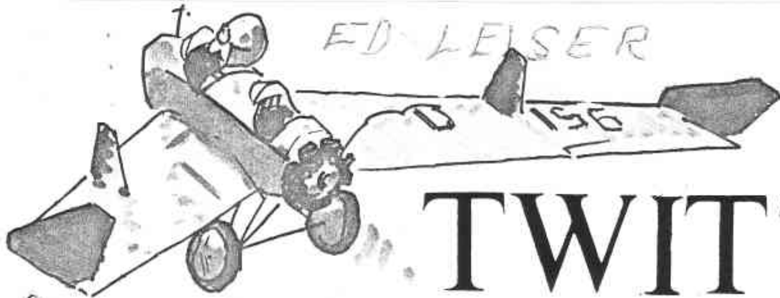

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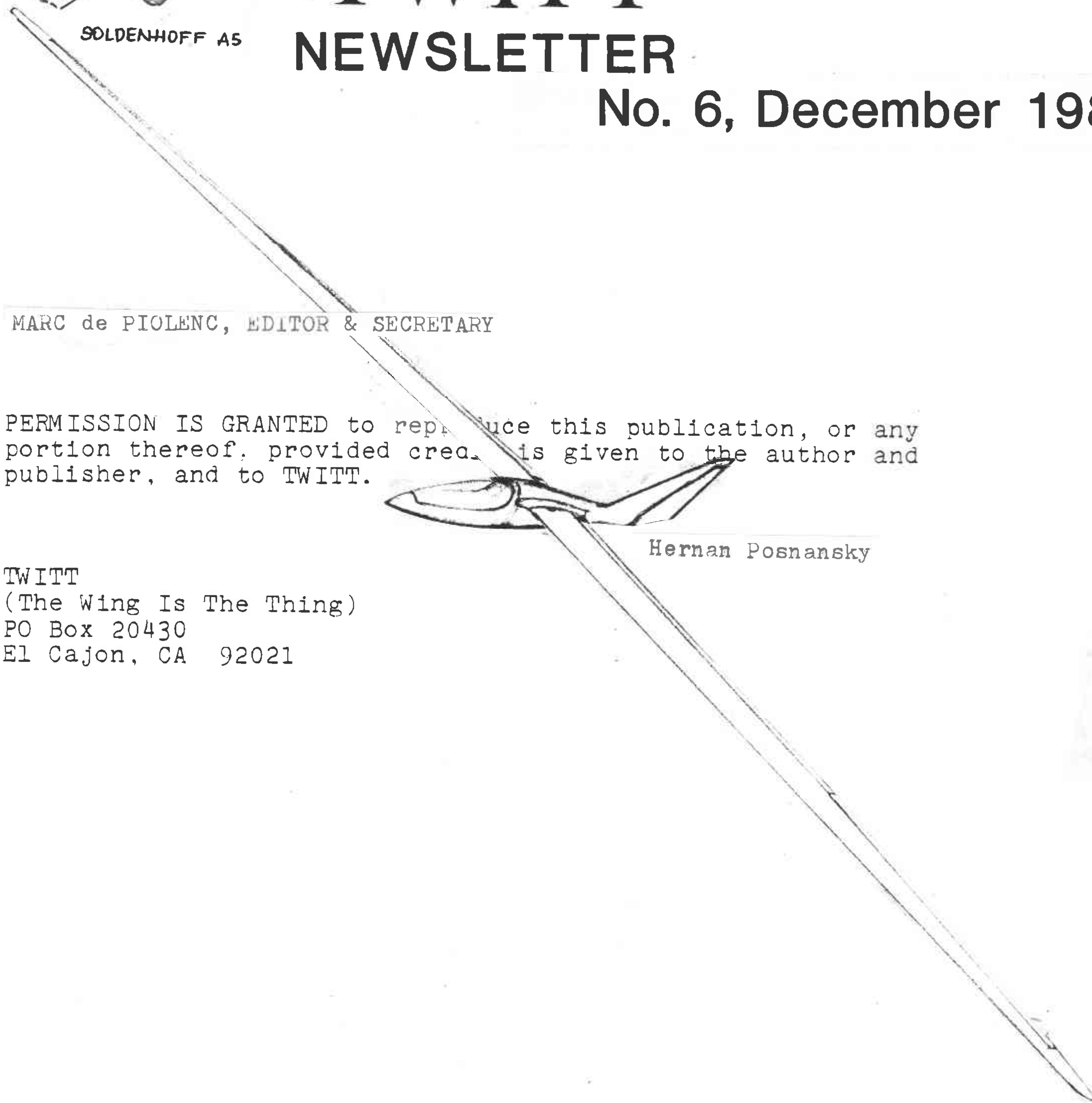
TWITT

NEWSLETTER

No. 6, December 1986



MARC de PIOLENC, EDITOR & SECRETARY

Hernan Posnansky

TWITT
(The Wing Is The Thing)
PO Box 20430
El Cajon, CA 92021

Telephone: (619) 224-1497 before 10 AM or after 10 PM

MINUTES OF NOVEMBER TWITT MEETING (From notes compiled by Bob Fronius, your Editor having missed the meeting)

Vern Oldershaw discussed the Eppler 634-636 flying-wing airfoils He brought with him drawings of airfoils generated by computer using the Davis formula Jerry Blumenthal discussed a flying wing model that he had built: it features an aft-swept wing with a straight trailing edge; the airfoil section was not reflexed Hernan Posnansky discussed our design goals. Danny Howell talked about the German SB-13 project. He has some correspondence on that project and will have a 2-page article for the next newsletter. Hernan began his talk at 2:14 His idea to optimize the performance of a flying wing sailplane is to employ variable wing sweep or weight shift to change the relative positions of the a.c and c.g. from a stable low performance configuration to an unstable but efficient one at will. In the unstable mode stability would be provided artificially by an active control system. The entire t.e. of the wing will be under the control of the pilot and/or the active control system.

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AVIATION 2000

Walter J. Boyne, retired Air Force colonel, has predicted that advances in computer technology and aircraft design could make it possible for flying to become a recreational sport on the scale of sailing and skiing in popularity. Light airplanes will have automatic stability built in through microchip auto-pilots and will be built of materials that are strong for their weight and suited to the speed that the airplane will be flying.

MINUTES OF TWITT SPECIAL MEETING 6 DECEMBER 1986

A special meeting of TWITT convened on the 6th of December 1986 at the home of Bruce Carmichael in Capistrano Beach CA. The purpose of the meeting was to settle on a basic design concept for the TWITT Wing and to determine its configuration. Present were:

Karl Sanders	John Krause	Vern Oldershaw
Bruce Carmichael	Georgie Carmichael	June Wiberg
Hernan Posnansky	Marc de Piolenc	Bob Fronius
Philip Burgers		

Bob Fronius opened the meeting by summarizing TWITT s purpose and the performance goals for the Wing: L/D of 40, minimum sink 1.1 m/s. Bob noted that 40 was moderate and could be achieved at reasonable cost, while each additional point of L/D cost one thousand dollars retail! Hernan then took the floor and summarized his thinking. He asked rhetorically what constraints on a flying wing could be dropped to eliminate the wing's span- and chord-wise efficiency disadvantage vis-a-vis the conventional type, to improve turning performance and to allow camber adjustments for different flight regimes. Answer: static stability in pitch. The airplane would be made flyable by an active control system. Karl Sanders said that he favored the fly-by-wire idea because the type of camber needed to stabilize a flying wing is the wrong kind for performance. Bruce Carmichael mentioned that he had flown a sailplane which was unstable in pitch; the ship kept him busy but was still manageable provided he kept his eyes on the horizon. An unstable high speed machine would be far more dangerous. Hernan said that an unstable machine must have a statically-stable mode of flight for takeoff and landing and to provide for failure of the active control system or actuators. Some possible ways to switch from one mode of flight to another include weight shift (using an inert mass or the pilot), wing sweep and wing translation. The configuration proposed by Hernan is slightly swept forward in the unstable mode and uses variable wing sweep to change modes. The wing trailing edge is hinged over the full span and has servo-tab assisted camber flaps in the center, ailerons outboard. Only a moderate sweep range (5-10 deg.) is practical; anything more requires a special twist distribution for each sweep angle. Vertical surfaces are needed for yaw damping and some active damping in yaw might be desirable. An argument for forward sweep is that it "cleans up" the forward fuselage (where laminar flow is possible) and improves the pilot's visibility. Vertical fins on an aft-swept machine increase wingtip mass, which could cause flutter problems. Consideration of ground angle also favors a straight or swept forward configuration. The fly-by-wire system consists essentially of a sensor, the control logic and a control servo. Hernan proposes a rate-gyro and an accelerometer for sensing; the rate info would be integrated to get attitude. An electrostatic sensor (Maynard Hill type) is also a possibility. A fluidic sensor alone would not be sufficient because it provides only rate information; an absolute attitude reference would still be needed. The servo would have to have very low inertia. If electric, it would probably need to be direct drive. Hydraulic actuators are well understood and should be considered. Marc de Piolenc suggested low-pressure pneumatic actuators like those designed by Doug Garner for his fluidic wing-leveler. Hernan did not rule those out. Karl Sanders commented that the idea of a translating wing had merit. He believed that NASA had patented just such a scheme and that a report in the TM-X-series existed on the concept. Rockwell had proposed such a wing in the sixties for an eighties-era fighter plane. The Bell X-5 had a wing which translated and swept. John Krause commented that anything that costs additional weight must be justified in terms of improved aerodynamic efficiency. Phil Burgers proposed the use of a large area-increasing flap to change the wing a.c. and make the transition from stable to unstable modes. Karl Sanders mentioned that wing mass is proportional to aspect ratio, all other parameters being equal. Hernan explained that TWITTs were constrained by money and time. He suggested that the Diamant 18 wing be used as the plug from which a female mold could be made by Harald Buettner in two to three weeks. The result would be a very accurate outer contour at a reasonable cost. We could add passive wingtip extensions to increase span at minimum additional cost. The wing would be tried on the White Knight first. Carbon fiber would be used for the spar caps and D-tube for stiffness. The center section and hinge fittings, if any, would be made of steel. Phil Burgers proposed moving the wing pivots 2-3 feet outboard, where the bending moments would be much less. Hernan liked this idea. Vern Oldershaw mentioned Paul McCready's development model for the scale pterodactyl. Should we invite him to a meeting? Someone suggested we move the meeting place to Pasadena to make it easier for Dr. McCready to accept. Marc suggested the home of a friend very near Caltech. Bruce suggested we try to get a meeting room at Caltech. Hernan said we need to evaluate the amount of pitch authority that the control system retains after active stabilization requirements are met. Vern said that his model (which, though statically stable, is geometrically similar to the machine proposed by Hernan) has excellent control authority in pitch. Bruce asked whether active controls would help an otherwise conventional sailplane. Hernan said that they would. Karl noted that a small shift in wing position has a large effect; the effect of the wing's own mass is "third order." Dr. John Lamar, NASA Langley, has an IBM PC version of the 3-D vortex-lattice program which he wrote in the Sixties for NASA. The current version requires the PC-AT with Supercalc and uses the Supercalc file structure. Julian Wolkowich and John Roncz have copies of this program. Boeing has a true 3-D program too, but it runs on a Cyber. Bruce Carmichael asked how much money the Wing was expected to cost. Bob gave the figure of twenty thousand dollars for the entire project. A break ensued. After the break, Hernan said that construction of the female molds would begin soon. The next step would be a test of the proposed control system on a flying scale model, followed by tests of the full-scale wing on the White Knight fuselage. Bob mentioned that Peter Selinger, co-author with Reimar Horten of the book <u>Nurfluegel</u>, is now TWITT's european correspondent. Phil Burgers has written him a letter asking for details of the various Akaflieg groups' flying-wing projects. He added that next month's TWITT meeting will take place on 15 January. In the meantime two newsletters will appear: one covering this meeting and one announcing the agenda, speaker etc. for the next one. Bruce Carmichael suggested that all TWITTs present consider simple configurations embodying the philosophy exposed at the meeting and bring their thoughts to the next meeting. He noted in passing that for a weight-shift scheme to work, the empty weight of the glider must be quite low. If this can be achieved, a fixed wing might be practical. Bob Fronius mentioned the rather odd "flying wing" project of one Scott Jenkins. Mr. Jenkins' machine, which embodies the ideas of Stratford and Kasper, is towed along the bottom of a silted-up body of water. The vortices it generates stir up the silt so the current can carry it off. This is one tailless idea that might bring in some money! At this point your editor got writer's cramp and stopped taking notes.

San Diego,12 November 1986.

Dear Peter:

We were delighted to receive your letter and more so to have learned of your interest in our activities.I will tell you what our objectives are but first let me tell you the following:I was born in Argentina and was very lucky to know Doctor Horten.I have visited him several times in Cordoba,and did learn a lot talking with him.A year and a half ago I came to the United States and met Bob Fronius,a very active man,interested and very experienced in everything that flies.He has founded this group called TWITT,(as you probably know,americans love acronyms,and this stands for "The Wing Is The Thing".)

The objective of the group is to study the feasibility and design of a high performance flying wing.The meeting are held once a month at Bob's hangar to listen to some talks about all aspects of design,construction and performance.The people that are actively participating and giving lectures are personalities like Irv Culver (aerodynamicist,worked at Lockheed "Skunk-Works",right hand of known designer "Kelly" Johnson),Bruce Carmichael (aerodynamicist,well known for his works with laminar flow).

Attached to this letter we send you the newsletters that we have published so far.At the next meeting we will be proud to tell our friends that the TWITT group has a new distinguished member:...YOU...

continued on page 12

ACTIVE STABILIZATION OF TAILLESS SAILPLANES-PART I

by HERNAN POSNANSKY

Active stabilization of a tailless sailplane allows noticeable performance increases aver basically stable tailless gliders with capabilities approaching, and even surpassing conventional sailplanes.
Active stabilization separates the the problem of providing adequate control and stability from the problem of optimizing performance. It does require control of the location of the center of gravity with respect to the aerodynamic center however.

1- CONVENTIONAL STABILIZATION

A conventional sailplane is stable in pitch if the aerodynamic center (AC) is behind the center of gravity (CG). High performance unswept wings have airfoil sections with substancial positive camber, this shifts the center of lift (CL: position of zero pitch moment) of the wing even farther behind the AC (remember AC: position of constant pitch moment with changing angle of attack). This requires a significant trimmed down force on the tailplane (See figure 1).

Two mechanisms are required for pitch stability: pitch stiffness and pitch damping.
Stiffness provides a restoring moment when the angle of attack has been perturbed from the trimmed angle of attack (static stability).
Damping provides a braking pitch moment when the aircraft rotates in pitch (dynamic stability).
Absence of static stability results in divergence of the pitch attitude from the trimmed attitude with a pitch rate determined by the damping characteristics.
Absence of damping results in an undamped pitch oscillation with a period ("short" period) determined by the pitch moment of inertia and the pitch stiffness.
Actually there is a second mechanism produced by the interaction of the flight path angle, the angle of attack and the flight speed that can cause an unstable flight path divergence or flight path oscillation (phugoid with a "long" period) even though the aircraft is stable in pitch,(active stabilization effectively stabilizes both).
Stability of a conventional sailplane is provided by the tail mounted way behind the wing. The static restoring moment is produced by the changed tailforce due to a change in tail angle of attack opposing the perturbation. The damping restoring moment is produced mainly by the resultant angle of attack of the tail as it moves up or down (see figure 1).

A large tail arm provides very effective damping.
In a tailless glider with no sweep this mechanism of pitch damping is not present. Weak damping is provided by the damping characteristics of the wing itself which is dependent on the wing chord. A high aspect ratio tailless sailplane does not have adequate damping unless it is swept, (Horten IV and VI).

2- What affects performance

High performance sailplanes derive their performance from their large span and from the variable geometry provided by the full span cruise flaps.
The best glide ratio or L/D value is given by the following expressions:

$$\frac{L}{D} = \frac{b}{2}\sqrt{\frac{\pi/(1+\delta)}{(C_D A)_{WING} + (C_D A)_{REST}}} = \frac{1}{2}\sqrt{\frac{\pi/(1+\delta)}{C_D\left(\frac{A}{b^2}\right) + \frac{(C_D A)_{REST}}{b^2}}}$$

or

$$\frac{L}{D} = \frac{\sqrt{b}}{2}\sqrt{\frac{\pi/(1+\delta)}{C_D \bar{c} + \frac{(C_D A)_{REST}}{b}}}$$

The dominant term is the wingspan (b). The wing area A, wing drag coefficient C_D and the drag area af the rest $C_D A$ (fuselage, control surfaces, interference, etc) are of secondary importance as is the term describing the deviation from elliptic distribution ( ). Practical span flaps result in excessive values of wich result in excessive penalty for the minimum sink condition. There the sink speed is:

$$V_{sink\ min} = 0.744(1+\delta)^{3/4}\sqrt{\frac{2L}{\rho}}\ \frac{1}{b^{3/2}}\left[(C_D A)_{wing} + (C_D A)_{REST}\right]^{1/4}$$

Typical values for a good advanced design are:

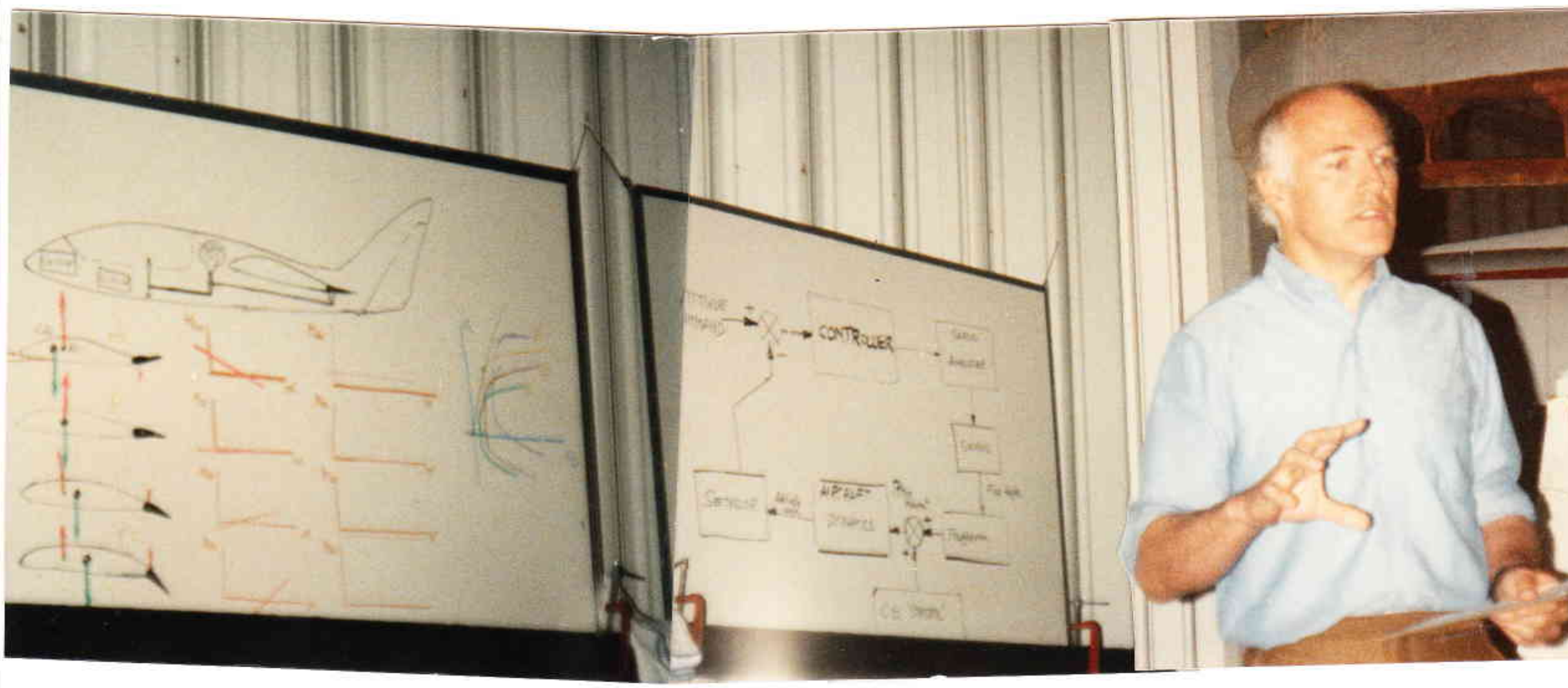
$$b = 15\ m = 49.2\ ft$$
$$A = 6.45\ m^2 = 69.4\ ft^2$$
$$\left.\right\}\ AR = \frac{b^2}{A} \approx 35$$
$$\bar{c} = 0.43\ m = 1.41\ ft$$
$$C_{D_W} = 0.009 \text{ at } Re = 10^6 \text{ and } C_L = 1.2.$$
$$(C_D A)_{REST} = 0.0392\ ;\ (C_D A)_{WING} = 0.0581$$
$$\delta = 0.03$$
$$L/D = 42$$

In a high aspect ratio configuration, the best L/D value es achieved at zero flap angle (=0). The optimum L/D is achieved when the induced drag equals the parasite drag. For minimum sink the lift coefficient must be higher, at the condition where the induced drag is three times the parasite drag. This requires the use of full span flaps to avoid stall as shown in Figure 2. For penetration at low lift coefficients negative flaps angles are to be used.

3- GENERAL DESIGN CONSIDERATIONS FOR A HIGH PERFORMANCE TAILLESS SAILPLANE

The foregoing discussion was presented in order to develop the fundamentals to justify the need for an active stabilization for a high performance tailless configuration: The sailplane must have a large span to achieve high performance (L/D, Vsink). The wing must have almost full span cruise flaps to achieve low sink speeds and high penetration speeds.
Large span does not allow large sweep angles due to CG positions constraints.
Small sweep angles do not have adequate damping characteristics. This and the need for cruise flaps make it necessary to use an active stabilization system if one wants to achieve high performance in a wide speed range.
The actively stabilized sailplane would have moderately foward swept high aspect ratio wings with almost full span flaps, the outer panels are used also as ailerons, (flaperons).

It would require a mechanism to provide variable sweep and/or a CG shift mechanism.
Figure 4 presents a typical configuration.
The control pitching moments are produced by flap deflections. The flap chord must be selected to provide, in conjunction with the available deflection angles, sufficient moments to overcome external pitch perturbations. Figure 3 presents typical flapped section characteristics.
During take-off and landing the wing should be swept back or weight would be translated foward to obtain a basically stable configuration that could be flown manually without assistance, there the required flap angle would be around 14 degrees up. Adequate lift coefficients are still available for acceptable approach and landing speeds.
The stabilization system would consist of an altitude sensor, an electronic analog or digital processor and servo amplifier, a servo for flap actuation and a servo for trimtab control (Figure 5).
The operation and implementation of the stabilization control system will be discussed in part II



NORTHROP FLYING WING CONTEST
The 20th annual meet at Mile Square Park was attended by [among others] Al Faulkner of San Diego. Al placed first in towline with a Jasco sailwing designed by Frank Zaic. Al also placed third in rubber with his own design.

The Elements of Tailless Airplane Design, by Al Backstrom, will appear in a future issue.

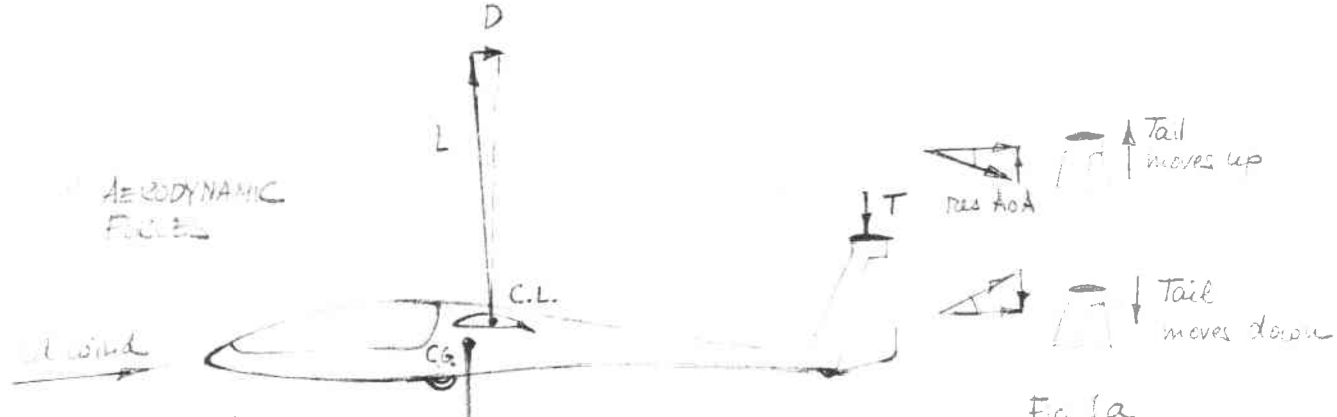


Figure 1

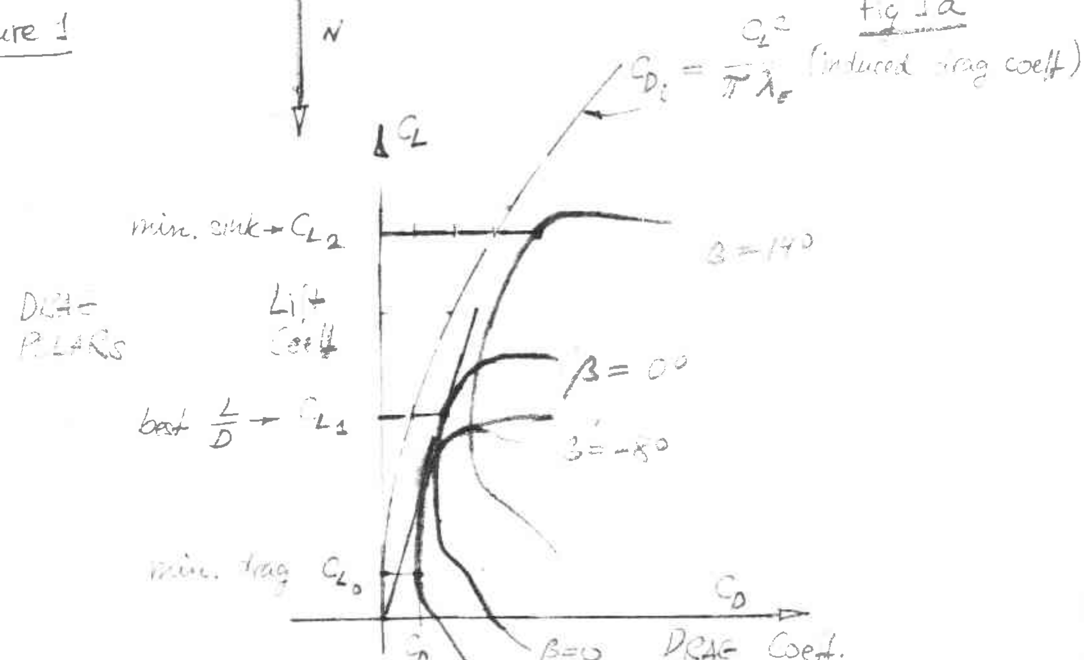


Figure 2

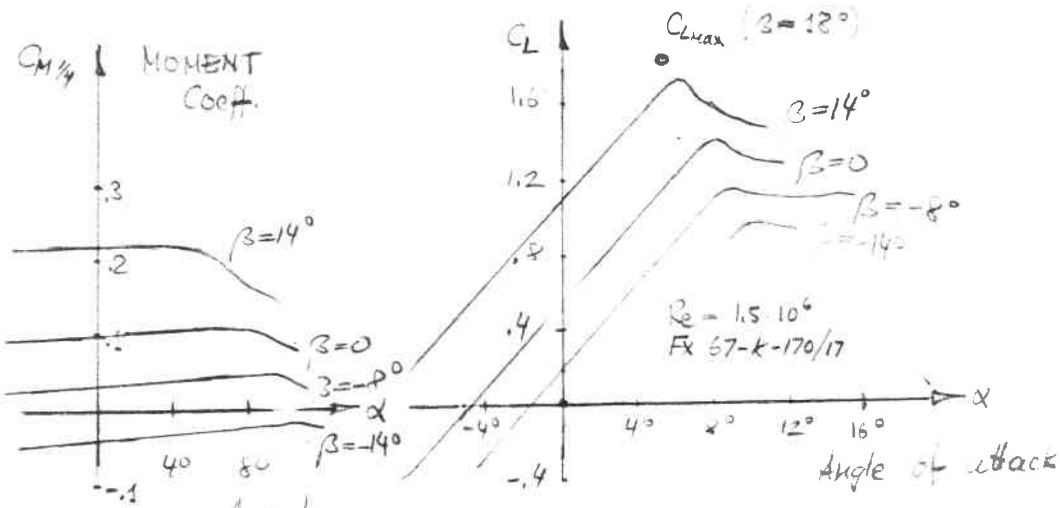


Figure 3

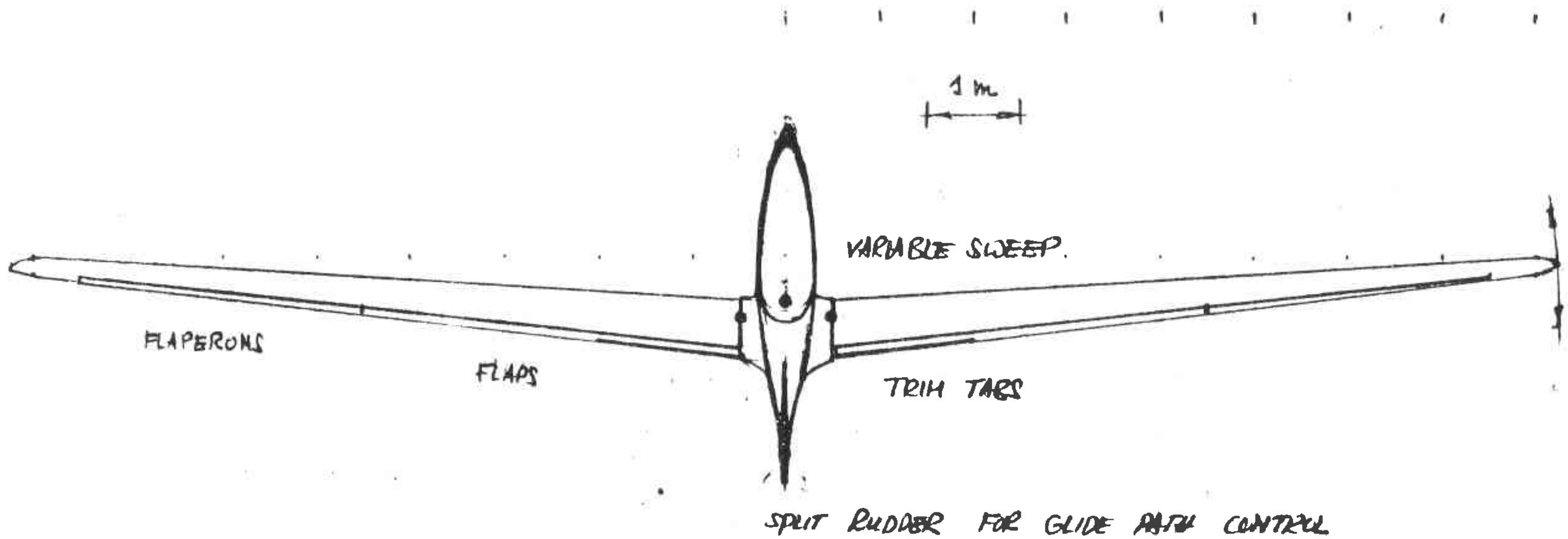


FIGURE 4

CONFIGURATION WITH ACTIVE STABILIZATION

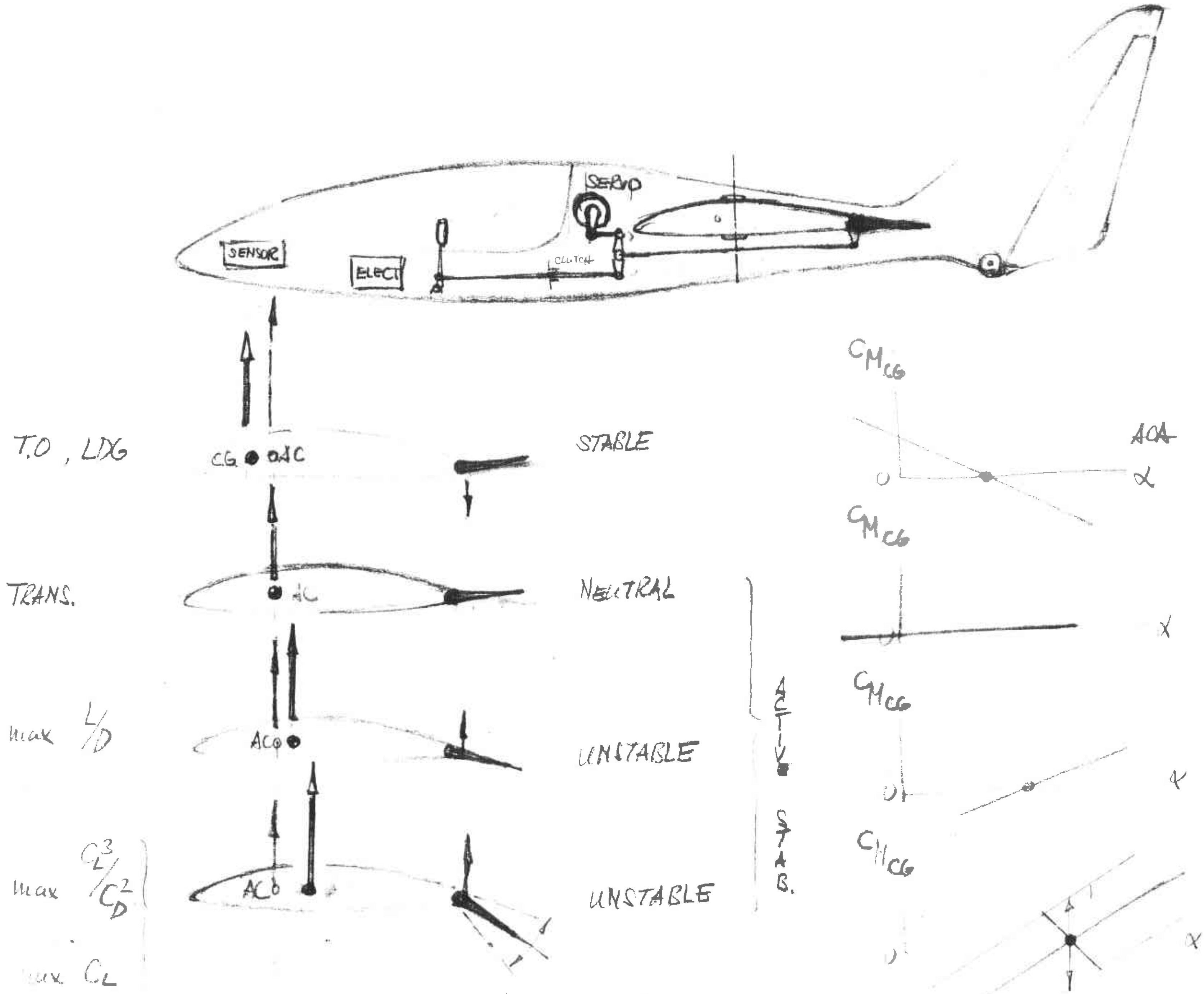

SENSOR
ELECT
SERVO
CLUTCH
T.O , LDG
CG
AC
STABLE
TRANS.
AC
NEUTRAL
max L/D
AC
UNSTABLE
max C_L^3/C_D^2
AC
UNSTABLE
max C_L
ACTIVE STAB.
$C_{M_{CG}}$
AOA
α
0

Figure 5

continued from page 4

As you can see,our newsletters try to inform our members of not only our activities,but to have an insight of international activities as well,and we all are aware that Germany,and specially AKAFLIEG is doing a very interesting and advanced job on our subject:could you possibly help us in gathering some information for us to publish it?.We would highly appreciate your cooperation.

Welcome aboard,Peter...!!!

In name of the TWITT group and from myself...
thanks for your interest.

Phillip Burgers.

VIRTUS--An undertaking that, at first sight, surpasses the strength of a person or group, yet in itself or its aims is too significant for the challenge to be resisted.

1986 Sailplane Design Contest - Tehachapi, Ca. August 30, 31, Sept. 1

We as judges are not the FAA or the military and there may not be enough paper in the world to handle the next project. The people who design and build sailplanes as a hobby are not financed by the Government and some cannot afford a staff of 50 engineers and 100 paper shufflers.

The contest committee is supposed to be expert in the various areas of design and development and should be able to ascertain the general adequacy of all areas of design, from inspecting the machine and some drawings. We are trying to encourage good design, not discourage it.

My suggested requirements for the contestants:
One month before the contest submit a 3-view drawing suitably dimensioned, with CG location and information on any unusual structure, aerodynamics or controls.

What does the contestant bring to the contest:
The ship and 1 copy of all available drawings.
A VG diagram.
A reasonable stress analysis or proof loading information as per Stan Hall.

The Early Birds

By Tom Latimer

Holy Moses! What's MacCready come up with this time?