AVRO AIRCRAFT

COVER SHEET.

FAX #1. TO D. HISLOP 1-403-236-5098

Hi
HERE IS THE AERODYNAMIC DATA YOU REQUESTED. THIS IS FROM MY WORK BOOK - BUT IS CORRECT. THE ORDINATES I SENT TO YOU ARE CORRECT FOR 1/8 SCALE (SUBJECT TO FAIRING CORRECTION AS WE DISCUSSED) SO SIMPLY MULTIPLY BY 8.

WILL SEND YOU MORE DURING THE WEEK AS I GET IT. THE FIRST RETURN BOX TO YOU WILL LEAVE HERE ON WEDNESDAY.

CHEERS

Joll.

FAX 1-905-659-2007

11 SHEETS INCL. COVER

TL.103-97/03

B2......................Similar to B1` but with area rule on aft nacelles (J 75 rear end).
B3......................B2 with 30 degree nose cone.

Wing.

W1......................3 1/2% cambered wing (corresponding to W3 of first series).
E.......................Extended leading edge outboard of transport joint (subscript denotes % extension).
N.......................Transport joint notch (subscript denotes % depth).
D.......................Leading edge droop (subscript denotes angular droop in degrees; the first figure inboard, followed by outboard).

Vertical tail.

V1......................Fin with separate rudder (V3 of first series).

Miscellaneous.

IF......................Faired intakes.
U.......................Undercarraige down. (U1 represents nose undercarraige reversed).
Co......................Open canopy. Closed canopy included in body symbols.
T.......................Belly tank.
SB......................Speed brakes.

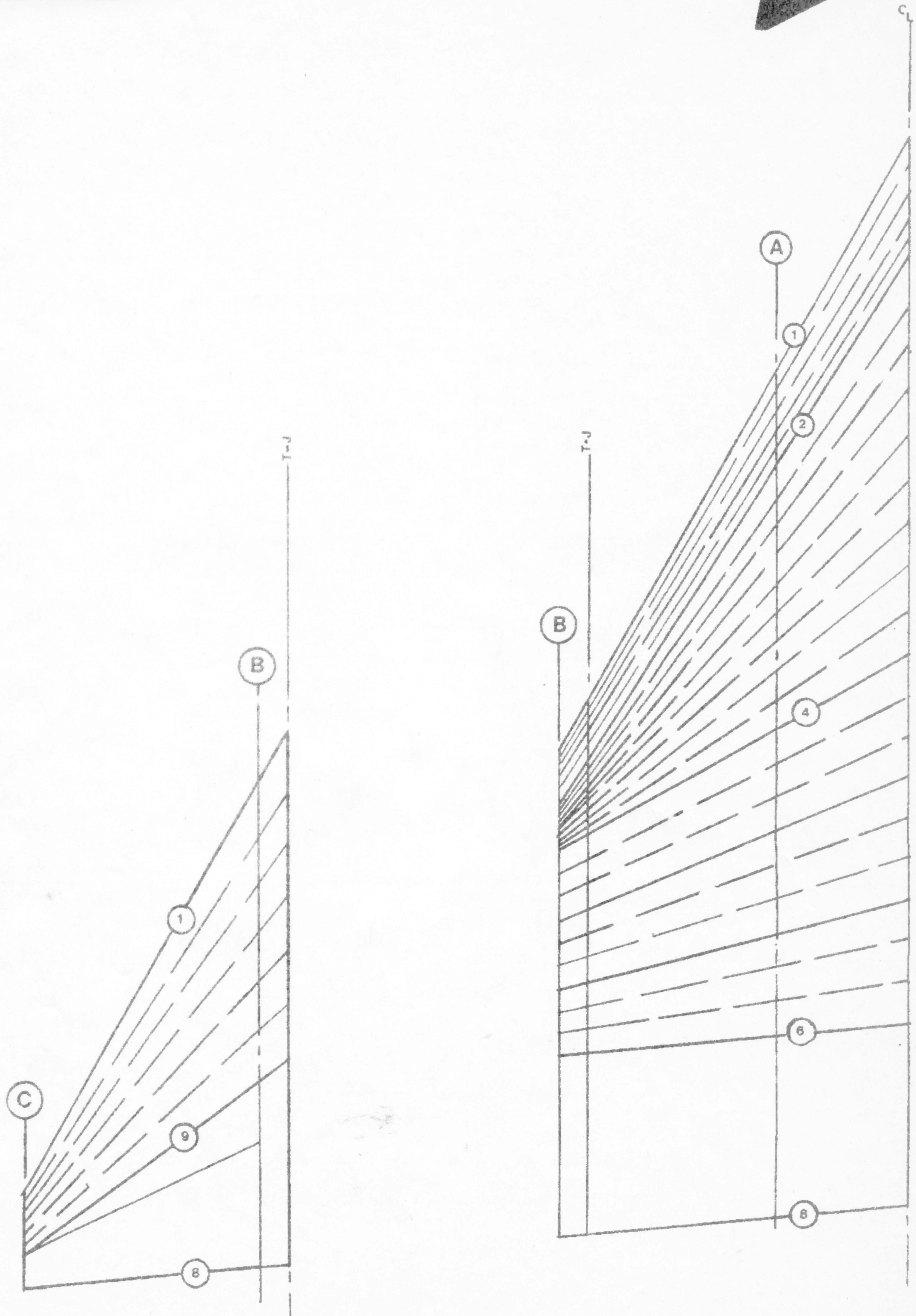
Tunnel configurations. (Applicable only to NAE No.3 tunnel)

U.......................Model upright on 3-point suspension.
UD......................U plus dummy struts.
I.......................Model inverted on 3-point suspension.
ID......................I plus dummy struts.
B.......................Single strut support.
BTS.....................B with addition of tail sting.

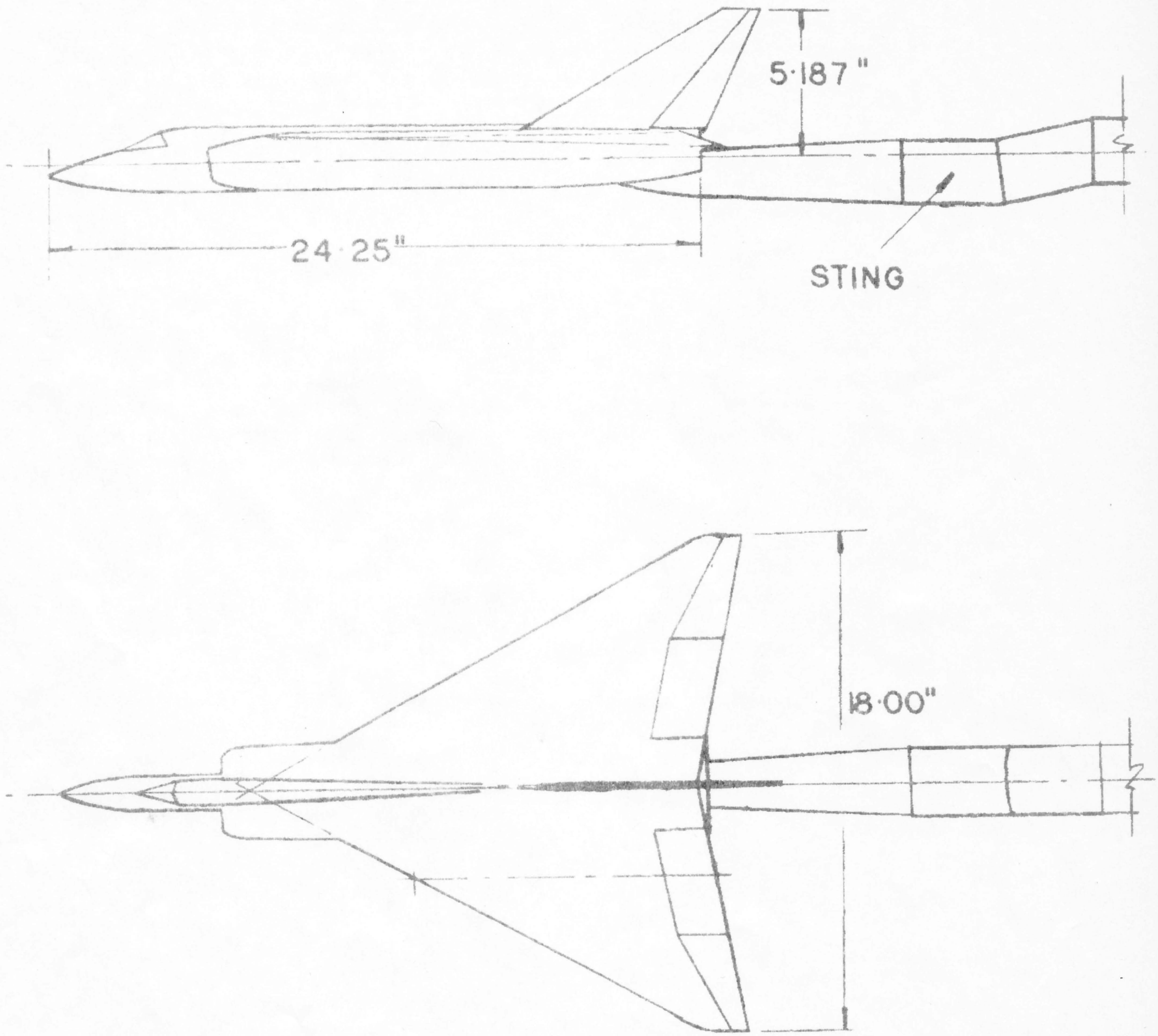
WING DATA C-105.

The profiles of the wing and vertical tail do not follow the usual conical pattern having the leading and trailing edge a generator of a single cone. Wing percent lines will therefore, not be straight unless they coincide with the generatrix pattern of the local "ruled surface".

The wing will contain two separate compatible groups of "ruled surfaces" terminating at the transport joint. (This joint on the Arrow Mk1 is at 3.5 inches outboard of Directrix B). These groups are generated from a pattern of three directrix curves located span-wise at wing chord stations "A - B & C". This now implies



Ruled Surface Pattern. C-105 Wing.



Wind Tunnel Model Mounted on Sting.

On the Arrow, the leading edge portions of the wing are drooped ahead of the front spars. The inboard wing portion is drooped at 9 degrees and the outboard portion is drooped at 8 degrees 25 minutes of angle.

The radius of curvature of the chord line varies from 51.380" at Directrix A to 128.64" at Directrix B for the inboard wing, and from 353.868" at Arrow Directrix B to 65.495" at Directrix C for the outboard wing.

On the outboard wing, the leading edge is extended also by 10% of local chord (basic), thus giving a multiplying factor obtained by dividing the total extension ahead of the front spar by its original distance.

For example:

The original distance of the front spar to the leading edge at Directrix B was 30.960". The chord at Directrix B (basic) is 269.400", giving a 10% extension of 26.940". When added to the original length this gives 30.96 + 26.940 = 57.900". Dividing this by 30.960 we have 57.900/30.960 = 1.870 (factor).

The Yr ordinates up to 30.96 are multiplied by this factor. The same factor is used at Directrix C thus giving the two generating aerofoils. Once these Yr units are plotted along the new "drooped" chord line and the Zu and Zl ordinates plotted in the usual manner.

The notch profile at Directrix B was derived by shortening the Yr ordinates by a factor wich was obtained as follows:

(30.960 - 13.464)/30.960 = .565 (factor). Multiplying the Yr ordinates by this factor and plotting along the radius of curvature will result in the correct profile.

LEADING EDGE NOTCH, EXTENSION AND DROOP.

Once again we must use the words of Jim Floyd in his lecture to the Royal Aeronautical Society:-

"Early in the design stages, modifications were made to the original clean wing. These were the addition of leading edge droop, and a semi-span notch with outer wing chord extension. These modifications were made as a result of wind tunnel tests, carried out at Cornell Laboratories in Buffalo on a 3% complete model, sting mounted. The approximate Reynolds number used during the tests was between 1 and 2 million. These tests showed that a pitch-up or non-linearity in the CM - curve was occurring at moderate angles of attack. This phenomenon is not peculiar to delta wings, being common to all swept wing aircraft. In flight it could easily cause a tightening in the turn.

Crudely, the condition appears to be caused by vortices which

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A. Basic 3-1/2% profile.

B. Basic Profile with 0.75% Negative Camber.

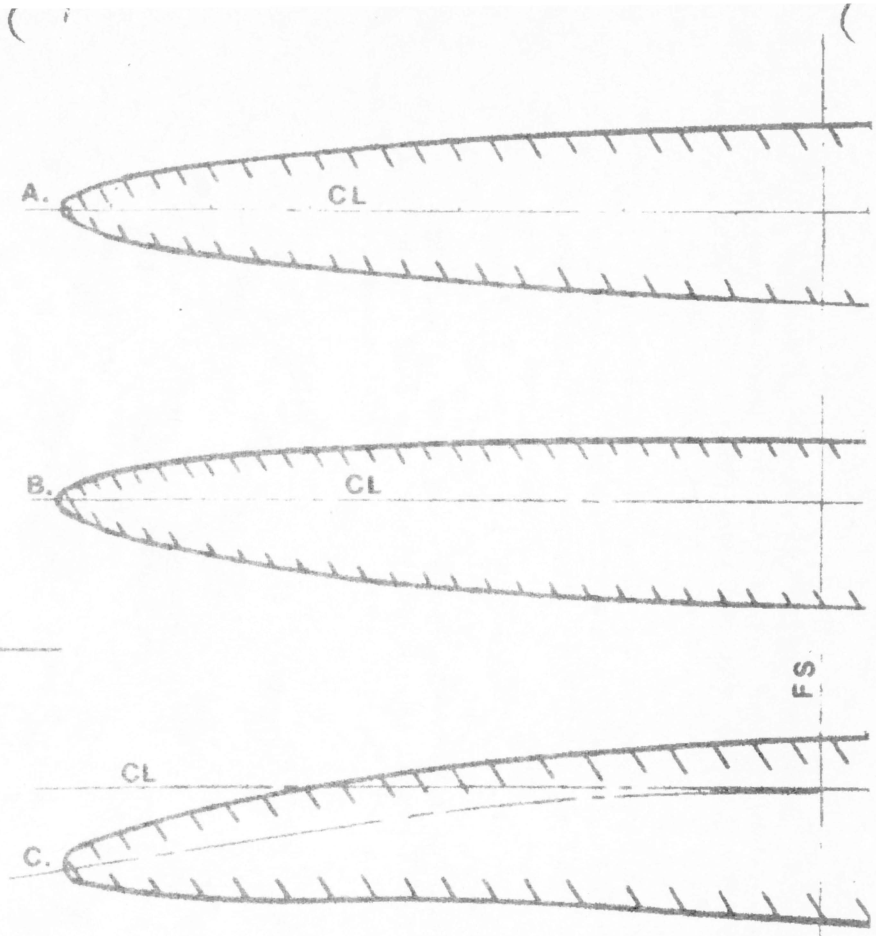
C. Basic Prifile with Camber and Droop.

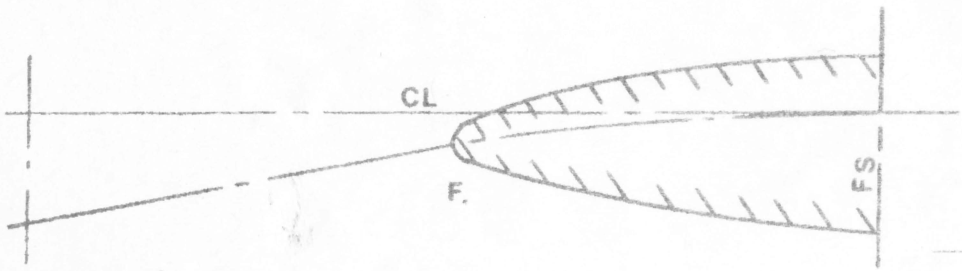
D. Basic Profile with Camber and Extension.

E. Basic Profile with Camber, Droop and Extension.

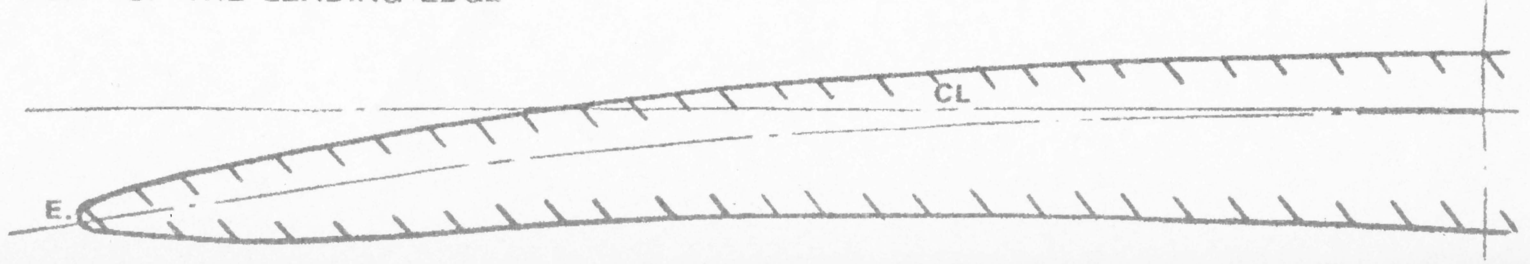
F. Notch Profile.

Note:- Profiles at Directrix B.





DEVELOPMENT OF THE LEADING EDGE



increase in the outboard leading edge, to cure pitch-up. Since it was realized that, if after investigation it was found that it would be advantageous to droop the leading edge, the extension would increase the amount of effective droop.

Droop was then installed on the wind tunnel model, 8 degrees inboard and approximately 4 degrees outboard. This increased the buffet boundary considerably. For instance, at Mach 0.925, which is the normal subsonic cruise Mach number, the CL at which the onset of buffet was estimated, was increased from .26 with the extension alone, to .41 with the extension plus droop. The buffet, or flow separation, was indicated by pressure plots on the ailerons in the Cornell Laboratory tunnel tests. The subsequent drag did not appear to be increased appreciably".

The progression of leading edge design is shown in the illustration entitled Transition from the C-104/2 to the CF-105.

It is of interest to note that the drooping, notching and extension of the leading edge was also carried out on the SAAB J29, the McDonnell Douglas F4 Phantom and the Convair F6 Delta Dart after they had appeared on the CF-105 and after the respective Company representatives had visted Avro.

that at the transport joint, the inner and outer wing profiles are the same up to the front spar, whereas in the original design, they were not as the outer wing panel was generated from station "C".

The directrix at chord "C" (tip), is a basic NACA 0003.8-63.7 section having its maximum thickness value (m) at 36.5% of the local chord. At chord "B", the (m) value has been factored to 34% of the local chord and at "A" the (m) value has been factored to 32.122% of the local chord with a basic section of NACA 0003.5-63.7.

The main panel extends from the aircraft centre line to the transport joint and is made up of four separate ruled surfaces. Ruled section 2-4 will have as outer generators the front and main spars. Ruled section 4-6 will have as outer generators the main and rear spars with the centre spars being generated within the ruled section 4-6. Ruled section 6-8 will have as outer generators the rear spar and trailing edge and will be flat in profile.

The outer panel extends from the transport joint (Directrix B). Ruled section 1-9 will have as outer generators the front spar and the flat plane tangent line at 62.5% of the local chord. Ruled section 9-8 will have as outer generators the tangent line and the trailing edge and being flat, the generators are not sensitive to any pattern.

The leading edge sections of both inner and outer panels will follow their own generators with the front spars and leading edges.

Since all three section aerofoils are different, it follows that no two generators are parallel or intersecting hence - a warped wing.

The camber 'mean line' is not sensitive to position and follows a normal pattern from root to tip. Its (m) value remains constant at 32.122% and its flat plane tangency at 62.5% of the local chord.

WING DATA - ARROW.

The ordinates at the transport joint (Arrow Directrix B), are derived from the ordinates at the elevator tip datum (Directrix B on the C-105), with the original ordinates factored to 3.5% thickness.

The Arrow front spar on the inner wing has the same origin on the Arrow Directrix B as on the C-105 front spar, therefore the generators will be the original front spar position (C-105) and the Arrow front spar position, rotated at the intersection point on Arrow Directrix B to Zu and Zl values at Directrix A.

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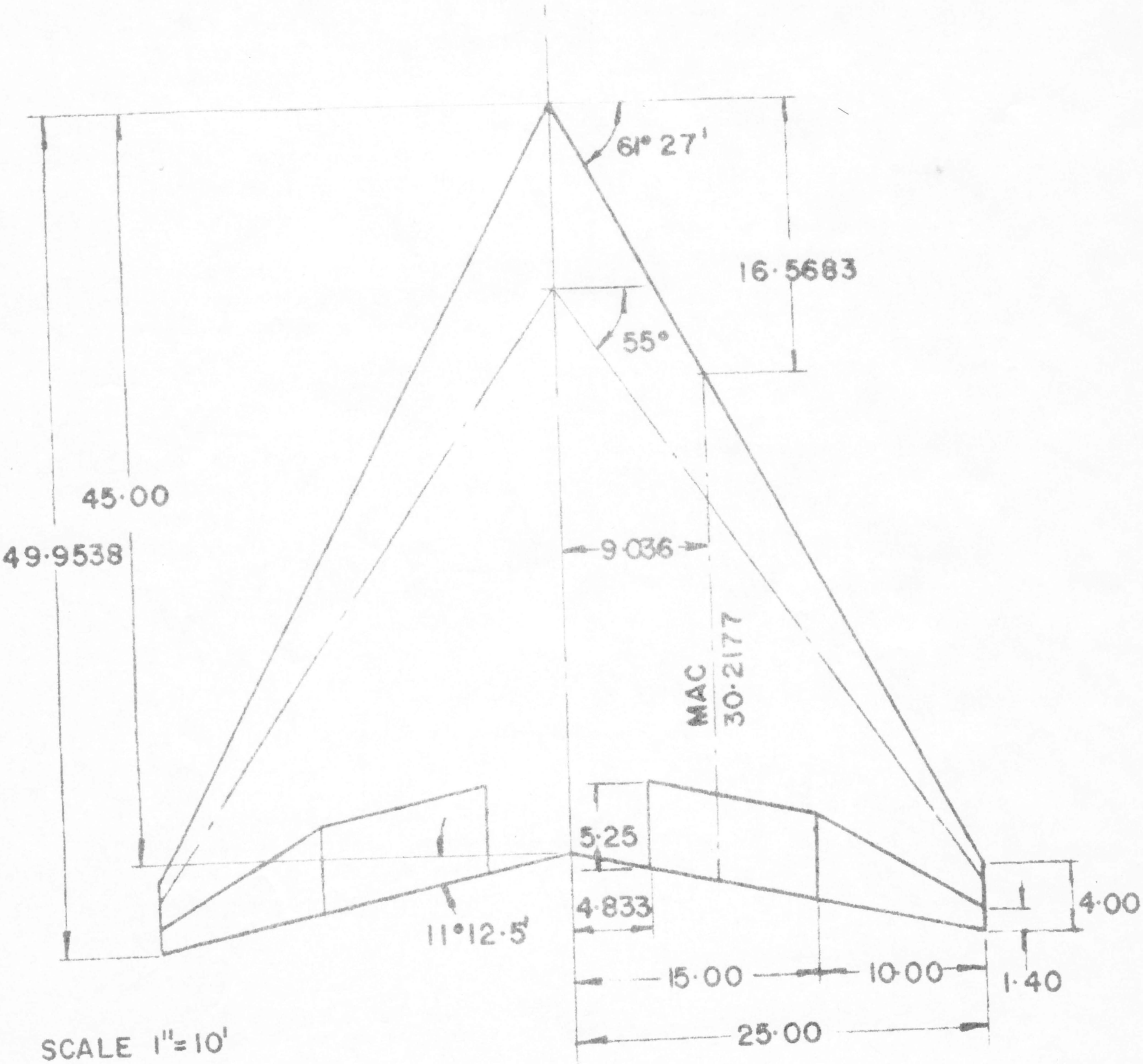
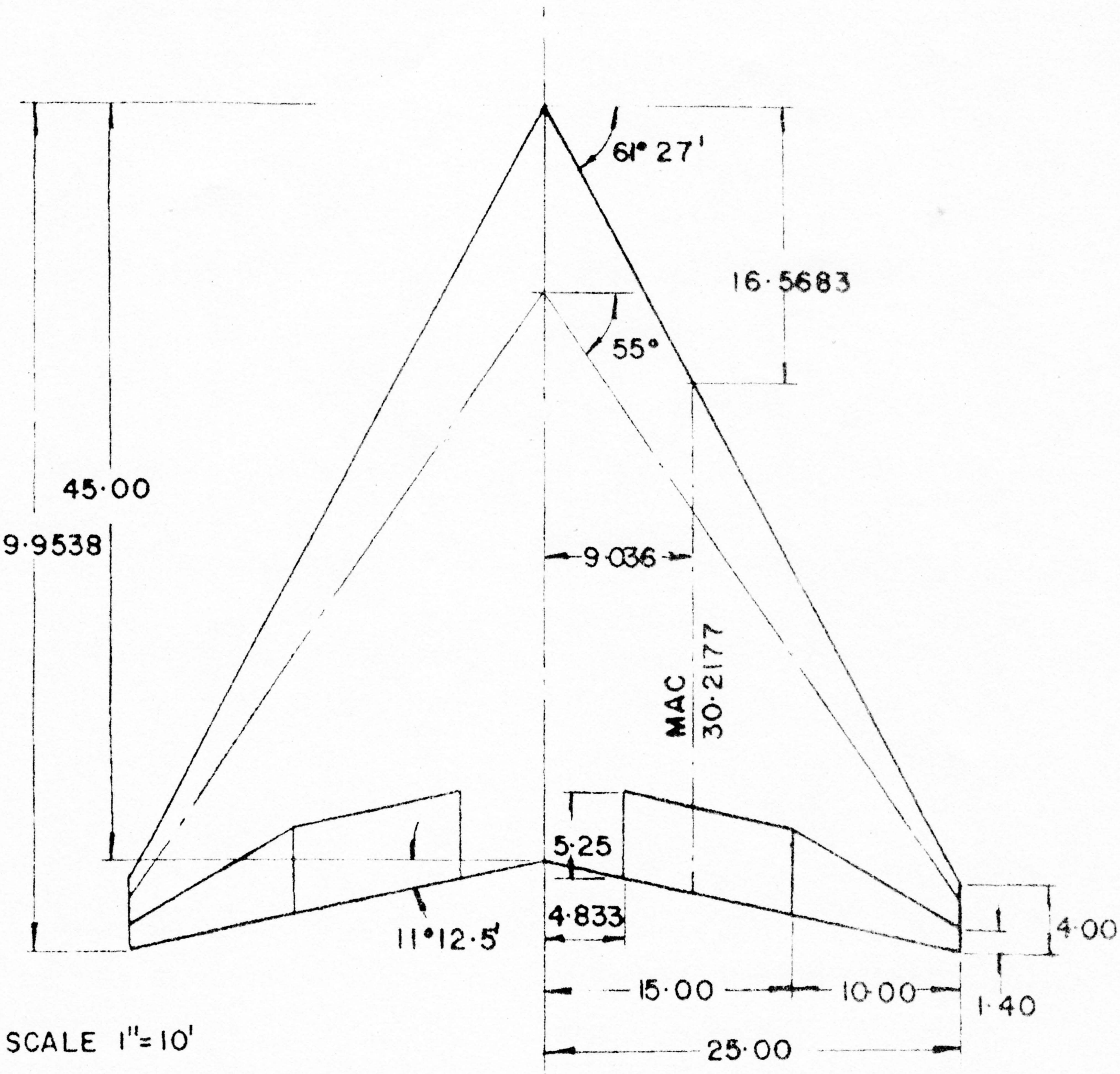
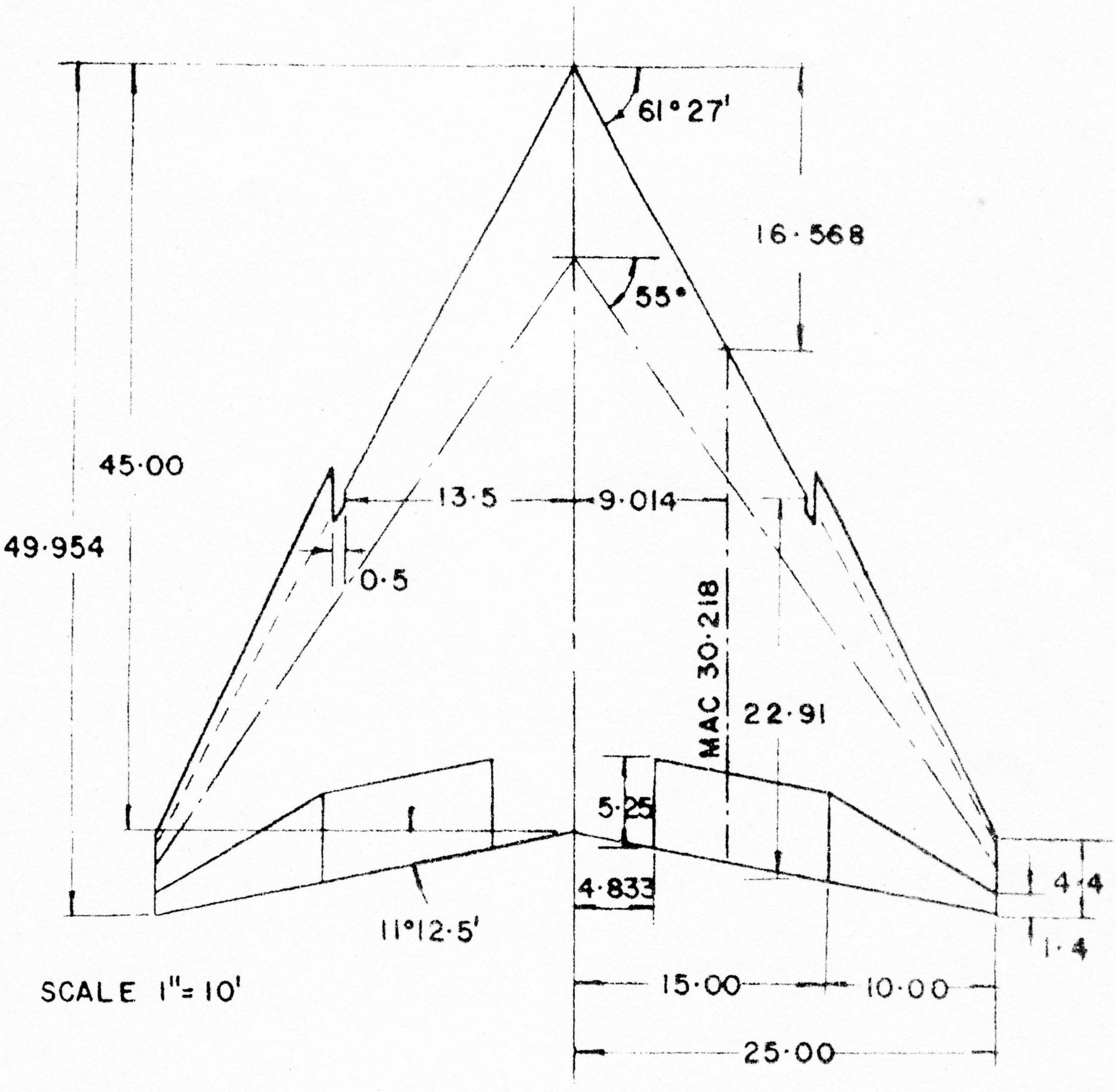
AVRO CANADA



C-104/u Wing Geometry.



C-104/u Wing Geometry.



C-105/CF-105 Wing Geometry.

start at the tip and move to the apex of the swept wing. Low pressure air is collected from the fuselage and causes a break-away outboard of the area covered by the vortex, which is mainly at the trailing edge. This is shown in the illustration and causes the effective aerodynamic centre to shift forward, giving a "pitch-up" or an abrupt change in the moment curve.

While the pitch-up appeared on test to be of small magnitude, and since very moderate amounts of pitch-up could be embarrassing to the pilot, an attempt was made to eliminate it.

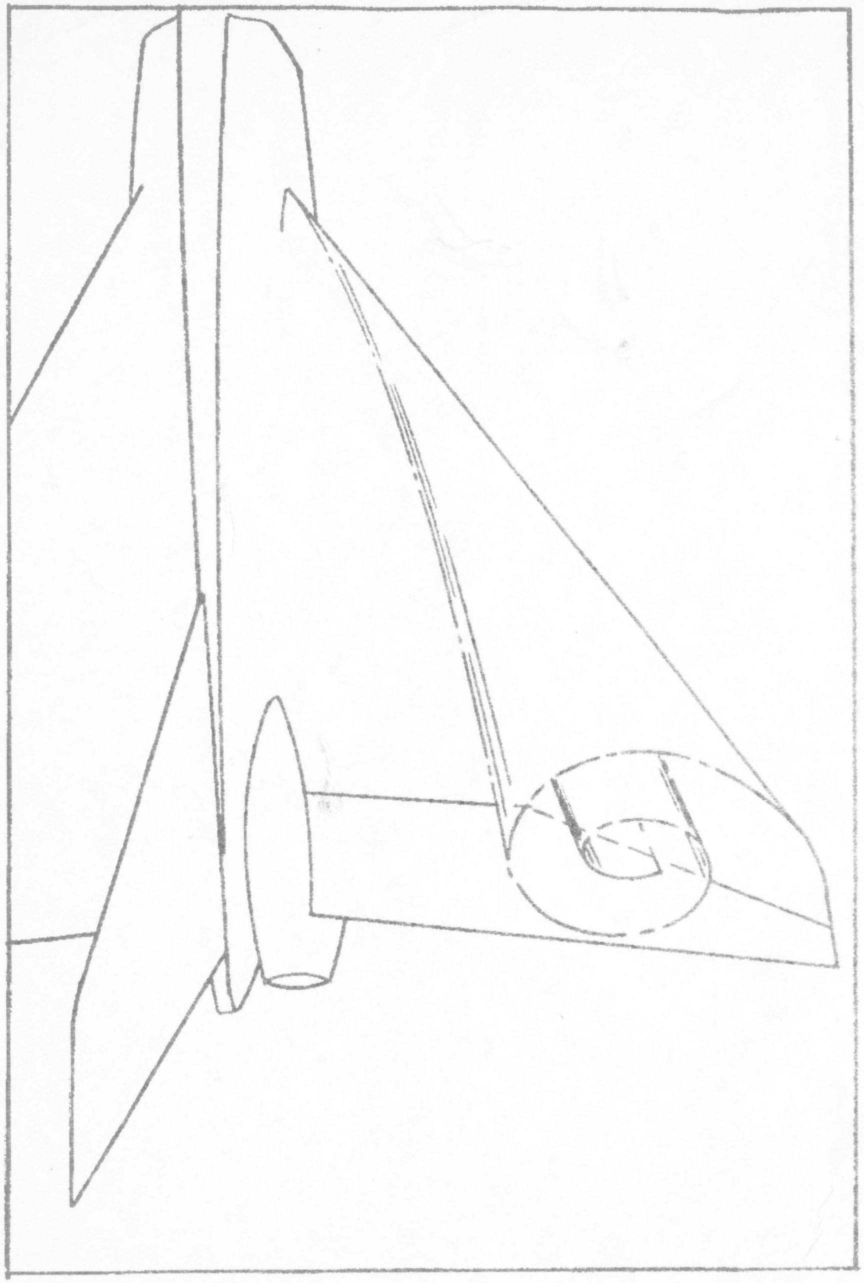
Avro was aware of the work that had been done by NACA and the RAE, and the fact that a number of other aircraft which had exhibited this tendency, had used either notches in the leading edge at about mid-span, or extensions of the wing leading edge outboard, in an attempt to prevent flow separation. The notch had been used, for instance, on the English Electric F-23, and the leading edge extension had been installed on a Grumman F9F9, and a Chance-Vought aircraft. The notch has a similar effect to a fence and causes the disturbing vortices to move away from the apex of the swept wing toward the notch, which is at mid-span, and reduces the area of disturbed flow over the wing. The notch however, produces these effects by air flow rather than as a physical barrier. It was the opinion at Avro that the effects of the notch were present over the whole speed range, whereas a fence is usually only effective over smaller speed ranges, and the notch was expected to increase the drag by a lesser amount than a fence.

In the tests however, it was found that with the notch alone, the test results were not repeatable; in other words, the same results could not be obtained in subsequent tests. When the leading edge extension was installed in addition to the notch, the results were far more repeatable. Eight different notches and three extended leading edges in various combinations were tried. The depth of the notch appeared to be the most critical paramet-er, and it had to be bourne in mind that too deep a notch would cause structural problems.

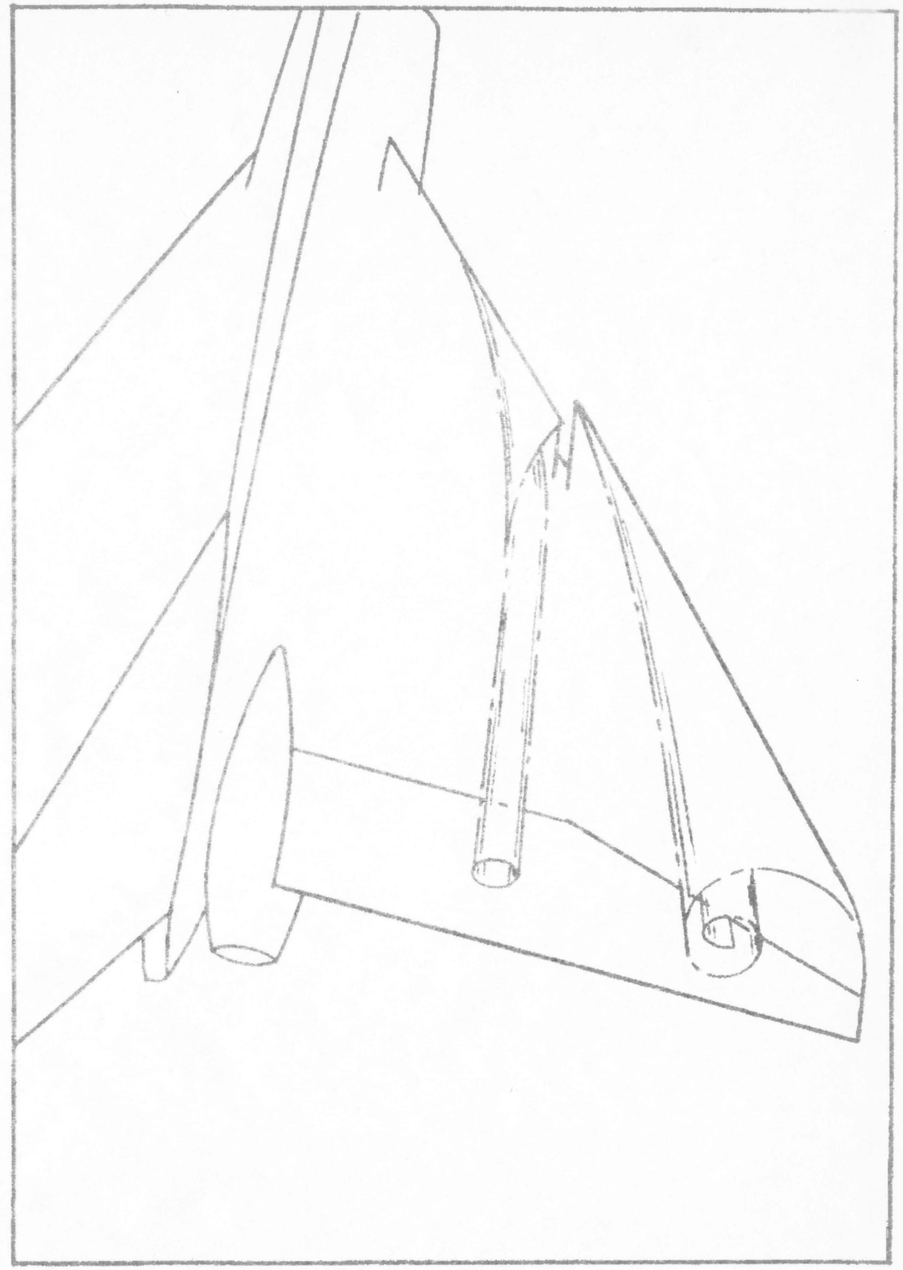
The illustrations show the effect of the 5% notch and 10% extension of the local chord on the outer wing, which was finally adopted, against the unmodified 3-1/2% wing at Mach 0.9, and at an elevator angle of -20 degrees.

DROOPING THE LEADING EDGE.

During the time that the tests were being carried out on the notch and leading edge extension, the work being done on the F-102 was being followed very closely with regard to a reduction in induced drag by drooping the wing leading edge, and also the work that was going on at Avro Manchester on the 707 series and Vulcan. They were drooping the leading edge to increase the buffet boundary by preventing leading edge breakaway at high angles of attack. This also influenced the choosing of the 10%



VORTEX PATTERN OF PLAIN WING



VORTEX PATTERN OF WING WITH
NOTCH AND EXTENDED LE