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CF-105 A/C Nos. 1, 2, 3, FAR/C105/1

CF-105 INSTRUMENTATION
ISSUE NO. 7

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Nov. 1956

Avro Aircraft Limited

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INTER-DEPARTMENTAL MEMORANDUM

Date November 27, 1956. Reference: 4028/02A/J.
To Mr. S.E. Harper - Chief Experimental Engineer.
From John Morris - Assistant Chief Aerodynamicist.
Subject CF-105 INSTRUMENTATION - ISSUE NO. 7.

Herewith a copy of Issue No. 7 of "CF-105 Instrumentation", this being a consolidated list of the instrumentation requirements for CF-105 aircraft numbers 1, 2 & 3. This replaces Issue No. 5 which was issued in a number of separate parts in Nov.- Dec. 1955.

Classification cancelled/changed to.....
by authority of.....(date).....
Signature.....Rank.....

John Morris,
Assistant Chief Aerodynamicist.

DNV/ah

cc Messrs: J.C. Floyd, R.N. Lindley, J.A. Chamberlin, G. Hake, F. Brame, F.P. Mitchell, K. Korsak, H. Malinowski, S. Whiteley, S. Kwiatkowski, I. Craig, G. Shaw, W.S. Sloan, E. Duret, J.C. McKillop, B. Wood, S. Brown, J. Cleminson, A. Crust (9), R. Young (2), Aero Files, Central Files (2)

UNCLASSIFIED

A. V. ROE CANADA LIMITED

MALTON - ONTARIO

TECHNICAL DEPARTMENT (Aircraft)

AIRCRAFT: CF-105

REPORT NO:

FILE NO:

NO. OF SHEETS:

TITLE:

CF-105 INSTRUMENTATION

ISSUE NO.7

PREPARED BY DATE

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ISSUE No	REVISION No	REVISED BY	APPROVED BY	DATE	REMARKS

FORM 1316A

AVRO AIRCRAFT LIMITED
MALTON - ONTARIO
TECHNICAL DEPARTMENT

REPORT No.
SHEET No. 1.

AIRCRAFT		PREPARED BY	DATE
CF-105	Instrumentation	CHECKED BY	DATE

INDEX

FORM 1319A

CF-105 INSTRUMENTATION, ISSUE NO. 7

This issue replaces Issue 5 which was issued in a number of separate sections in November and December, 1955. Issue 6 applied only to the "Engine Installation" instrumentation and it also is superseded by this issue.

Changes from Issue 5 are indicated by underlining or by a vertical line in the margin. The changes are summarised below.

Section 1 Stability and Control

Items 1 & 2 Triple range instrumentation introduced.
7 Yaw rate replaces azimuth rate.
8 Yaw acceleration replaces azimuth acceleration.
14 Instrument range increased to -32 to +32 ft/sec^2 from -16 to +16 ft/sec^2.

A number of items previously required at 20/sec are now required on continuous trace.

Section 2 Flying Control Hydraulics

Items 2 to 12 inclusive now required at 40/sec instead of at 10/sec.
18 to 32 inclusive added.

Section 3 Engine Installation

Items 1 & 2 Oil pressure range increased from 0-50 to 0-80 psi.
21 to 26 inclusive added.
27 & 28 Lower limit of mass flow range raised to 600 lb/hr. from 0 lb/hr.
31 added, this replaces items 25, 26 & 27 of Issue 5 which are deleted.
32 to 41 inclusive - Instrumentation range changed to have lower limit of 100°F instead of 0°F
48 to 56 inclusive added.
57 to 60 inclusive - Range changed to have lower limit of -5 psi. instead of 0 psi.

Section 4 Fuel System

Location 3 - Temperature in starboard wing added.
12 - Temperature of pressurization air added.
5 - Pressure range increased to 0-35 psia from 0-30 psia.
Mass flow - Range of flows to be measured now defined separately for engine and afterburner.

Section 5 Utility Hydraulics

Items 2 & 3 added.

Section 6 Air Conditioning

Location 3 - Instrument range and accuracy changed from 0-10 psi. and ±0.20 to 0-5 psi. and ±0.25 respectively.
7 - Instrument range and accuracy changed from 0-10 psi. and ±0.20 to 0-1 psi. and ±0.05 respectively.
9 - Total head pressure, $P_t 9$, added.

Information in Inter-Departmental Memo, ref. 9882/16A/J, dated June 18, 1956, should be disregarded.

Section 7 Electrics

Item 22 added.

Section 8 Structural Integrity

Requirements for telemetery of vibration pick-up accelerometers are changed.

Section 9 Undercarriage

No change.

CF-105 INSTRUMENTATION - ISSUE 7

STABILITY AND CONTROL

In the following list, the instrumentation has been grouped under four headings:-

1. Ambient Conditions.
2. Motion of Aircraft.
3. Control Surface Motion.
4. Control Mechanism.

Three sketches are provided to show the location of instrumentation, or to define quantities to be measured.

Items marked * - Phase shift at 15 cps. must not exceed 3°.

Items marked X - ~~Required on continuous trace as well as at specified sampling frequency~~. Provision to be made to telemeter each of these items ~~on continuous trace~~, but no more than eight of these items will be telemetered at any one time. Required accuracy in ~~continuous trace recording and in~~ telemetry is ± 3%.

Changes from issue 5, Ref. 4833/22/J, (October 20, 1955), are underlined.

1. AMBIENT CONDITIONS (see Fig. 1)

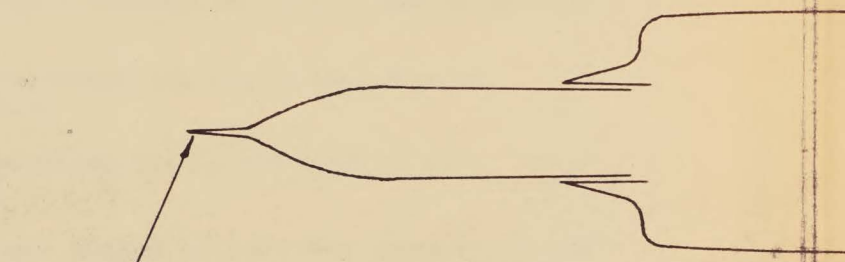
	ITEM	RANGE	ACCURACY	ACCURACY % of full range	SAMPLING FREQUENCY
	Ambient Conditions				
1.	Aircraft static pressure	0 - 2160 lb/ft.^{2}	± 15 lb/ft^2	± 0.75%	1/2 sec. X
	Limited range	0 - 720 lb/ft.^{2}	± 5 lb/ft^2	± 0.75%	1/2 sec.
	Limited range	0 - 283 lb/ft.^{2}	± 2 lb/ft^2	± 0.75%	1/2 sec.
2.	Differential pressure (Total head - aircraft static)	0 - 2880 lb/ft.^{2}	± 20 lb/ft^2	± 0.75%	1/2 sec. X
	Limited range	0 - 1440 lb/ft.^{2}	± 10 lb/ft^2	± 0.75	1/2 sec.
	Limited range	0 - 720 lb/ft.^{2}	± 5 lb/ft^2	± 0.75%	1/2 sec.
3.	Free Air Total Temperature	-65 +350°F	± 2°F	± 0.5%	1/2 sec.

2. MOTION OF AIRCRAFT (see Fig. 2)

	ITEM	Range	Accuracy	Accuracy % of full range	Sampling Frequency	
4.	Angle of Pitch θ *	-60 +60°	± 0.5°	± 0.5%	10/sec	
	Limited Range *	-10 +10°	± 0.1°	± 0.5%	10/sec	
5.	$\dot{\theta}$	-30 +30°/sec	± 0.3°/sec	± 0.5%	Cont.	×
6.	Azimuth Angle ψ *	0-360°	± 0.5°	± 0.1%	10/sec	
	Limited range *	-10 +10°	± 0.1°	± 0.5%	10/sec	
7.	Rate of yaw $\dot{\psi}$	-30 +30°/sec	± 0.3°/sec	± 0.5%	Cont	×
8.	$\ddot{\psi}$	-50 +50°/sec^2	± 0.5°/sec^2	± 0.5%	10/sec	X
9.	Angle of Bank ϕ *	-85 +85°	± 0.5°	± 0.5%	10/sec	X
	Limited range *	-25 +25°	± 0.25°	± 0.5%	10/sec	
10.	$\dot{\phi}$	-300 +300°/sec	± 2.0°/sec	± 0.5%	10/sec	X
11.	Angle of Attack α	-10 +40°	± 0.1°	± 0.2%	Cont	×
12.	Angle of Sideslip β	-15 +15°	± 0.1°	± 0.5%	Cont	×
13.	Longitudinal Acceleration X	-32 +32 ft/sec^2	± 0.3 ft/sec^2	± 0.5%	5/sec	
14.	Lateral Acceleration $\ddot{Y}$	-32 +32 ft/sec^2	± 0.3 ft/sec^2	± 0.5%	Cont	×
15.	Normal Acceleration $\ddot{Z}$	-100 +300ft/sec^2 (-3 +8g)	± 2 ft/sec^2	± 0.5%	Cont	×

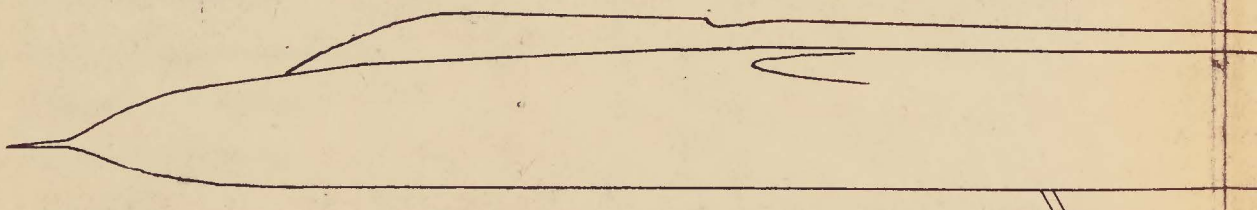
3. CONTROL SURFACE MOTION (see Fig. 1)

ITEM	Range	Accuracy	Accuracy % of full range	Sampling Frequency	
16. Port Elevator Angle δe *	-30 + 20°	± 0.3°	± 0.5%	Cont.	×
Limited Range *	-10 + 10°	± 0.1°	± 0.5%	20/sec	
17. Port Elevator Angular Acceleration * $\ddot{\delta e}$	-200 + 200°/sec^2	± 2°/sec^2	± 0.5%	Cont.	×
18. Stbd Elevator Angle δe *	-30 + 20°	± 0.3°	± 0.5%	Cont.	×
Limited Range*	-10 + 10°	± 0.1°	± 0.5%	20/sec	
19. Port Aileron Angle δa *	-19 + 19°	± 0.2°	± 0.5%	Cont.	×
Limited Range *	-10 + 10°	± 0.1°	± 0.5%	20/sec	
20. Port Aileron Angular Acceleration * $\ddot{\delta a}$	-200 + 200°/sec^2	± 2°/sec^2	± 0.5%	Cont	×
21. Stbd Aileron Angle δa *	-19 + 19°	± 0.2°	± 0.5%	Cont	×
Limited Range *	-10 + 10°	± 0.1°	± 0.5%	20/sec	
22. Angle of Rudder δr *	-30 + 30°	± 0.3°	± 0.5%	Cont	×
Limited Range *	-10 + 10°	± 0.1°	± 0.5%	20/sec	
23. Angular Acceleration of Rudder * $\ddot{\delta r}$	-200 +200°/sec^2	± 2°/sec^2	± 0.5%	Cont	×
24. Port Airbrake Angle	0-60°	± 2°	± 3%	5/sec	
25. Stbd Airbrake Angle	0-60°	± 2°	± 3%	5/sec	

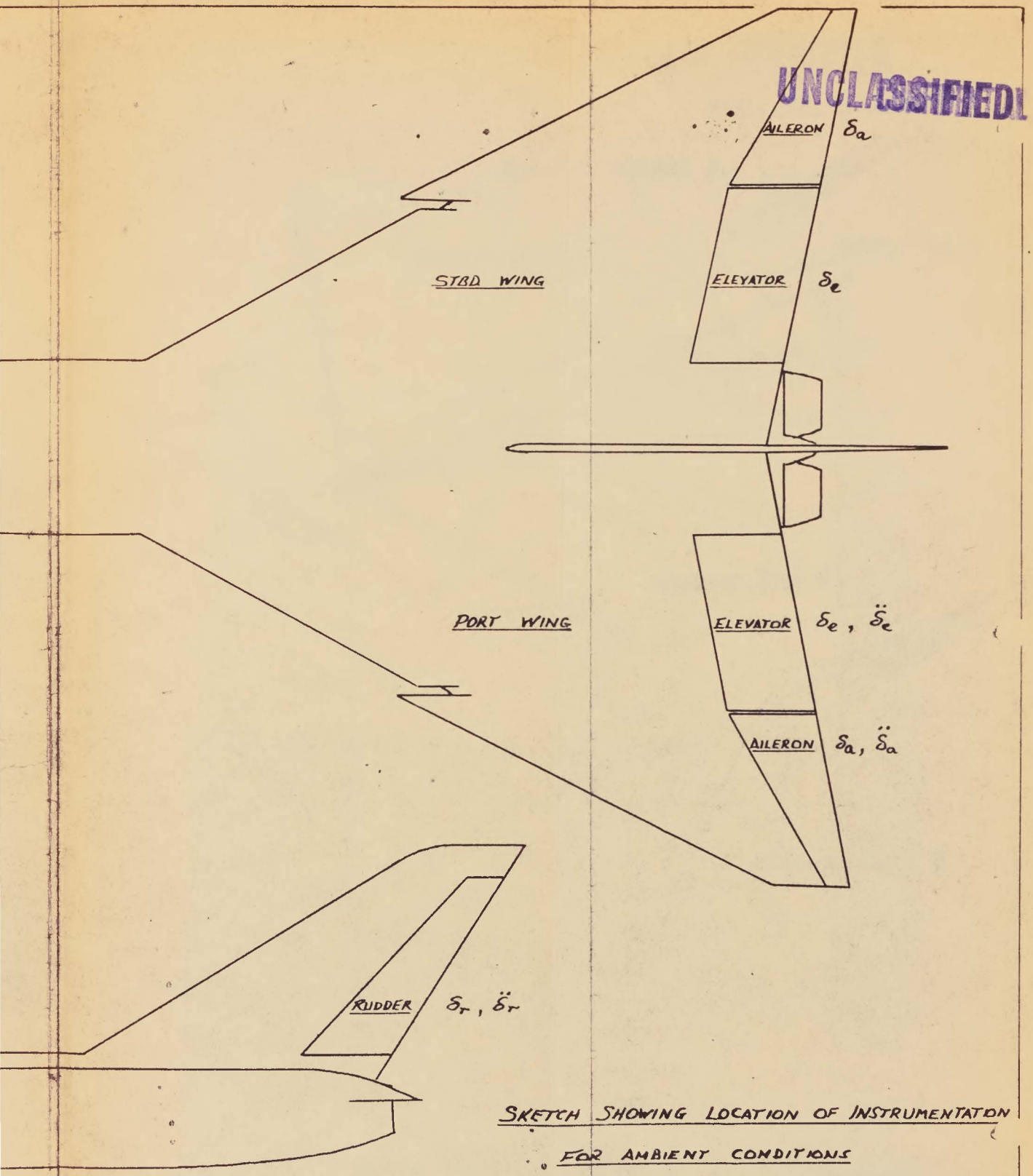


AIRCRAFT STATIC VENT

(LOCATION OF TOTAL HEAD AND TOTAL TEMPERATURE PROBES NOT YET DECIDED)



AIRBRAKE



SKETCH SHOWING LOCATION OF INSTRUMENTATION FOR AMBIENT CONDITIONS & CONTROL SURFACE MOTION

FIG. 1

RBRAKE ANGLE - PORT & STBD.

DESCRIPTION OF SKETCH

Let OX, OY and OZ be three mutually perpendicular axis with origin O, such that:-

OX is parallel to the longitudinal datum of the aircraft,
OY is parallel to the lateral or spanwise datum,
and OZ is perpendicular to the plane XOY.

Let O be projected into a horizontal plane in O', also project OX into O' X', OY into O' Y',. Let O'C' be a reference direction in the horizontal plane, and let OC be the reference direction in the plane of the aircraft.

Let the horizontal plane through O intersect XX' in X'', and YY' in Y'', then,

ANGLE OF PITCH θ = $\angle$XOX'', the angle between the longitudinal datum of the aircraft and the horizontal plane.

ANGLE OF BANK ϕ = $\angle$YOY", the angle between the lateral datum of the aircraft and the horizontal plane.

AZIMUTH ANGLE ψ = $\angle$C'O'X', the angle between the reference direction and the projection of the longitudinal datum of the aircraft in the horizontal plane.

YAW ANGLE χ = $\angle$COX, the angle between the reference direction and the longitudinal datum of the aircraft, in the plane of the aircraft, XOY.

Further, let OR lie parallel to the direction of the relative wind, and let OR_s and ORp be projections of OR in planes XOY and XOZ respectively, then,

ANGLE OF ATTACK α = $\angle XOR_p$, the component of the relative wind in the plane XOZ.

ANGLE OF SIDESLIP = $\angle XOR_s$, the component of the relative wind in the plane XOY.

ITEM	QUANTITIES TO BE MEASURED		
Angle of Pitch	θ	$\dot{\theta}$	
Angle of Bank	ϕ	$\dot{\phi}$	
Azimuth Angle	ψ		
Angle of Attack	α		
Angle of Sideslip	β		
Longitudinal Acceleration			$\ddot{X}$
Lateral Acceleration			$\ddot{Y}$
Normal Acceleration			$\ddot{Z}$
Yaw angle		$\dot{\chi}$	$\ddot{\chi}$

NOTE ON FLYING CONTROL MECHANISM

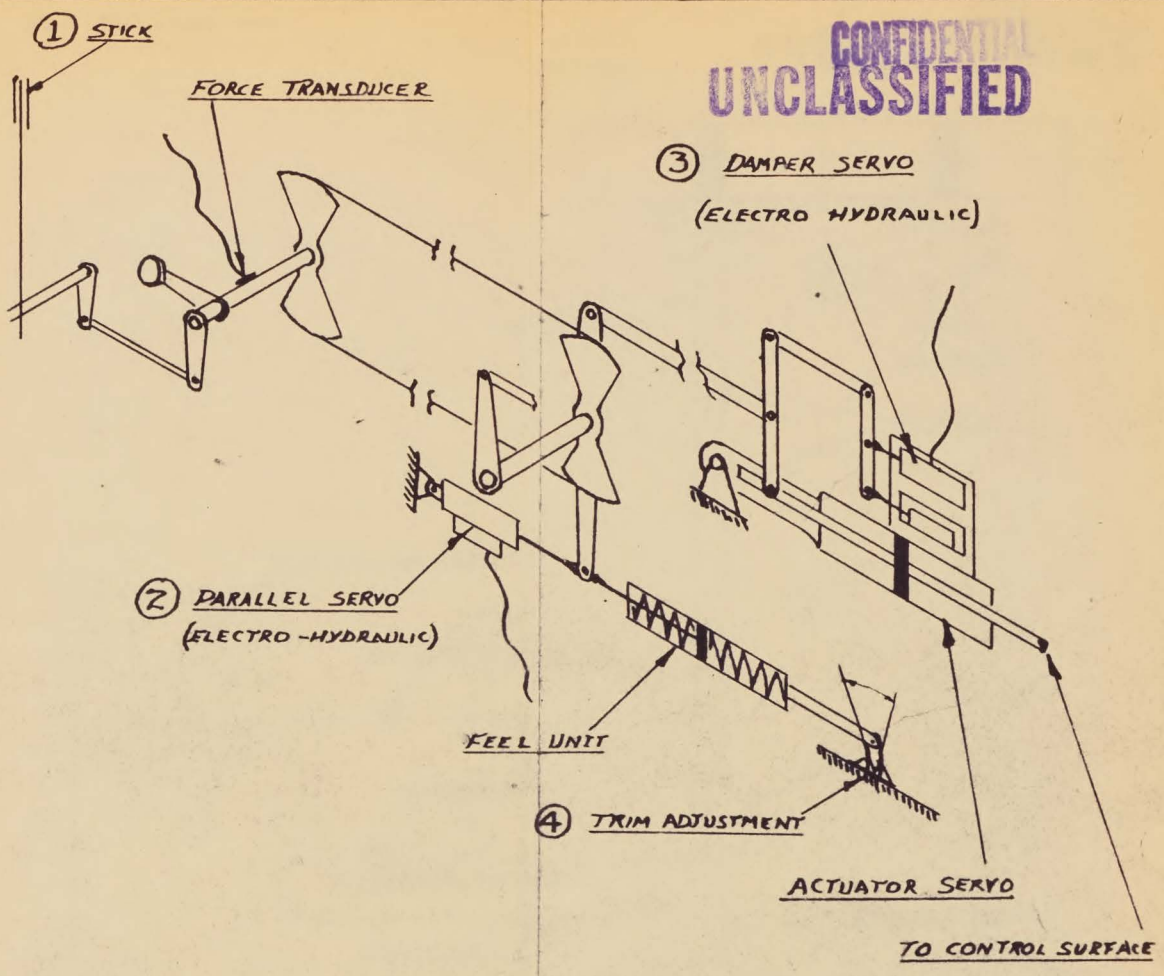
The sketch opposite, shows the elevator control system in its essentials, for the purpose of describing the instrumentation.

While the aileron system is practically identical to the elevator system, the rudder system has no parallel servo.

In the elevator and aileron systems the feel unit and trim adjustment are employed only in Emergency Manual mode of operation, when the parallel servo is by-passed and the damper servo is centralised by a centralising device. The rudder damper servo is also provided with a centralising arrangement, and has duplicate electrical and hydraulic systems.

In Manual Mode of operation, the pilot's effort on the stick strains the mechanism from the stick grip to the rear quadrant against the parallel servo, which operates in response to an "error" signal. The strain is picked-up by a force transducer, the signal being balanced against the signal from the "feel" network which may consist of - stick position, q, stick force/g, etc., components.

The resulting "error" signal, suitably amplified, is fed to the parallel servo, which moves in such a direction as to reduce the error signal to zero.



SKETCH OF FLYING CONTROL MECHANISM

REF: BROCHURE F.C.

Key:

1. Stick Force - Elevator, Aileron, and Rudder Pedal Force.
   Stick Position - Elevator, Aileron, and Rudder Pedal Position.

2. Position of Parallel Servos - Elevator and Aileron.

3. Damper servo signal - Elevator, Aileron, Rudder and Emergency Rudder.
   Damper servo position - Elevator Port & Stb'd, Aileron Port & Stb'd, and Rudder.

4. Trimmer position - Elevator, Aileron, and Rudder.

FIG. 3

CF-105 - INSTRUMENTATION - ISSUE 7

FLYING CONTROL HYDRAULICS

In the following list, changes from Issue 5, Ref. 4861/22/J, dated October 21, 1955, are underlined, or indicated by a vertical line in the margin.

The sketch, on the following page, indicates the location of instrumentation in the Flying Control Hydraulic System.

	Item	System	Range	Accuracy	Accuracy % of full range	Sampling Frequency
	Location (1) see sketch					
1.	Port engine pump inlet temp.	B	-65 +300°F	± 5°F	± 2%	2/min
2.	Port engine pump inlet press.	B	0 -200 psi	± 5 psi	± 3%	40/sec
3.	Port engine pump outlet press.	B	0 -5000 psi	± 100 psi	± 2%	40/sec
	Location (2) see sketch					
4.	Port elevator valve inlet press.	A	0 -5000 psi	± 100 psi	± 2%	40/sec
5.	Port elevator valve inlet press.	B	0 -5000 psi	± 100 psi	± 2%	40/sec
6.	Port elevator jack return press.	B	0 -2000 psi	± 40 psi	± 2%	40/sec
7.	Port aileron valve inlet press.	A	0 -5000 psi	± 100 psi	± 2%	40/sec
8.	Port aileron valve inlet press.	B	0 -5000 psi	± 100 psi	± 2%	40/sec
9.	Port aileron jack return press.	B	0 -2000 psi	± 40 psi	± 2%	40/sec
10.	Rudder valve inlet pressure.	A	0 -5000 psi	± 100 psi	± 2%	40/sec
11.	Rudder valve inlet pressure.	B	0 -5000 psi	± 100 psi	± 2%	40/sec
12.	Rudder jack return pressure.	B	0 -2000 psi	± 40 psi	± 2%	40/sec
	Location (3) see sketch					
13.	No. 1 Heat Ex. inlet temperature	B	-65 +300°F	± 5°F	± 2%	2/min
14.	No. 1 Heat Ex. outlet temperature	B	-65 +300°F	± 5°F	± 2%	2/min
15.	No. 2 Heat Ex. outlet temperature	B	-65 +300°F	± 5°F	± 2%	2/min
	Location (4) see sketch					
16.	Accumulator piston position	B	0 - 9.6"	± 0.1"	± 1%	10/sec
	Location (5) see sketch					
17.	Compensation piston position	B	0 -10.75"	± 0.2"	± 2%	10/min

(Cont'd.)

Item	Range	Accuracy	Accuracy % of full range	Sampling Frequency
Location (2) see sketch				
Port Elevator Jack				
18. Pressure in chamber (a)	0-5000 psi	± 100 psi	± 2%	40/sec
19. Pressure in chamber (b)	0-5000 psi	± 100 psi	± 2%	40/sec
20. Pressure in chamber (c)	0-5000 psi	± 100 psi	± 2%	40/sec
21. Pressure in chamber (d)	0-5000 psi	± 100 psi	± 2%	40/sec
Port Aileron Jack				
22. Pressure in chamber (a)	0-5000 psi	± 100 psi	± 2%	40/sec
23. Pressure in chamber (b)	0-5000 psi	± 100 psi	± 2%	40/sec
24. Pressure in chamber (c)	0-5000 psi	± 100 psi	± 2%	40/sec
25. Pressure in chamber (d)	0-5000 psi	± 100 psi	± 2%	40/sec
Rudder Jack				
26. Pressure in chamber (a)	0-5000 psi	± 100 psi	± 2%	40/sec
27. Pressure in chamber (b)	0-5000 psi	± 100 psi	± 2%	40/sec
28. Pressure in chamber (c)	0-5000 psi	± 100 psi	± 2%	40/sec
29. Pressure in chamber (d)	0-5000 psi	± 100 psi	± 2%	40/sec
Valve Position				
30. Port elevator valve	0 - 0.25 in.	± 0.002	± 1%	40/sec
31. Port aileron valve	0 - 0.14 in.	± 0.002	± 1%	40/sec
32. Rudder valve	0 - 0.10 in.	± 0.002	± 2%	40/sec

(Friction of the valve position indicator potentiometers should not exceed 0.02 lb.)

NOTE ON FLYING CONTROL HYDRAULIC (See Sketch Opposite).

The flying controls are operated by two independent but practically identical hydraulic systems, A & B, each system having in parallel a pump driven by the Port engine and a pump driven by the starboard engine.

Whereas each system contains a number of actuators and servo units in parallel, as detailed in the following table, only one actuator has been drawn in the sketch:-

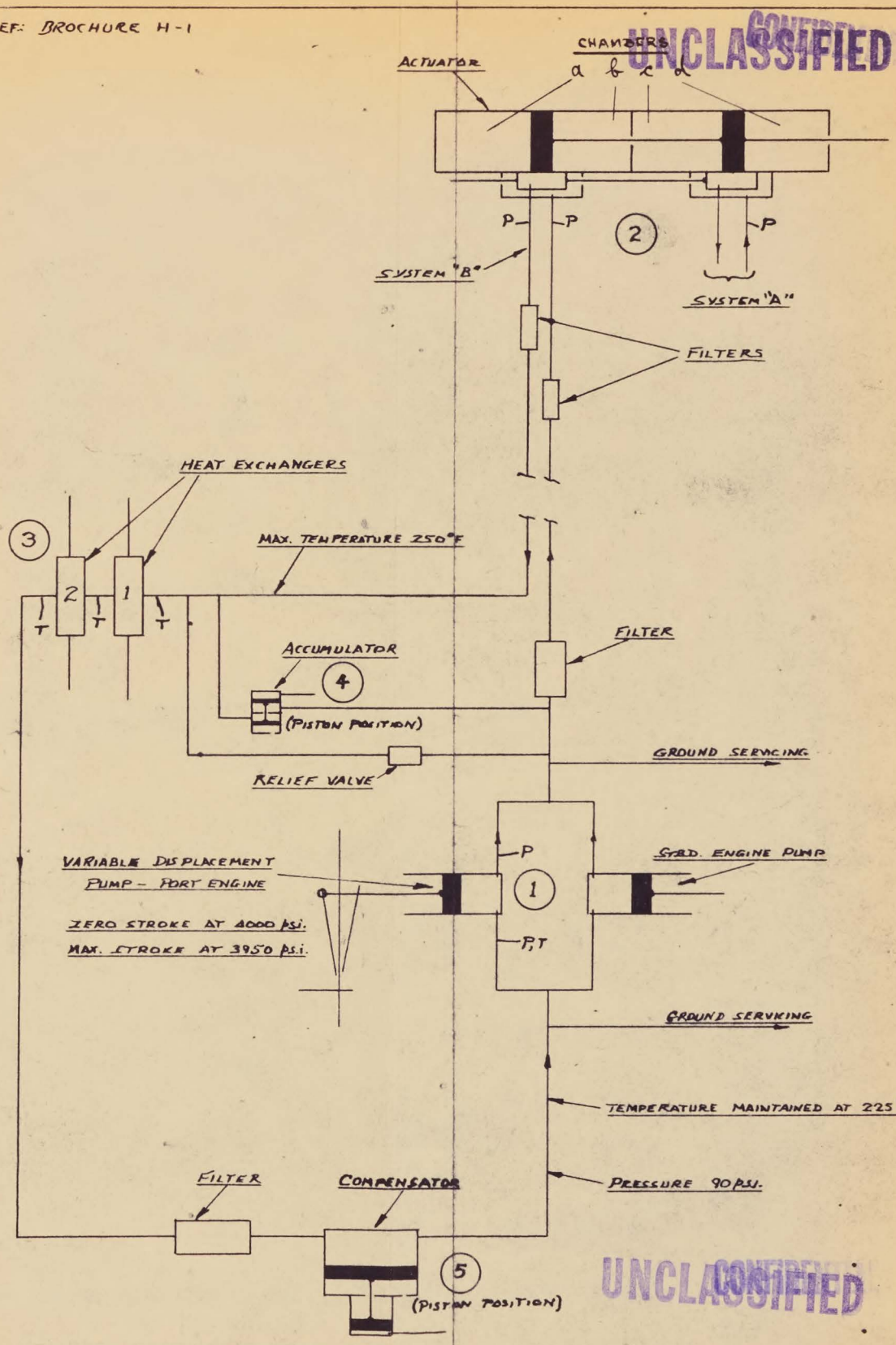
System "A"	System "B"
Port Elevator Jack.	Port Elevator Jack. Port Elevator Damper Servo.
Stbd Elevator Jack.	Stbd Elevator Jack. Stbd Elevator Damper Servo.
Port Aileron Jack.	Port Aileron Jack. Port Aileron Damper Servo.
Stbd Aileron Jack.	Stbd Aileron Jack. Stbd Aileron Damper Servo.
Rudder Jack. Rudder Emergency Damper Servo.	Rudder Jack. Rudder Damper Servo. Elevator Parallel Servo. Aileron Parallel Servo.

The control surface actuator jacks are each composed of two units in tandem as indicated in the sketch, one unit being supplied by System "A", the other unit by System "B".

Key:

Location In Sketch	Quantities to be Measured
1.	Port engine pump - System "B" Pump inlet temp. and pressure: pump outlet pressure.
2.	Port elevator, port aileron, and rudder jacks. System "A" valve inlet pressure: System "B" valve inlet and outlet pressures. Jack internal pressures. Valve positions.
3.	Heat exchangers System "B". Inlet temperature to H. Ex. No.1: outlet temp. H. Ex. No. 1: outlet temp, H.Ex. No. 2.
4.	Accumulator piston position, System "B"
5.	Compensation piston position, System "B".

REF: BROCHURE H-1



FLYING CONTROL HYDRAULIC SYSTEM - SYSTEM "B"

INTER-DEPARTMENTAL MEMORANDUM

CONFIDENTIAL
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Ref 9777/02A/J
Date July 23, 1957
To S. E. Harper - Chief of Experimental Engineer
From J. D. Hodge, - Technical Flight Test Coordinator
Subject ARROW 1 INSTRUMENTATION FAR/C105/1 - PART 3, ISSUE 9

Herewith Issue 9 of Part 3 of FAR/C105/1, "CF-105 Instrumentation - J75 Engine Installation", superseding all previous issues of Part 3.

The Major changes from Issue 8 are as follows:-

1. Items 17 to 20 incl. have been deleted.

2. Items 58a and 63 have been added.

3. The ranges of Items 3, 4, 9 - 12, 25, 26, have been amended, and all temperature ranges have been made to conform where possible with the ranges proposed in Flight Test Dept. Memo Ref: 6360/22/J dated 25 March 1957.

All changes from Issue 8 are shown underlined in this issue.

J. D. Hodge,
Technical Flight Test
Co-ordinator

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FAR/C105/1
Part 3, Issue 9

CF105 Instrumentation (A/C Nos. 1, 2 & 3)
Part 3: J75 Engine Installation
Issue No. 9 July 23rd 1957

Note: 1. All changes introduced since Issue No. 8 are shown underlined.

2. Items 17 to 20 incl. have been deleted.

3. Items 58a and 63 have been added.

4. The majority of temperature ranges have been amended to reduce the number of different instrument ranges in the interest of simplicity and ease of calibration between flights.

1. LUBRICATION (No Sketch)

	Item	Range	Accuracy	Accuracy % of full range	Sampling Frequency
1.	Port engine oil pressure	0 to 80 psi	± 2 psi	±4%	5/min
2.	Stbd.engine oil pressure	0 to 80 psi	± 2 psi	±4%	5/min
3.	Oil Temp at port engine inlet	-75 to +250°F	±6.5°F	±2%	2/min
4.	Oil temp at Stbd.engine inlet	-75 to +250°F	±6.5°F	±2%	2/min
5.	Port engine gearbox air/oil heat exchanger inlet temperature	-75 to +500°F	±10°F	±2%	2/min
6.	Stbd.engine gearbox air/oil heat exchanger inlet temperature	-75 to +500°F	±10°F	±2%	2/min

2. ENGINE CONDITIONS (No Sketch)

7.	Port engine power lever position+	0 to 100 deg.	± 1 deg.	±1%	2/min
8.	Stbd.engine power lever position+	0 to 100 deg.	± 1 deg.	±1%	2/min
9.	Port engine L.P. compressor R.P.M.‡	0 to 110%		±0.5%	12/min
10.	Stbd.engine L.P. compressor R.P.M.‡	0 to 110%		±0.5%	12/min
11.	Port engine H.P. compressor R.P.M. ✱	0 to 110%		±0.5%	12/min
12.	Stbd.engine H.P. compressor R.P.M. ✱	0 to 110%		±0.5%	12/min
13.	Port engine intake static pressure (P_{s_2})	0 to 30 psia	±0.3 psi	±1%	20/sec
14.	Stbd.engine intake static pressure (P_{s_2})	0 to 30 psia	±0.3 psi	±1%	20/sec
15.	Port engine intake total head pressure (P_{t_2})	0 to 30 psia	±0.3 psi	±1%	12/min
16.	Stbd.engine intake total head pressure (P_{t_2})	0 to 30 psia	±0.3 psi	±1%	12/MIn

+ To be measured at the engine end of the flexible drive to the engine.
‡ Visual indication of both L.P. compressor speeds is required in pilot's cockpit if possible
✱ Visual indication of both H.P. compressor speeds is a definite requirements in the pilot's cockpit.

2. ENGINE CONDITIONS (cont'd)

	Item	Range	Accuracy	Accuracy % of full range	Sampling Frequency
17. 18. 19. 20.	DELETED				
21.	Turbine discharge press. (P_{t_7}) Port	0 to 45 psia	±0.45 psi	±1%	12/min
22.	Turbine discharge press. (P_{t_7}) Stbd.	0 to 45 psia	±0.45 psi	±1%	12/min
23.	Turbine discharge temp. (T_{t_7}) Port.	0 to 1400° F	±14F°	±1%	12/min
24.	Turbine discharge temp. (T_{t_7}) Stbd.	0 to 1400° F	±14F°	±1%	12/min
25.	L.P. compressor inlet temp. (T_{t_2}) Port	-75 to+350°F	±4F°	±1%	12/min
26.	L.P. compressor inlet temp. (T_{t_2}) Stbd.	-75 to+350°F	±4F°	±1%	12/min
26a	Bleed valve shut indication++				Cont. ind.

++ Wiring provision only, to auto observer. For ground test only.

3. FUEL FLOW (no sketch)

27.	Fuel weight flow to port engine	600 to 25,000 lb/hr	±125 lb/hr	±0.5%	12/min
28.	Fuel weight flow to Stbd.engine	600 to 25,000 lb/hr	±125 lb/hr	±0.5%	12/min
29.	Fuel temp. at inlet to port engine burner	-75 to +350°F	±8°F	±2%	2/min
30.	Fuel temp. at inlet to stbd.engine burner	-75 to +350°F	±8°F	±2%	2/min

4. COOLING (see fig. 1)

(Port engine only except item no. 58 q.v.)

Unless otherwise stated, structural temperatures are required at the locations listed.

Item	Range	Accuracy	Accuracy % of full range	Sampling Frequency
31. Centre rear mount, station 711	0 to 1000°F	± 10°F	± 1%	1/min
32. Former below turbine (on upper flange)	0 to 500°F	± 5°F	± 1%	1/min
33. On hat section at T1-24ST shroud joint at Stn. 698	0 to 500°F	± 5°F	± 1%	1/min
34. Top inboard shroud (on outer surface of shroud) at Stn.742	0 to 500°F	± 5°F	± 1%	1/min
35. Top inboard shroud (on outer surface of shroud) at Stn.780	0 to 500°F	± 5°F	± 1%	1/min
36. Top of titanium former (shroud) at Stn. 803	0 to 500°F	± 5°F	± 1%	1/min
37. Shroud at bolt from lower latch at Stn. 803	0 to 500°F	± 5°F	± 1%	1/min
38. Top of shroud inner flange at Stn. 803	0 to 500°F	± 5°F	± 1%	1/min
39. Top of shroud inner flange at kink, Stn.803	0 to 500°F	± 5°F	± 1%	1/min
40. Inner surface of slitter on slitter ℄ Stn.855	0 to 1000°F	± 20°F	± 2%	5/min
41. Inboard, shroud (on outer surface, on engine ℄) Stn. 836	0 to 500°F	± 10°F	± 2%	5/min
42. Air temp. top rear compressor, zone 1	0 to 500°F	± 5°F	± 1%	1/min
43. Air temp. under turbine, zone 2	0 to 500°F	± 5°F	± 1%	1/min
44. Air temp. above turbine, zone 2	0 to 500°F	± 5°F	± 1%	1/min
45. Air temp. above engine, zone 2, stn. 803	0 to 500°F	± 5°F	± 1%	1/min
46. Air temp. below engine, zone 2, stn. 803	0 to 500°F	± 5°F	± 1%	1/min
47. Ambient air temp. forward of parachute bay (not shown in fig)	0 to 500°F	± 5°F	± 1%	1/min
48. Engine can next centre rear mount, Stn. 710	0 to 1000°F	± 10°F	± 1%	1/min
49. Lower side of engine can, Stn. 710	0 to 1000°F	± 10°F	± 1%	1/min
50. Top flange of I-beam on ℄ through heat exchangers Stn. 592¥	0 to 500°F	± 5°F	± 1%	1/min
51. Top flange of former directly below firewall, stn. 663	0 to 500°F	± 5°F	± 1%	1/min
52. Structure 3 1/2" aft of aux. ejector (inner surface of lower skin) Stn. 663	0 to 500°F	± 5°F	± 1%	1/min

¥ On beam, as near to top as possible

4. COOLING (cont'd)

Item	Range	Accuracy	Accuracy % of full range	Sampling Frequency
53. Blow-in doors outside of bend of lower hose, at Stn. 673	0 to 1000°F	± 10°F	± 1%	1/min
54. Lower longeron engine bay, Stn. 591 (Not shown in fig.)	0 to 500°F	± 5°F	± 1%	1/min
55. Bottom of light frame (on web) at Stn. 586 (Not shown in fig.)	0 to 500°F	± 5°F	± 1%	1/min
56. Bottom of light frame (on web) at Stn. 656 (Not shown in fig.)	0 to 500°F	± 5°F	± 1%	1/min
57. Gills shut indication lights, port, 2 * per engine	* One on side gills indicating "shut - not shut"; one on oil cooler gill, at the bottom, indicating "shut - fully open"			Cont.
58. Gills shut indication lights, stbs. 2 * per engine				Cont.
58a Air temperature, alternator exhaust (Not shown in fig.)	75 to 500°F	± 6°F	± 1%	5/min

5. STATIC PRESSURES (see fig. 1.)

(Port engine only)

59. Top centre compressor, differential between zone 1 and 2.	5 to 20 psid	±0.25 psi	± 1%	6/min
60. Zone 2, top rear compressor	0 to 35 psia	±0.35 psi	± 1%	6/min
61. Zone 2, bottom mid section of tailpipe	0 to 35 psia	±0.35 psi	± 1%	6/min
62. Differential between zone 2 and parachute bay at centre fuselage (not shown in fig.)	5 to 5 psid	±0.1 psi	± 1%	6/min
63. Differential in ejector shroud, rel. to ambient. Between Stns. 820 & 825 at bottom of shroud	3 to 0 psig‡	±0.05 psi	± 2%	6/min

‡ Actual differential pressure range may be -3 to +18 psi.

CF-105 INSTRUMENTATION - ISSUE 7

FUEL SYSTEM

Changes from issue no. 5 are indicated either by being underlined or by a vertical line in the margin.

1. LIST OF INSTRUMENTATION

Numbers refer to location in system, see Figs. 1, 2 and 3, which show Layout of Fuel Tanks, Fuel Transfer System, and Fuel Tank Pressurization System, respectively. Locations 1 to 8 correspond to fuel tanks 1 to 8.

T - instrument to measure temperature.

P - instrument to measure pressure.

Q - instrument to measure fuel contents of tank.

M - instrument to measure mass flow of fuel.

Location See Sketches	Instruments Required			Description
1			Q	forward fuselage tank.
2		P	Q	rear fuselage tank.
3	T		Q	temperature in stbd. wing only, contents in port and stbd. tanks.
4			Q	port and stbd. wing tanks.
5	T	P	Q	temperature and pressure in stbd. tank only. Contents in port and stbd. tanks.
6			Q	port and stbd. wing tanks.
7		P	Q	pressure in stbd. tank only. Contents port and stbd.
8			Q	port and stbd. tanks.
9	T			fuel entering H.E., stbd. line.
10		P	M	fuel to port engine/AB combination.
11	T	P	M	fuel to stbd. engine/AB combination.
12	T			pressurization air entering tank.

(Continued/...

(Continued/...

2. SUMMARY

2.1 Temperature

Instrument	Range (°F)	Accuracy (F°)	Accuracy (% of Range)	Recording Frequency
T5	-65 +160	±5	2%	2/min
T9	-65 +200	±5	±2%	2/min
T11	-65 +250	±5	2%	1/min
T3	-65 +185	±5	2%	1/min
T12	-65 +350	±5	2%	1/min

2.2 Pressure

Instrument	Range (psia)	Accuracy (psi)	Accuracy (% of Range)	Recording Frequency
P2	0-30	±0.5	2%	1/min
P5	0-35	±0.5	2%	10/min
P7	0-30	±0.5	2%	1/min
P10	0-75	±2	2%	2/min
P11	0-75	±2	2%	2/min

(Continued/...

(Continued/...

2.3 Fuel Contents (This information has been added since Issue 4)

Instrument	Range (Gals.)	Accuracy (Gals.)	Accuracy (% of Range)	Recording Frequency
Q1	0-277	± 6	± 2%	1/Min.
Q2	0-281	± 6	± 2%	1/Min.
Q3 Port	0-151	± 3	± 2%	1/Min.
Stbd.	0-151	± 3	± 2%	1/Min.
Q4 Port	0-90	± 2	± 2%	1/Min.
Stbd.	0-90	± 2	± 2%	1/Min.
Q5 Port	0-146	± 3	± 2%	6/Min.
Stbd.	0-146	± 3	± 2%	6/Min.
Q6 Port	0-154	± 3	± 2%	1/Min.
Stbd.	0-154	± 3	± 2%	1/Min.
Q7 Port	0-279	± 6	± 2%	1/Min.
Stbd.	0-279	± 6	± 2%	1/Min.
Q8 Port	0-173	± 4	± 2%	1/Min.
Stbd.	0-173	± 4	± 2%	1/Min.

2.4 Mass Flow

The total flow to each engine is required (see locations 10 and 11). This may be measured as the total to each engine/afterburner combination or as the separate flows to afterburner and engine; whichever is most convenient.

The range of flows to be covered is as follows (for J.75 engine):

Engine only, 600-25,000 lbs/hr, accuracy 1% of max. i.e. ±250 lbs.

Afterburner only, 5000-65,000 lbs/hr, accuracy 1% of max. i.e. ±650 lbs.

Total Flow: 2000-90,000 lbs/hr.

LAYOUT OF FUEL TANKS SHOWING
STARBOARD WING ONLY

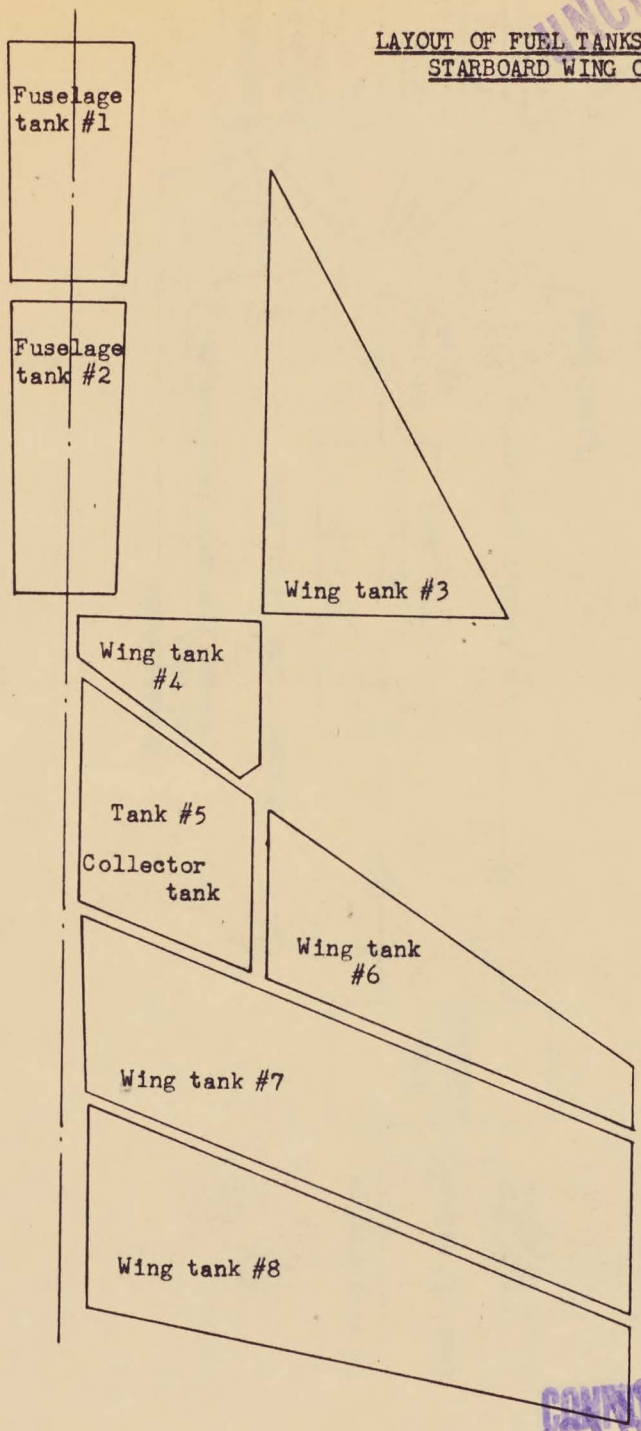
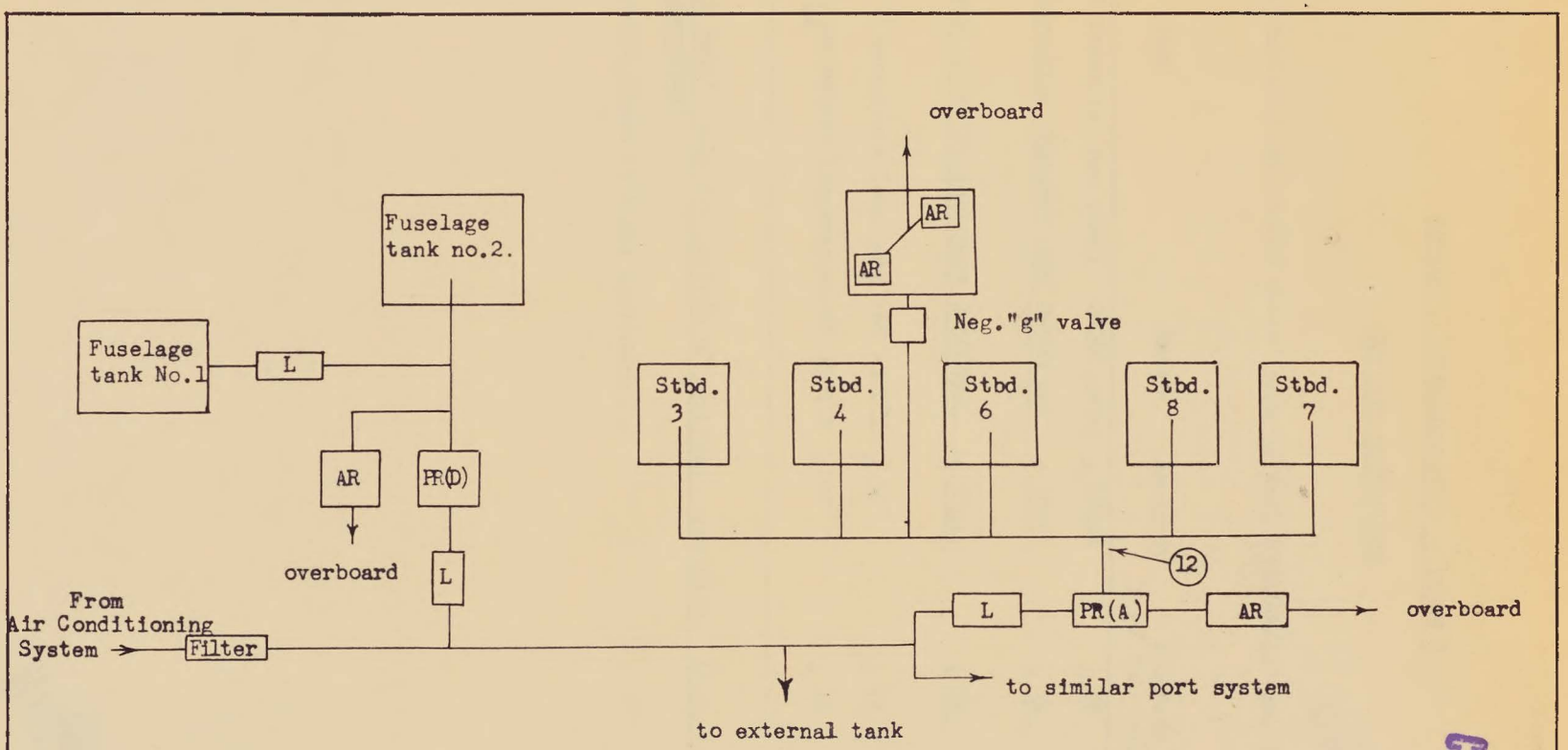


FIG. I



L - Air flow limiter
PR (D) - Pressure regulating valve (differential)
PR (A) - Pressure regulating valve (absolute)
AR - Air relief valve

CONFIDENTIAL

CONFIDENTIAL

FUEL TANK PRESSURISATION SYSTEM

Ref: Drawing No. 7-1600-40

FIG. 3

November, 1956.

CF-105 - INSTRUMENTATION - ISSUE 7

UTILITY HYDRAULICS

Items underlined are added since Issue 5, Ref. 6302/22/J, Jan. 3, 1956.

	Item	Range	Accuracy	Accuracy % of full range	Sampling Frequency
1.	Pump inlet pressure (one pump)	0-200 psia	± 10psi	± 5%	10/sec
2.	Pressure Regulator "Return" port press.	0-500 psi	± 10psi	± 2%	Cont. *
3.	Pressure Regulator "System" port press.	0-5000psi	± 50psi	± 1%	Cont. *
4.	Pump inlet temperature (one pump)	-65 +300°F	± 5F°	± 1%	2/min
5.	Brake cylinder return temperature (one off) **	-65 +500°F	±10F°	± 2%	1/sec

* Recordings requ'd only for periods of equipment operation. (i.e., U/c up or down and S/B operation)

** To be measured close to brake cylinder.

Avro Aircraft Limited

INTER-DEPARTMENTAL MEMORANDUM

Ref 6549/02A/J.
Date March 29, 1957.
To Mr. S.E. Harper - Chief Experimental Engineer
From J.D. Hodge - Technical Flight Test Co-ordinator
Subject ARROW I INSTRUMENTATION - PART 6 - ISSUE 8

Herewith Issue 8 of Part 6 of "CF-105 Instrumentation" covering the air conditioning system. It will be noted that in most cases this amounts to a re-location of the instruments as a result of ground-rig tests.

This replaces Issue 7 of Part 6, November 27th, 1956.

J.D. Hodge,
Technical Flight Test
Co-ordinator

JDH/h

cc Messrs: J.C. Floyd, R.N. Lindley, J.A. Chamberlin, G. Hake, F.H. Brame, W.D Raymond, F.P. Mitchell, K. Korsak, H. Malinowski, S. Whiteley, S. Kwiatkowski, I. Craig, G. Shaw, W.S. Sloan, E. Duret, J.C. McKillop, B. Wood, S. Brown, J. Cleminson, D.N. Scard (6), A. Crust (9), R. Young (2), Aero Files, Central Files (2)

March, 1957.

CF-105 - INSTRUMENTATION - ISSUE 8

AIR CONDITIONING SYSTEM

Items underlined are changed from Issue 7, Ref. 4028/02A/J, November 2[illegible], 1956.

1. LIST OF INSTRUMENTATION

Number indicates location in system, see sketch.

T - instrument to measure temperature.

P_s - instrument to measure static pressure.

P_t - instrument to measure total head pressure.

ΔP - $P_t - P_s$.

Location See Sketch	Instruments Required	Description
1	T P_s	As close to Port engine bleed as possible.
2	P_s	Downstream from the reducing valve on Port engine line at such a distance that the valve does not affect the measurement.
3	T P_s ΔP	Mass flow for fuel pressurization system.
4	T P_t	Turbine inlet conditions.
5	T P_s (rake)	Turbine outlet conditions. The temperature probe should be located downstream from the turbine outlet at the junction point.
6	T RPM	Fore and aft bearing temperatures and shaft R.P.M.
7A	T	Cabin inlet (at temperature sensor).
7B	T P_s ΔP	Mass flow from cabin. Measure temperature at sensor and pressure downstream from this.
8	T P_s	Cabin conditions. Temperature to be measured at six points.
9	T P_s or P_t (rake)	As closed as possible to fan inlet. (Static or total may be measured)
10	T P_s or P_t (rake)	As close as possible to fan outlet. (Static or total may be measured)
11	T	Ram air exit.
12	T	In equipment duct.

(Continued.....

2. SUMMARY

2.1 Temperature

Instrument	Range (°F)	Accuracy (F°)	Accuracy (% of Range)	Recording Frequency
T1	+100 +1000	±10	1%	1/sec
T3	-20 +400	±5	1%	5/min
T4	-20 +250	±5	2%	5/min
T5	-30 +100	±4	2%	5/min
T6	0 +500	(to be built into turbine unit)		2/min
T7A&B	-20 +130	±5	3%	5/min
T8 (6 off)	0 +200	±2	1%	
T9	0 +500	±10	2%	5/min
T10	0 +600	±10	2%	5/min
T11	0 +500	±10	2%	5/min
T12	0 +140	±5	3%	5/min

2.2 Static Pressure

Instrument	Range (psia)	Accuracy (psi)	Accuracy (% of Range)	Recording Frequency
P_s1	0-360	±10	2%	1/sec
P_s2	0-100	±1	1%	1/sec
P_s3	0-100	±1	1%	5/min
P_s5 (rake)	0-20	±0.2	1%	5/min
P_s7	0-20	±0.2	1%	5/min
P_s8	0-20	±0.1	0.5%	1/sec
P_s9 (rake)	0-20	±0.2	1%	5/min *
P_s10(rake)	0-20	±0.2	1%	5/min *

* Note: Either static or total may be measured.

(Continued.....

2.3 Total Head Pressure

Instrument	Range	Accuracy (psi)	Accuracy (% of Range)	Recording Frequency
$\Delta P3$	0-5 psi	± 0.25	5%	5/min
$P_t 4$	0-100 psia	± 1	1%	5/min
$\Delta P7$	0-1 psi	± 0.05	5%	5/min
$P_t 9$ rake	0-30 psia	± 0.3	1%	5/min *
$P_t 10$ rake	0-30 psia	± 0.3	1%	5/min *

* See note Page 23.

2.4 Miscellaneous

In addition, it is required to measure turbine R.P.M., see location 6 in sketch. As in the case of bearing temperature, transducers will be built into the unit by AIResearch.

The sampling rate required for turbine R.P.M. is 5/sec.

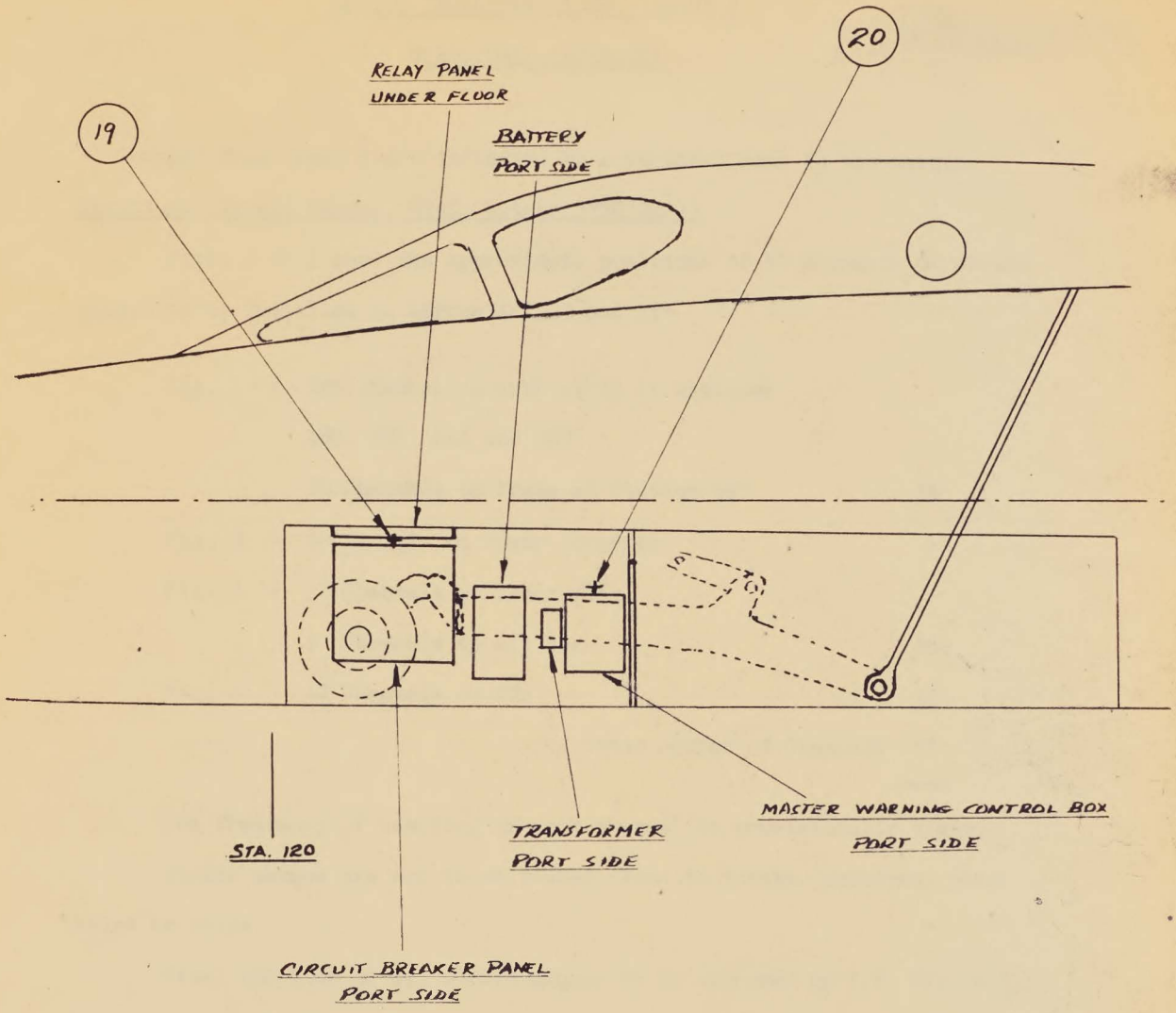
CF-105 - INSTRUMENTATION - ISSUE 7

ELECTRICS

Items which have been added or changed since Issue 5, Ref. 6219/22/J, Dec. 27/55 are underlined in the following list:

	Item	Range	Accuracy	Accuracy % of full range	Sampling Frequency
1.	Temp of aft bearing - port alternator.	-70 +450°F	±10F°	± 2%	2/min
2.	Voltage A Ø port alternator.	0-130VAC	± 0.75V	± 0.5%	1/min
3.	Voltage B Ø port alternator.	0-130VAC	± 0.75V	± 0.5%	1/min
4.	Voltage C Ø port alternator.	0-130VAC	± 0.75V	± 0.5%	1/min
5.	Voltage A Ø stbd alternator.	0-130VAC	± 0.75V	± 0.5%	1/min
6.	Voltage B Ø stbd. alternator.	0-130VAC	± 0.75V	± 0.5%	1/min
7.	Voltage C Ø stbd. alternator.	0-130VAC	± 0.75V	± 0.5%	1/min
8.	Current A Ø port alternator.	0-80A	± 0.4A	± 0.5%	1/min
9.	Current B Ø port alternator.	0-80A	± 0.4A	± 0.5%	1/min
10.	Current C Ø port alternator.	0-80A	± 0.4A	± 0.5%	1/min
11.	Current A Ø stbd. alternator.	0-80A	± 0.4A	± 0.5%	1/min
12.	Current B Ø stbd. alternator.	0-80A	± 0.4A	± 0.5%	1/min
13.	Current C Ø stbd. alternator.	0-80A	± 0.4A	± 0.5%	1/min
14.	D.C. voltage of trans rect unit port.	0-32VDC	± .16V	± 0.5%	1/min
15.	D.C. voltage of trans rect unit stbd.	0-32VDC	± .16V	± 0.5%	1/min
16.	D.C. current of trans rect unit port.	0-135A	± .75A	± 0.5%	1/min
17.	D.C. current of trans rect unit stbd.	0-135A	± .75A	± 0.5%	1/min
18.	Exhaust temp of T.R.U.S. (one unit only).	0-200°F	± 4F°	± 2%	1/min
19.	Temp of N.W. well, above circuit breaker (See Fig. 1)	0-200°F	± 4F°	± 2%	1/min
20.	Temp of N.W. well, above master warning box (See Fig. 1)	0-200°F	± 4F°	± 2%	1/min
21.	Temp of electrical bay. *	-70 +275°F	± 7F°	± 2%	1/min
22.	Temp of main wheel well (one side only) above brakes.	0-450°F	± 9F°	± 2%	1/min (after retracting wheels for 15 mins.)

* To be measured above the power box (aft of Sta. 485).



SKETCH OF NOSE WHEEL WELL

SHOWING ELECTRICAL EQUIPMENT AND

POSITION OF THERMOCOUPLES

FIG. 1

October, 1956.

CF-105 INSTRUMENTATION - ISSUE 7

STRUCTURAL INTEGRITY

Changes from Issue 5 are indicated by a vertical line in the margin.

Structural Strain Gauges. (Ref. Letter 3770/22/J)

Figs. 1 to 4 show the approximate positions of 52 channels of strain gauges to be installed in aircraft 1, 2 and 3:-

Fig. 1 -	One channel on each strut at stations 485, 591, 644 and 697	
	10 Channels on frame at Station 697	18
Fig. 2 -	6 Channels on lower longeron	6
Fig, 3 -	12 Channels on inner wing	
	4 Channels on aft box	16
Fig. 4	12 Channels on fin	12
	Total number of Channels	52

The frequency of sampling in each channel is provisionally 5/sec.

Strain gauges are not to be placed close to joints, doublers, rivet holes or bolts.

Final position of all strain gauges to be approved by F.P. Mitchell, Chief Stress Engineer.

Vibration Pick-Up Accelerometers (to be installed in aircraft 1 & 2 only)

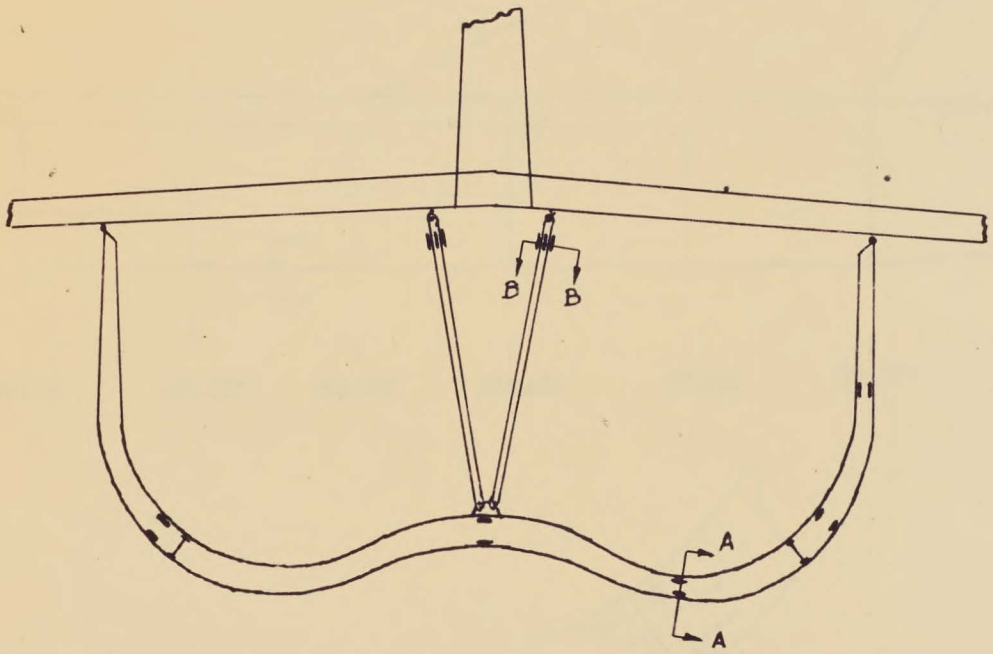
Figure 5 shows the approximate location of 57 vibration pick-up accelerometers; the precise location is to be obtained from J. McKillop of the Aerodynamics Department. The required range is -10 to +10 g with an accuracy of ± 0.25 g, and the instruments should be capable of recording. frequencies up to 60 cycles/sec.

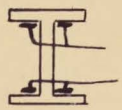
Airborne continuous trace recording of all accelerometers is required and telemetering of each should be possible (but not simultaneously). During normal flight testing, telemetering of only two accelerometers will be required, and then only if control surface characteristics are being telemetered for the stability programme; if this is not being done then the telemetering of two accelerometers only will provide no useful information and may be dispensed with.

During a specific flutter programme, the requirement for telemetry of accelerometers may be greater, the number required being dependent on the availability of telemetry channels.

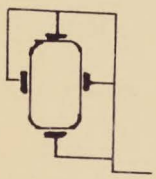
C/S FRAME & STRUTS AT STATION 697

ALSO STRAIN GAUGE STRUTS AT STATIONS - 485, 591, & 644





SECTION A-A

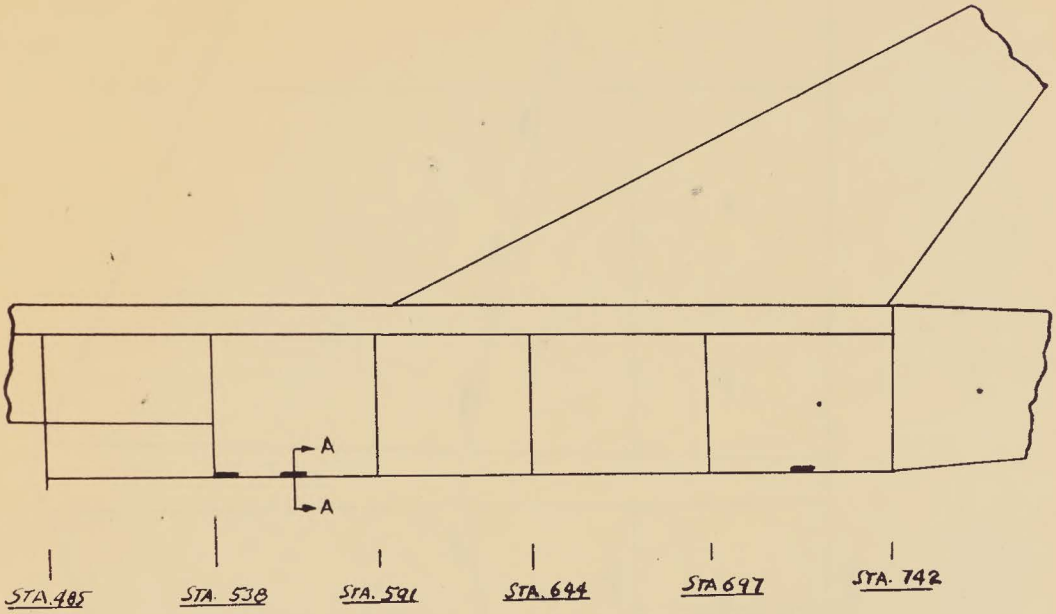


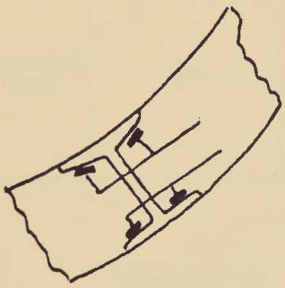
SECTION B-B

NUMBER OF CHANNELS ON FRAME - 10

TOTAL NUMBER OF CHANNELS ON STRUTS - 8

FIG. 1



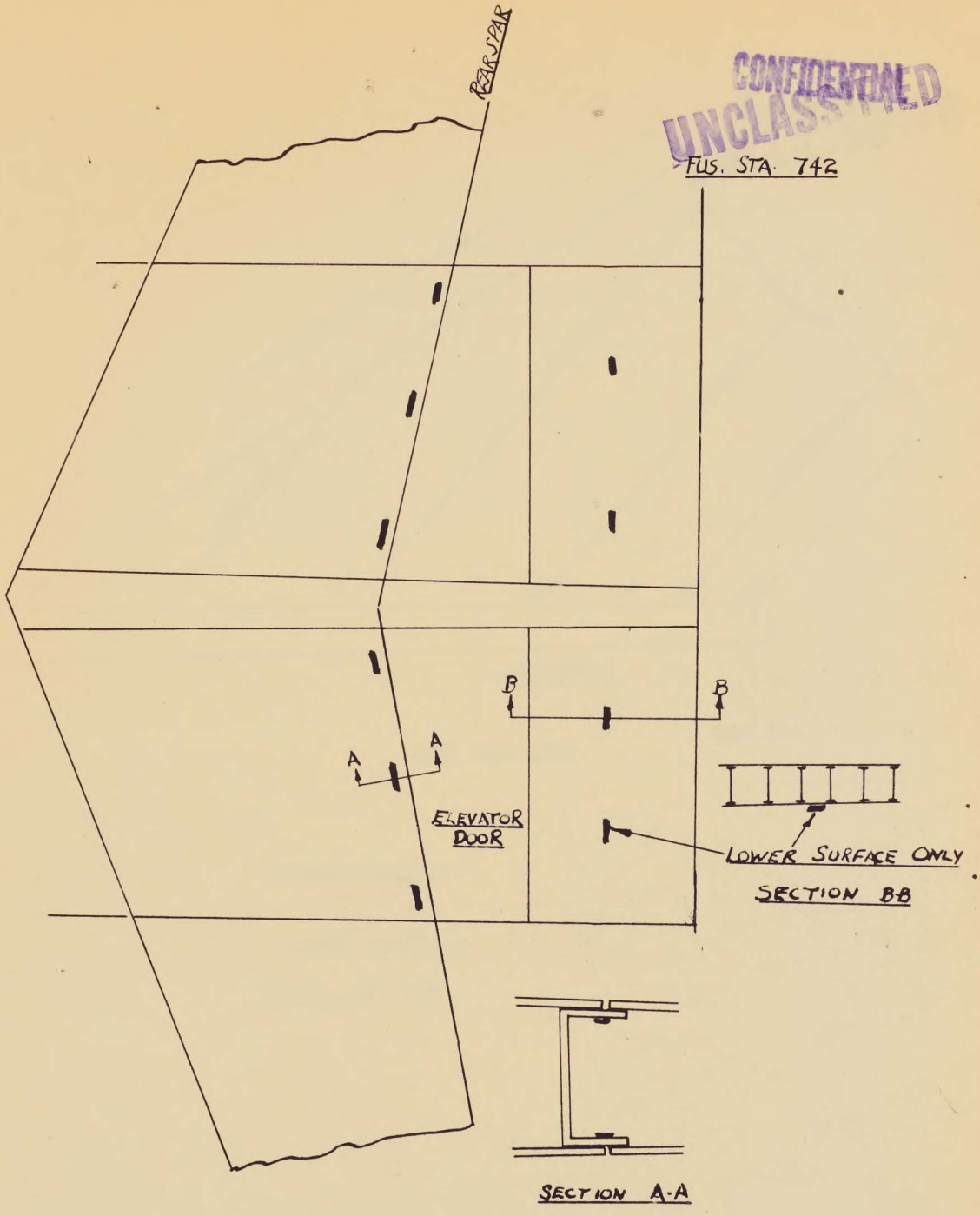


SECTION A-A

LOWER LONGERON - ONE SIDE ONLY

NUMBER OF CHANNELS - 6

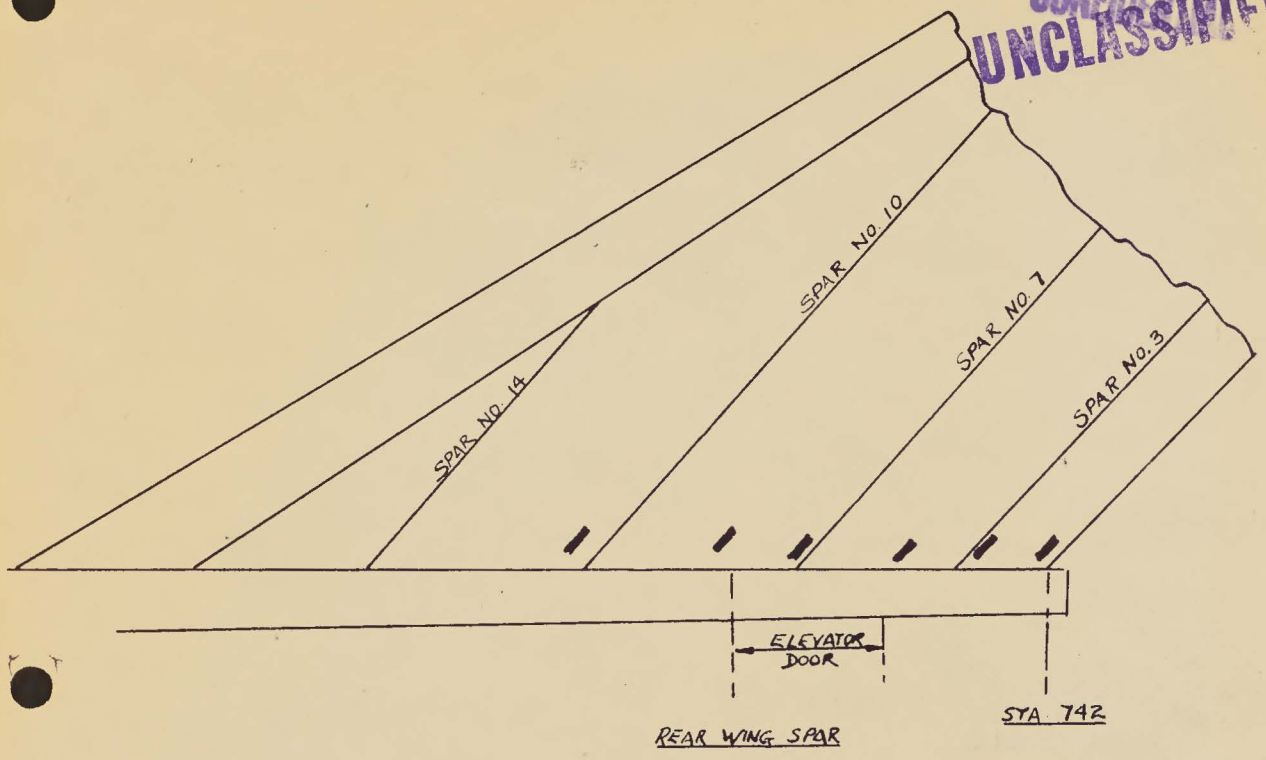
FIG. 2

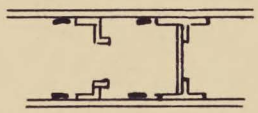


INNER WING & AFT BOX

TOTAL NUMBER OF CHANNELS - 16

FIG. 3





TYPICAL SECTION

FIN

NUMBER OF CHANNELS - 12

FIG. 4

CF-105 - INSTRUMENTATION - ISSUE 7

UNDERCARRIAGE

No changes have been made in this instrumentation list since issue no. 5, ref. 6355/22/J, dated January 5, 1956.

	Item	Range	Accuracy	Accuracy % of full range	Sampling Frequency
1.	U/C leg acceleration fore and aft (port undercarriage) *	-75 +75g	± 3g	± 4%	50/sec
2.	U/C leg acceleration fore and aft (starboard undercarriage) *	-75 +75g	± 3g	± 4%	50/sec

* Accelerometer should be mounted on the lower end of the undercarriage leg, close to the wheels.

Avro Aircraft Limited UNCLASSIFIED

INTER-DEPARTMENTAL MEMORANDUM

Date December 21, 1956. Reference: 4510/02B/J
To Mr. S.E. Harper
From John Morris
Subject CF105, INSTRUMENTATION, ISSUE NO. 7

In section 1 "Stability and Control" of CF105 Instrumentation - Issue No. 7, an X mark, indicating that provision should be made for telemetery, was omitted from the following items.

Item numbers: 1 (complete range), 2 (complete range), 5, 7, 11, 12, 14, 15, 16 (complete range), 17, 18 (complete range), 19 (complete range), 20, 21 (complete range), 22 (complete range), 23, 34 to 42 inclusive.

The definition of the symbol X given on sheet no. 1 of the instrumentation schedule is to be ammended to read as follows:

"Items marked X - Provision is to be made to telemeter each of these items, but telemetery of no more than eight will be required at any one time. The required accuracy in telemetery is 3%.

John Morris,
Assistant Chief Aerodynamicist.

DNV/rs

cc Messrs: J.C. Floyd, R.N. Linuley, J.A. Chamberlin, G. Hake, F. Brame, F.P. Mitchell, K. Korsak, H. Malinowski, S. Whitely, S. Kwiatkowski, I. Craig, G. Shaw, W.S. Sload, E. Duret, J.C. McKillop, B. Wood, S. Brown, J. Cleminson

A. Crust (9)
R. Young (2)
Aero Files
Central Files (2)