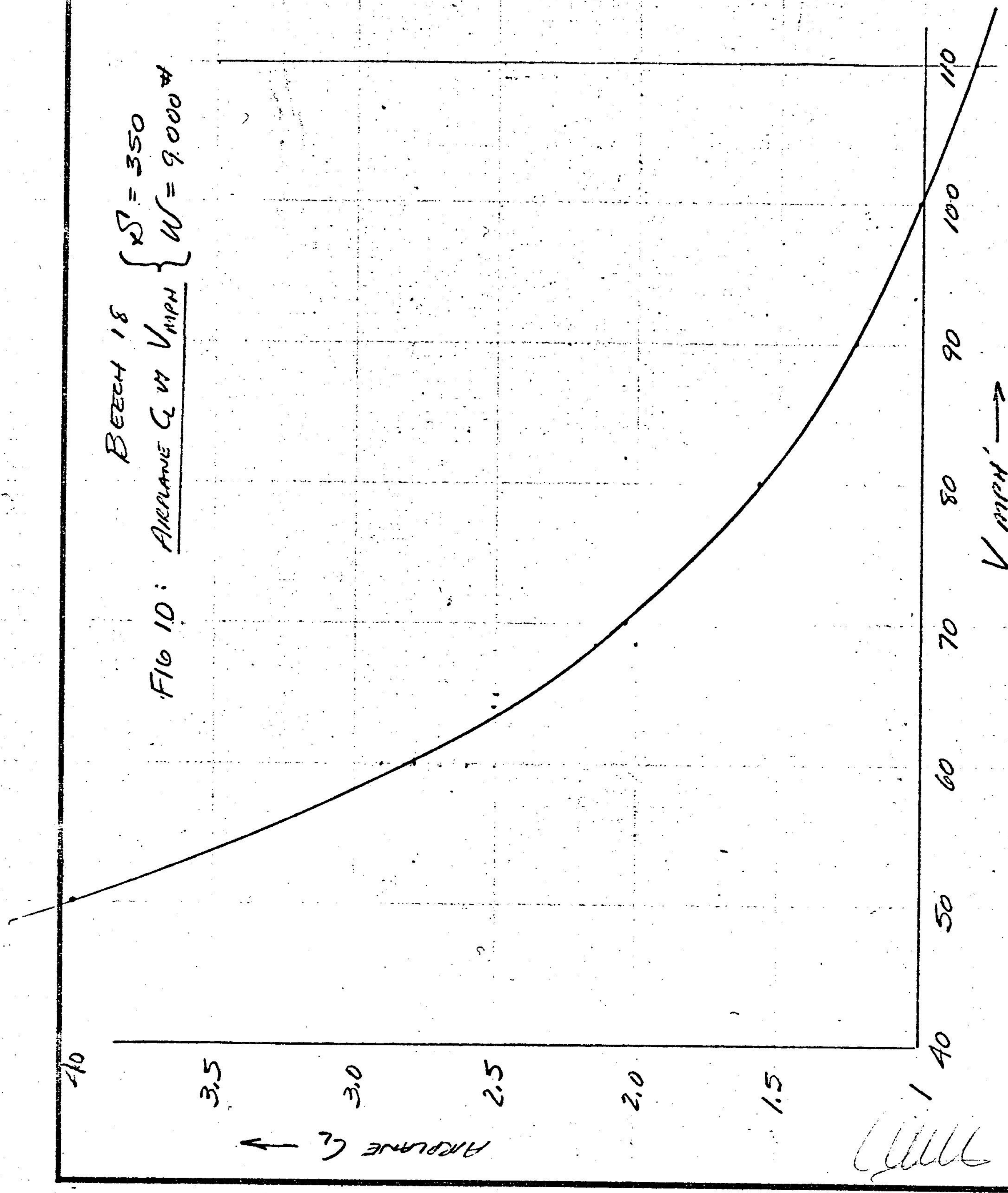

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FIG 10: AIRPLANE C_L vs V_{MPH} $\left\{ \begin{array}{l} S = 350 \\ W = 9.000\# \end{array} \right.$