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CF-105 A/C Nos. 1, 2, 3, FAR/C105/1  
CF-105 INSTRUMENTATION  
ISSUE NO. 7  
**UNCLASSIFIED** Nov. 1956

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INTER-DEPARTMENTAL MEMORANDUM

Date November 27, 1956.  
 To Mr. S.E. Harper - Chief Experimental Engineer.  
 From John Morris - Assistant Chief Aerodynamicist.  
 Subject CF-105 INSTRUMENTATION - ISSUE NO. 7.

Reference: 4028/02A/J.

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).....

*[Handwritten Signature]*  
 signature.....Rank.....

*[Handwritten Signature]*

DNV/ah

John Morris,  
 Assistant Chief Aerodynamicist.

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AIRCRAFT: **CF-105**

REPORT NO. \_\_\_\_\_

FILE NO. \_\_\_\_\_

NO. OF SHEETS: \_\_\_\_\_

TITLE:

CF-105 INSTRUMENTATION

ISSUE NO. 7

PREPARED BY \_\_\_\_\_ DATE \_\_\_\_\_

CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

SUPERVISED BY \_\_\_\_\_ DATE \_\_\_\_\_

APPROVED BY \_\_\_\_\_ DATE \_\_\_\_\_

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| ISSUE No | REVISION No | REVISED BY | APPROVED BY | DATE | REMARKS |
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REPORT NO. \_\_\_\_\_

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Instrumentation

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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 Issue 6 applied only to the "Engine Installation" instrumentation and it also is superseded by this issue.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<sup>2</sup> from -16 to +16 ft/sec<sup>2</sup>.
- 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.

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Instrumentation

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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  $\pm 0.20$  to 0-5 psi. and  $\pm 0.25$  respectively.
- 7 - Instrument range and accuracy changed from 0-10 psi. and  $\pm 0.20$  to 0-1 psi. and  $\pm 0.05$  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 telemetry of vibration pick-up accelerometers are changed.

Section 9 Undercarriage

No change.

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CF-105 INSTRUMENTATION - ISSUE 7STABILITY 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.

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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  $\pm 3\%$ .

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

1. AMBIENT CONDITIONS (see Fig. 1)

| <u>ITEM</u>  | <u>RANGE</u>                 | <u>ACCURACY</u>              | <u>ACCURACY</u><br>% of full range | <u>SAMPLING</u><br><u>FREQUENCY</u> |
|--|------------------------------|------------------------------|------------------------------------|-------------------------------------|
| <u>Ambient Conditions</u>                                  |                              |                              |                                    |                                     |
| 1. Aircraft static pressure                                | 0 - 2160 lb/ft. <sup>2</sup> | $\pm 15$ lb/ft. <sup>2</sup> | $\pm 0.75\%$                       | 1/2 sec. X                          |
| Limited range  | 0 - 720 lb/ft. <sup>2</sup>  | $\pm 5$ lb/ft. <sup>2</sup>  | $\pm 0.75\%$                       | 1/2 sec.                            |
| Limited range  | 0 - 288 lb/ft. <sup>2</sup>  | $\pm 2$ lb/ft. <sup>2</sup>  | $\pm 0.75\%$                       | 1/2 sec.                            |
| 2. Differential pressure<br>(Total head - aircraft static) | 0 - 2880 lb/ft. <sup>2</sup> | $\pm 20$ lb/ft. <sup>2</sup> | $\pm 0.75\%$                       | 1/2 sec. X                          |
| Limited range  | 0 - 1440 lb/ft. <sup>2</sup> | $\pm 10$ lb/ft. <sup>2</sup> | $\pm 0.75\%$                       | 1/2 sec.                            |
| Limited range  | 0 - 720 lb/ft. <sup>2</sup>  | $\pm 5$ lb/ft. <sup>2</sup>  | $\pm 0.75\%$                       | 1/2 sec.                            |
| 3. Free Air Total Temperature                              | -65 +350°F                   | $\pm 2$ °F                   | $\pm 0.5\%$                        | 1/2 sec.                            |

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2. MOTION OF AIRCRAFT (see Fig. 2)

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

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3. CONTROL SURFACE MOTION (see Fig. 1)

| ITEM  | Range                            | Accuracy                           | Accuracy<br>% of full range | Sampling<br>Frequency |   |
|---|----------------------------------|------------------------------------|-----------------------------|-----------------------|---|
| 16. Port Elevator Angle $\delta_e$ *<br>Limited Range * | -30 + 20°<br>-10 + 10°           | $\pm 0.3^\circ$<br>$\pm 0.1^\circ$ | $\pm 0.5\%$<br>$\pm 0.5\%$  | Cont.<br>20/sec       | × |
| 17. Port Elevator Angular<br>Acceleration * $\delta_e$  | -200 + 200°/<br>sec <sup>2</sup> | $\pm 2^\circ/\text{sec}^2$         | $\pm 0.5\%$                 | Cont.                 | × |
| 18. Stbd Elevator Angle $\delta_e$ *<br>Limited Range * | -30 + 20°<br>-10 + 10°           | $\pm 0.3^\circ$<br>$\pm 0.1^\circ$ | $\pm 0.5\%$<br>$\pm 0.5\%$  | Cont.<br>20/sec       | × |
| 19. Port Aileron Angle $\delta_a$ *<br>Limited Range *  | -19 + 19°<br>-10 + 10°           | $\pm 0.2^\circ$<br>$\pm 0.1^\circ$ | $\pm 0.5\%$<br>$\pm 0.5\%$  | Cont.<br>20/sec       | × |
| 20. Port Aileron Angular<br>Acceleration * $\delta_a$   | -200 + 200°/<br>sec <sup>2</sup> | $\pm 2^\circ/\text{sec}^2$         | $\pm 0.5\%$                 | Cont                  | × |
| 21. Stbd Aileron Angle $\delta_a$ *<br>Limited Range *  | -19 + 19°<br>-10 + 10°           | $\pm 0.2^\circ$<br>$\pm 0.1^\circ$ | $\pm 0.5\%$<br>$\pm 0.5\%$  | Cont<br>20/sec        | × |
| 22. Angle of Rudder $\delta_r$ *<br>Limited Range *     | -30 + 30°<br>-10 + 10°           | $\pm 0.3^\circ$<br>$\pm 0.1^\circ$ | $\pm 0.5\%$<br>$\pm 0.5\%$  | Cont<br>20/sec        | × |
| 23. Angular Acceleration of<br>Rudder * $\delta_r$      | -200 + 200°/<br>sec <sup>2</sup> | $\pm 2^\circ/\text{sec}^2$         | $\pm 0.5\%$                 | Cont                  | × |
| 24. Port Airbrake Angle                                 | 0-60°                            | $\pm 2^\circ$                      | $\pm 3\%$                   | 5/sec                 |   |
| 25. Stbd Airbrake Angle                                 | 0-60°                            | $\pm 2^\circ$                      | $\pm 3\%$                   | 5/sec                 |   |

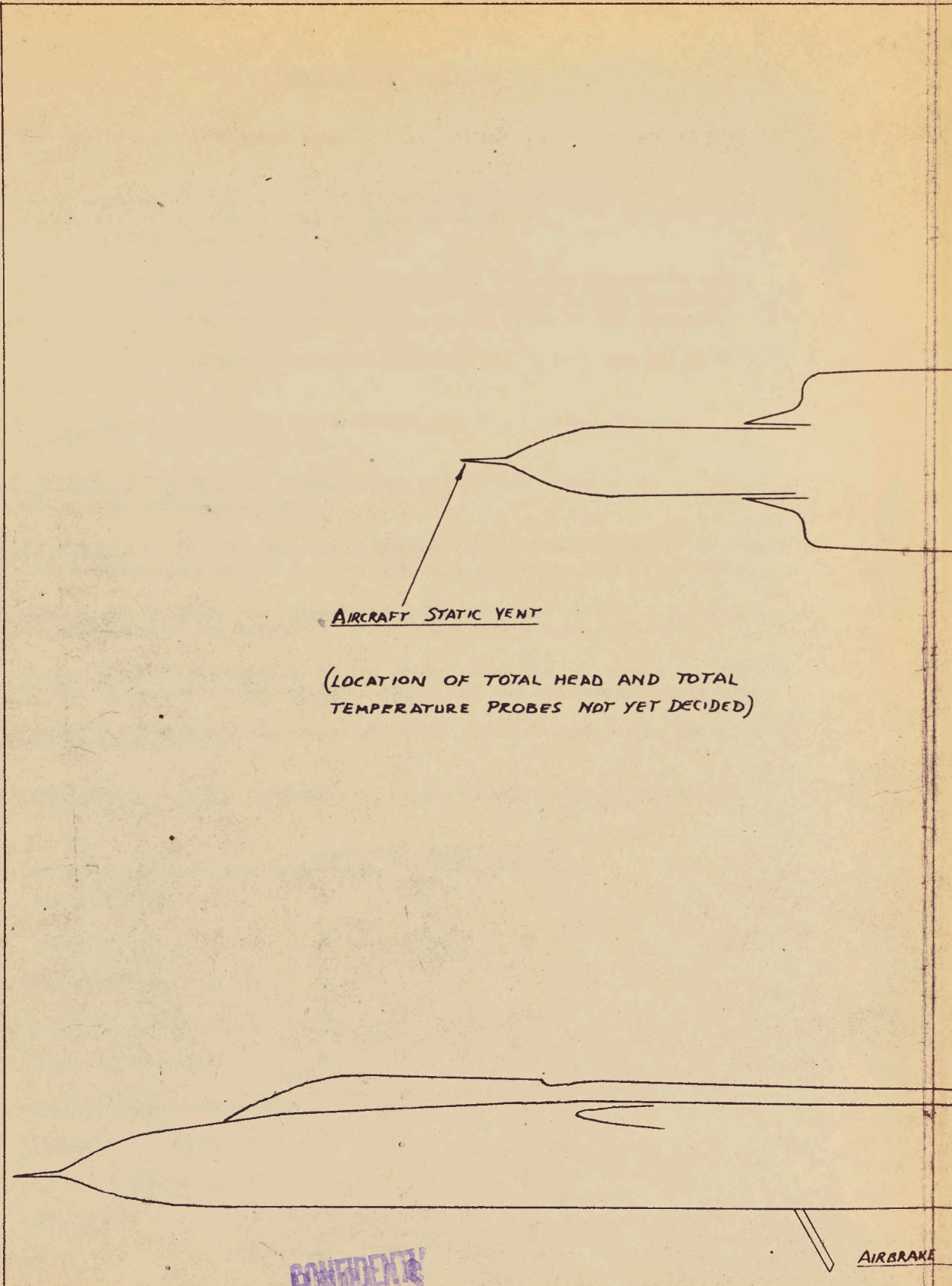
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4. CONTROL MECHANISM (see Fig. 3)CONFIDENTIAL  
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| <u>Item</u>                               | <u>Range</u> | <u>Accuracy</u> | <u>Accuracy</u><br><u>% of Full Range</u> | <u>Sampling</u><br><u>Frequency</u> |   |
|---|--------------|-----------------|---|-------------------------------------|---|
| <u>Location (1), Fig. 3</u>               |              |                 |   |                                     |   |
| 26. Elevator Stick Force                  | -80 +120 lb  | ± 2 lb          | ± 1%                                      | 10/sec                              | X |
| Limited Range                             | -20 + 40 lb  | ± 0.6 lb        | ± 1%                                      | 10/sec                              |   |
| 27. Aileron Stick Force                   | -30 + 30 lb  | ± 1 lb          | ± 1%                                      | 10/sec                              | X |
| 28. Rudder Pedal Force                    | -250 +250lb  | ± 5 lb          | ± 1%                                      | 10/sec                              |   |
| 29. Stick position Elevator               | 0 - 11"      | ± 0.2"          | ± 2%                                      | 10/sec                              |   |
| 30. Stick position Aileron                | 0 - 10"      | ± 0.2"          | ± 2%                                      | 10/sec                              |   |
| 31. Rudder Pedal Position                 | 0 - 6.65"    | ± 0.15"         | ± 2%                                      | 10/sec                              |   |
| <u>Location (2), Fig. 3</u>               |              |                 |   |                                     |   |
| 32. Elevator Parallel Servo Position      | 0 - 3"       | ± 0.06"         | ± 2%                                      | Cont.                               |   |
| 33. Aileron Parallel Servo Position       | 0 - 3"       | ± 0.06"         | ± 2%                                      | Cont.                               |   |
| <u>Location (3), Fig. 3</u>               |              |                 |   |                                     |   |
| 34. Elevator Damper Signal                |              |                 | ± 2%                                      | Cont.                               | X |
| 35. Aileron Damper Signal                 |              |                 | ± 2%                                      | Cont.                               | X |
| 36. Rudder Damper Signal                  |              |                 | ± 2%                                      | Cont.                               | X |
| 37. Emergency Rudder Damper Signal        |              |                 | ± 2%                                      | Cont.                               | X |
| 38. Port Elevator Damper Servo Position * | -0.6 +0.6"   | ± 0.01"         | ± 1%                                      | Cont.                               | X |
| 39. Stbd Elevator Damper Servo Position * | -0.6 +0.6"   | ± 0.01"         | ± 1%                                      | Cont.                               | X |
| 40. Port Aileron Damper Servo Position *  | -0.6 +0.6"   | ± 0.01"         | ± 1%                                      | Cont.                               | X |
| 41. Stbd Aileron Damper Servo position *  | -0.6 +0.6"   | ± 0.01"         | ± 1%                                      | Cont.                               | X |
| 42. Rudder Damper Servo *                 | -0.5 + 0.5"  | ± 0.01"         | ± 1%                                      | Cont.                               | X |
| <u>Location (4), Fig. 3</u>               |              |                 |   |                                     |   |
| 43. Elevator Trimmer Position             | 0 - 59°      | ± 0.5°          | ± 1%                                      | 5/sec                               |   |
| 44. Aileron Trimmer Position              | 0 - 47.1°    | ± 0.5°          | ± 1%                                      | 5/sec                               |   |
| 45. Rudder Trimmer Position               | 0 - 39°      | ± 0.4°          | ± 1%                                      | 5/sec                               |   |

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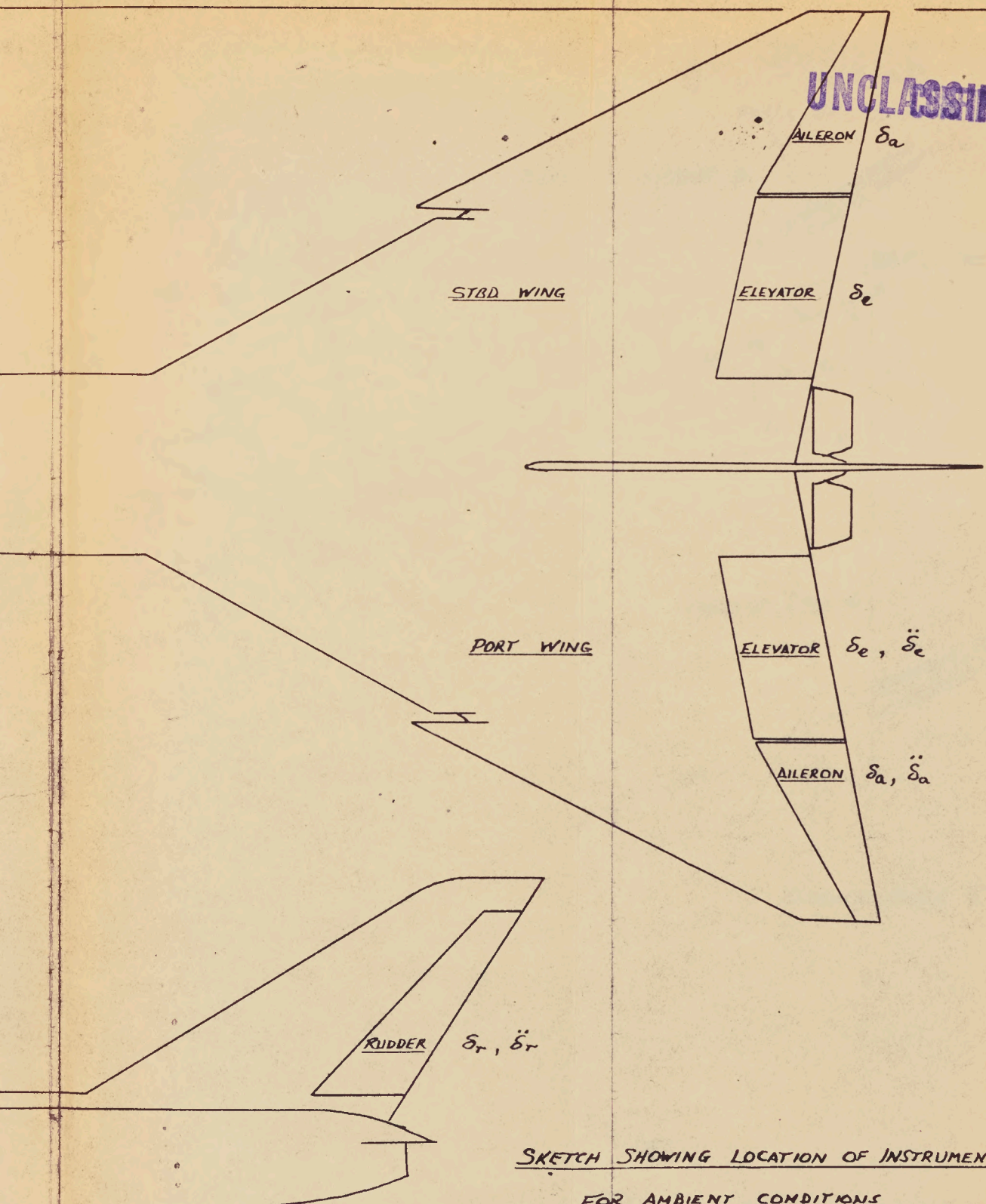
AIRCRAFT STATIC VENT

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

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SKETCH SHOWING LOCATION OF INSTRUMENTATION

FOR AMBIENT CONDITIONS

& CONTROL SURFACE MOTION

ANGLE - PORT & STBD.

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FIG. 1

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  $\theta = \angle XO'X''$ , the angle between the longitudinal datum of the aircraft and the horizontal plane.

ANGLE OF BANK  $\phi = \angle YO'Y''$ , the angle between the lateral datum of the aircraft and the horizontal plane.

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

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

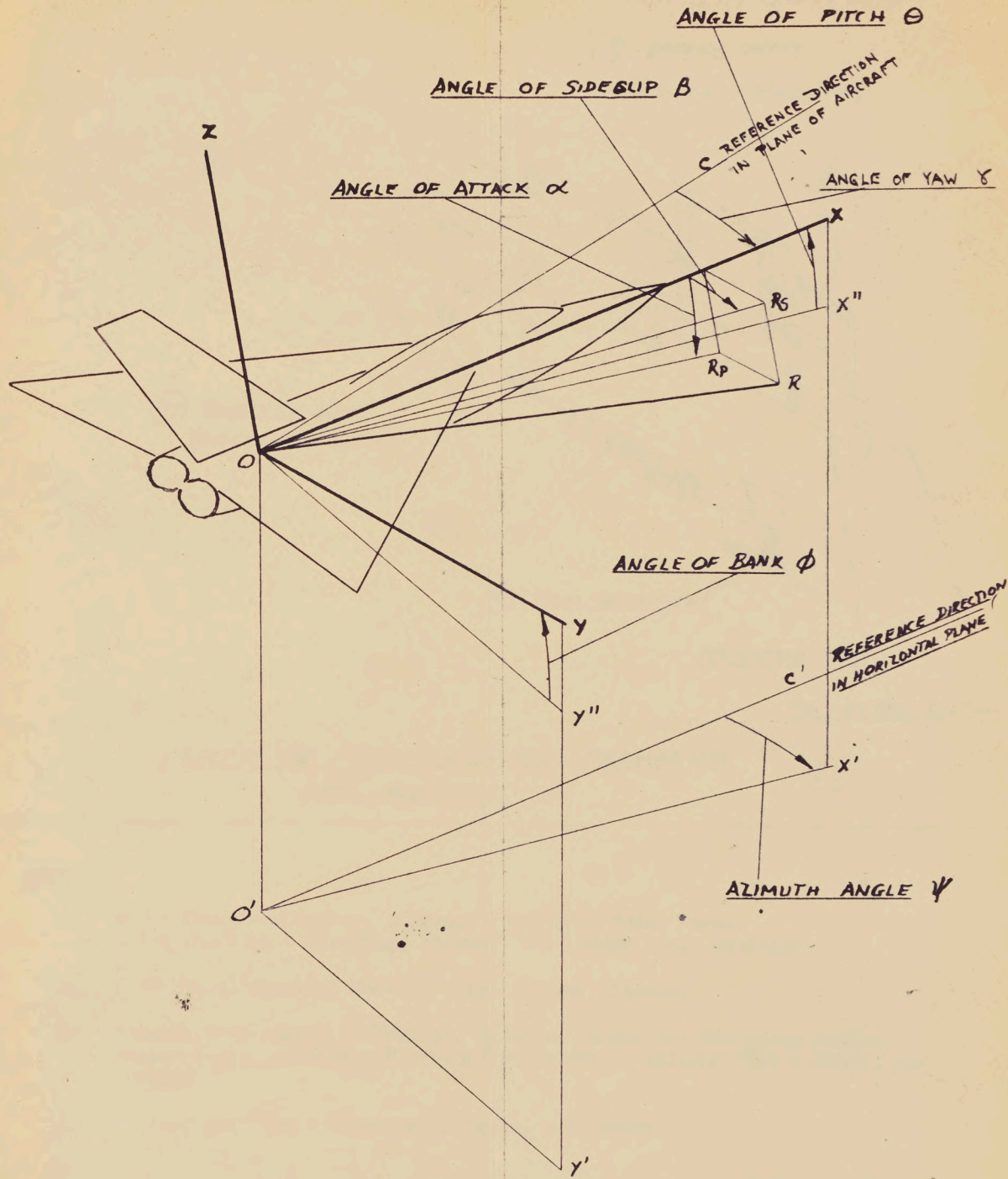
Further, let OR lie parallel to the direction of the relative wind, and let OR<sub>s</sub> and OR<sub>p</sub> be projections of OR in planes XOY and XOZ respectively, then,

ANGLE OF ATTACK  $\alpha = \angle XOR_p$ , 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            | $\theta$                  | $\dot{\theta}$ |                 |
| Angle of Bank             | $\phi$                    | $\dot{\phi}$   |                 |
| Azimuth Angle             | $\psi$                    |                |                 |
| Angle of Attack           | $\alpha$                  |                |                 |
| Angle of Sideslip         | $\beta$                   |                |                 |
| Longitudinal Acceleration |                           |                | $\ddot{X}$      |
| Lateral Acceleration      |                           |                | $\ddot{Y}$      |
| Normal Acceleration       |                           |                | $\ddot{Z}$      |
| Yaw angle                 |                           | $\gamma$       | $\ddot{\gamma}$ |

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SKETCH DEFINING MOTION OF AIRCRAFT

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#### NOTE ON FLYING CONTROL MECHANISM

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

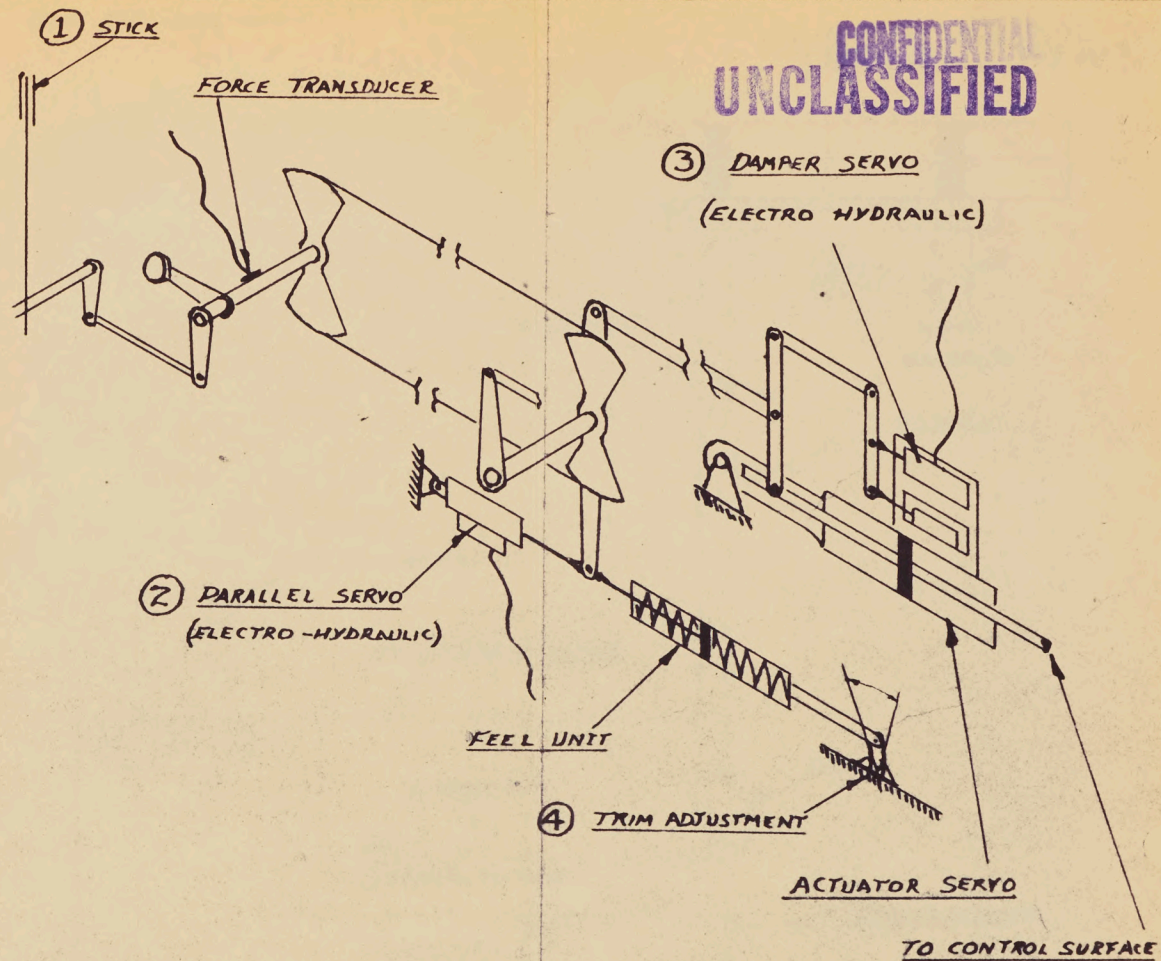
While the aileron system is practically identical to the elevator system, the rudder system has no parallel servo.

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.

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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.

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FIG. 3

## CF-105 - INSTRUMENTATION - ISSUE 7

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

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(Cont'd.)

| Item                           | Range        | Accuracy  | Accuracy<br>% of full range | Sampling<br>Frequency |
|--------------------------------|--------------|-----------|-----------------------------|-----------------------|
| <u>Location (2) see sketch</u> |              |           |                             |                       |
| 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.)

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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:-

| <u>System "A"</u>              | <u>System "B"</u>           |
|--------------------------------|-----------------------------|
| Port Elevator Jack.            | Port Elevator Jack.         |
| Stbd Elevator Jack.            | Port Elevator Damper Servo. |
| Port Aileron Jack.             | Stbd Elevator Jack.         |
| Stbd Aileron Jack.             | Stbd Elevator Damper Servo. |
| Rudder Jack.                   | Port Aileron Jack.          |
| Rudder Emergency Damper Servo. | Port Aileron Damper Servo.  |
|                                | Stbd Aileron Jack.          |
|                                | Stbd Aileron Damper Servo.  |
|                                | Rudder Jack.                |
|                                | Rudder Damper Servo.        |
|                                | Elevator Parallel Servo.    |
|                                | Aileron Parallel Servo.     |

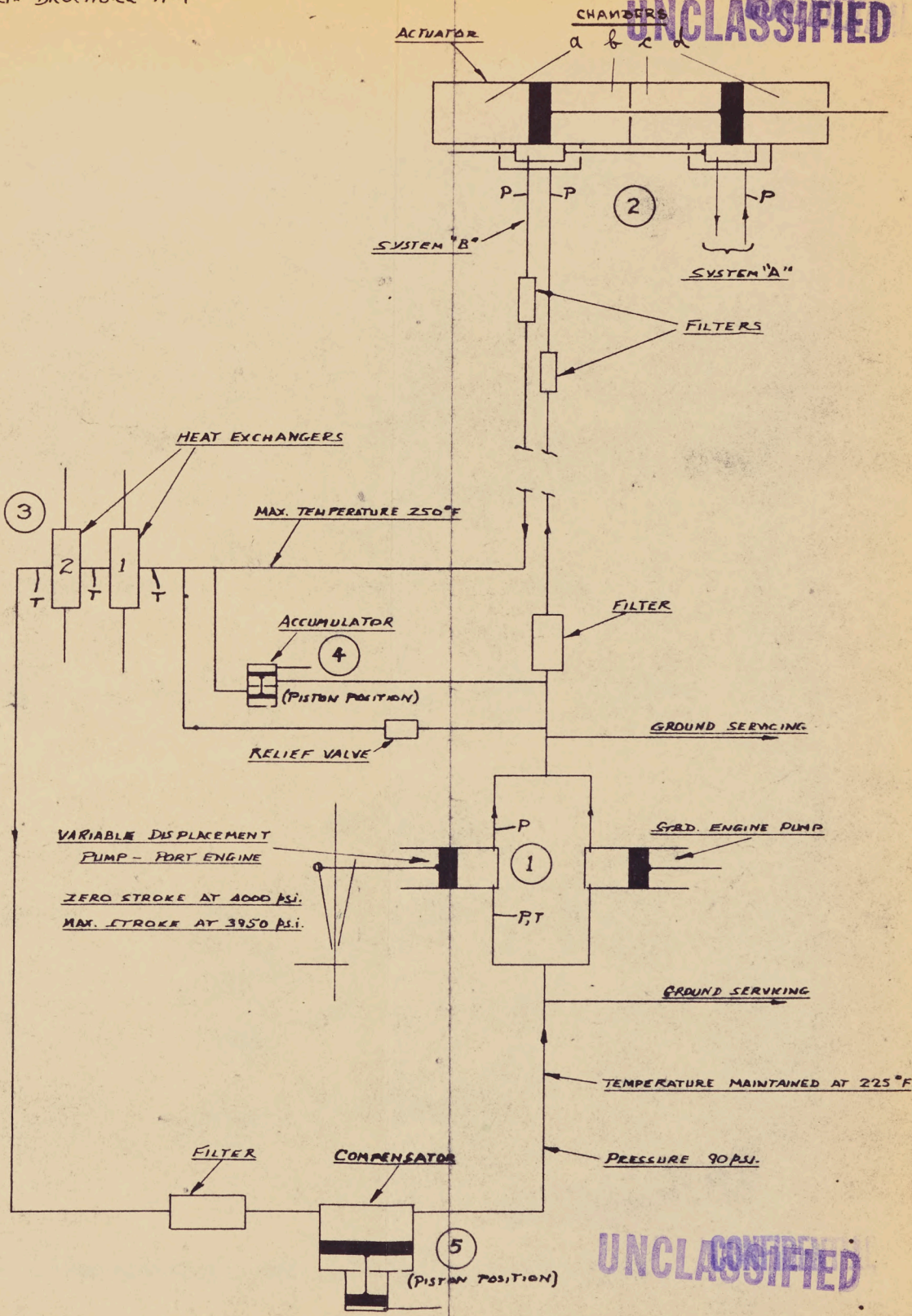
The control surface actuator jacks are each composed of two units in tandem as indicated in the sketch, one unit being supplied by System "A", the other unit by System "B".

(Ref: Procedure 4-1, Flying Control Hydraulic System).

| <u>Key:</u><br><u>Location In Sketch</u> | <u>Quantities to be Measured</u>  |
|--|---|
| 1.                                       | Port engine pump - System "B"<br>Pump inlet temp. and pressure: pump outlet pressure.   |
| 2.                                       | Port elevator, port aileron, and rudder jacks.<br>System "A" valve inlet pressure: System "B" valve inlet and outlet pressures. Jack internal pressures. Valve positions. |
| 3.                                       | Heat exchangers System "B".<br>Inlet temperature to H. Ex. No.1: outlet temp.<br>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

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FLYING CONTROL HYDRAULIC SYSTEM - SYSTEM "B"

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INTER-DEPARTMENTAL MEMORANDUM

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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.

CBL/bb

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

c.c.

Messrs J. A. Chamberlin  
W. D. Raymond  
F. P. Mitchell  
G. Hake  
E. Duret  
S. Whiteley  
F. Brame  
R. Young (2)  
D. Scard (5)  
J. Ames  
J. Morris  
J. Booth  
A. Buley

Central Files

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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.

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1. LUBRICATION (No Sketch)

| Item   | Range         | Accuracy | Accuracy<br>% of full range | Sampling<br>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 (Ps2)      | 0 to 30 psia  | ±0.3 psia | ±1%   | 20/sec |
| 14. Stbd. engine intake static pressure (Ps2)     | 0 to 30 psia  | ±0.3 psia | ±1%   | 20/sec |
| 15. Port engine intake total head pressure (Pt2)  | 0 to 30 psia  | ±0.3 psia | ±1%   | 12/min |
| 16. Stbd. engine intake total head pressure (Pt2) | 0 to 30 psia  | ±0.3 psia | ±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.

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2. ENGINE CONDITIONS (cont'd)

| Item                             | Range                                   | Accuracy      | Accuracy % of full range | Sampling Frequency |
|----------------------------------|---|---------------|--------------------------|--------------------|
| 17. }<br>18. }<br>19. }<br>20. } | <u>DELETED</u>                          |               |                          |                    |
| 21.                              | Turbine discharge press. (Pt7) Port     | 0 to 45 psia  | ±0.45 psi                | 12/min             |
| 22.                              | Turbine discharge press. (Pt7) Stbd.    | 0 to 45 psia  | ±0.45 psi                | 12/min             |
| 23.                              | Turbine discharge temp. (Tt7) Port.     | 0 to 1400° F  | ±14°F                    | 12/min             |
| 24.                              | Turbine discharge temp. (Tt7) Stbd.     | 0 to 1400° F  | ±14°F                    | 12/min             |
| 25.                              | L.P. compressor inlet temp. (Tt2) Port  | -75 to +350°F | ±4°F                     | 12/min             |
| 26.                              | L.P. compressor inlet temp. (Tt2) Stbd. | -75 to +350°F | ±4°F                     | 12/min             |
| 26a                              | Bleed valve shut indication             |               | ±1%                      | 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 | 12/min |
| 28. | Fuel weight flow to Stbd. engine           | 600 to 25,000 lb/hr | ±125 lb/hr | 12/min |
| 29. | Fuel temp. at inlet to port engine burner  | -75 to +350°F       | ±8°F       | 2/min  |
| 30. | Fuel temp. at inlet to stbd. engine burner | -75 to +350°F       | ±8°F       | 2/min  |

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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<br>% of full range | Sampling<br>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  | ± 50°F   | ± 1%                        | 1/min                 |
| 33. On hat section at T1-24ST shroud joint at Stn. 698                        | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 34. Top inboard shroud (on outer surface of shroud) at Stn. 742               | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 35. Top inboard shroud (on outer surface of shroud) at Stn. 780               | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 36. Top of titanium former (shroud) at Stn. 803                               | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 37. Shroud at bolt from lower latch at Stn. 803                               | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 38. Top of shroud inner flange at Stn. 803                                    | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 39. Top of shroud inner flange at kink, Stn. 803                              | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 40. Inner surface of slitler on Stn. 855                                      | 0 to 1000°F | ± 20°F   | ± 2%                        | 5/min                 |
| 41. Inboard, shroud (on outer surface, on engine E) Stn. 836                  | 0 to 500°F  | ± 10°F   | ± 2%                        | 5/min                 |
| 42. Air temp. top rear compressor, zone 1                                     | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 43. Air temp. under turbine, zone 2   | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 44. Air temp. above turbine, zone 2   | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 45. Air temp. above engine, zone 2, stn. 803                                  | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 46. Air temp. below engine, zone 2, stn. 803                                  | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 47. Ambient air temp. forward of parachute bay (not shown in fig)             | 0 to 500°F  | ± 50°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 E through heat exchangers Stn. 592W               | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 51. Top flange of former directly below firewall, stn. 663                    | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |
| 52. Structure 1/2" aft of aux. ejector (inner surface of lower skin) Stn. 663 | 0 to 500°F  | ± 50°F   | ± 1%                        | 1/min                 |

W On beam, as near to top as possible

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4. COOLING (cont'd)

| Item   | Range   | Accuracy | Accuracy<br>% of full range | Sampling<br>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";<br>one on oil cooler gill, at the bottom, indicating<br>"shut - fully open" | ± 5°F    | ± 1%                        | Cont.                 |
| 58. Gills shut indication lights, stbs. 2 * per engine             |   |          |                             |                       |
| 58a Air temperature, alternator exhaust (Not shown in fig.)        | 75 to 500°F   | ± 6°F    | ± 1%                        | Cont.<br>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.

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GILLS OPEN ABOVE M=0.5

DOORS CLOSED

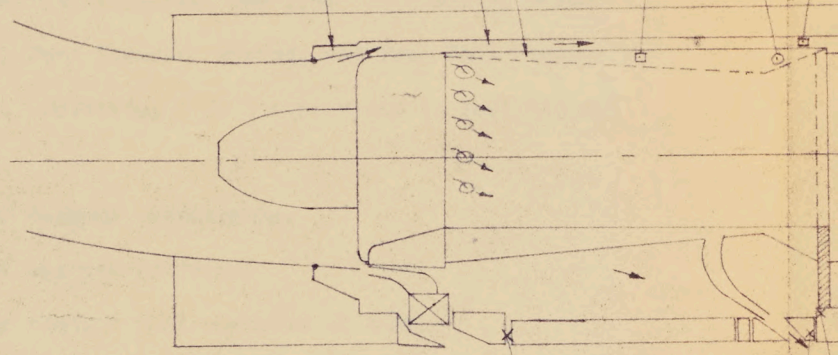
59P

42A

60

ZONE 1

ZONE 2



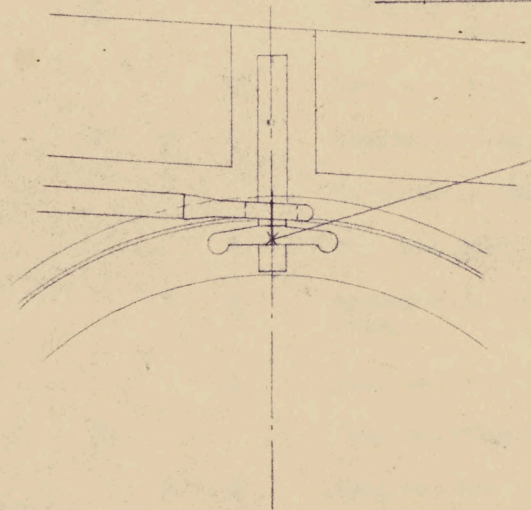
X S - STRUCTURAL TEMPERATURE  
 O A - AIR TEMPERATURE  
 □ P - STATIC PRESSURE

50S

52S

SECTION B-B

SECTION A-A



31S

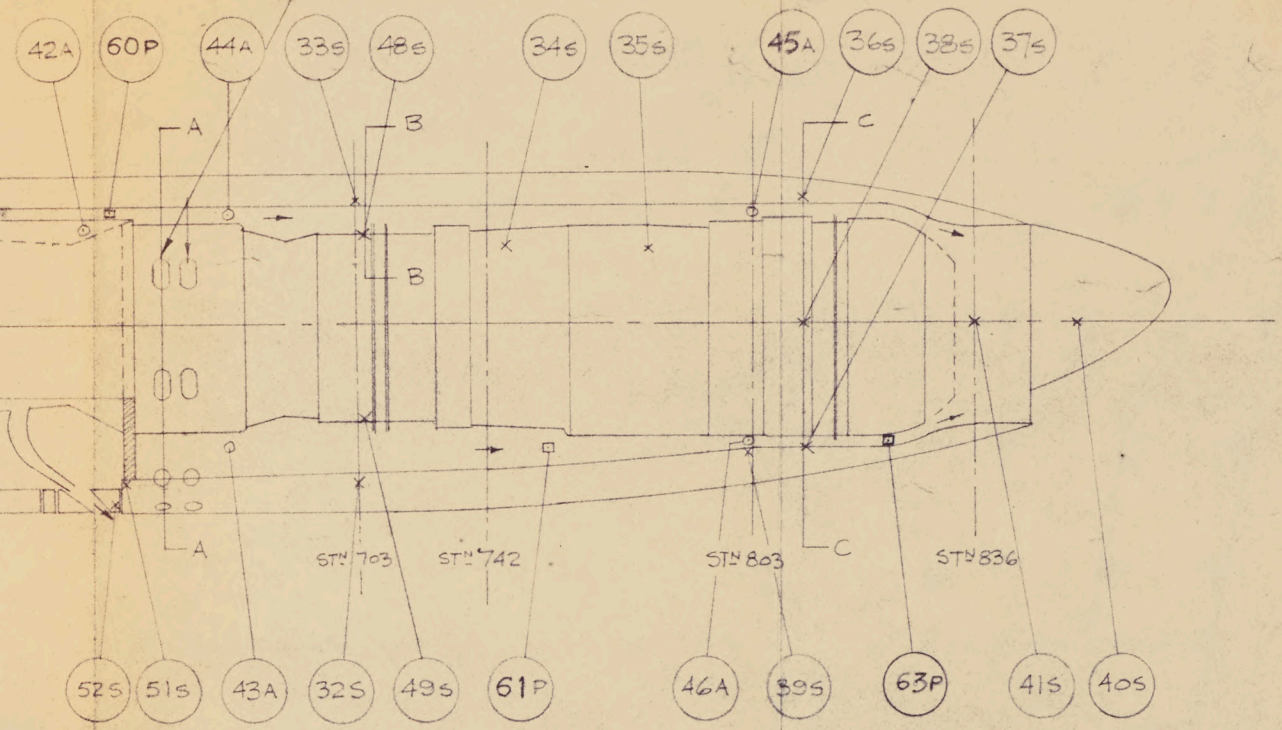
53S



COOLING

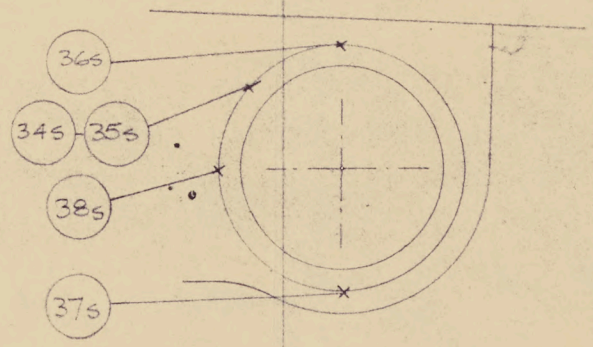
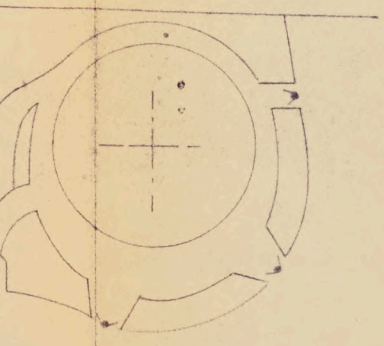
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DOORS CLOSED ABOVE M=0.5



SECTION A-A

SECTION C-C



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COOLING SYSTEM INSTRUMENTATION FOR J-75 ENGINE INSTALLATION

Fig. 1

CF-105 INSTRUMENTATION - ISSUE 7FUEL SYSTEM

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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.

| <u>Location<br/>See Sketches</u> | <u>Instruments<br/>Required</u> | <u>Description</u>  |
|----------------------------------|---------------------------------|---|
| 1                                | Q                               | forward fuselage tank.  |
| 2                                | P Q                             | rear fuselage tank.   |
| 3                                | <u>T</u> Q                      | <u>temperature in stbd. wing only</u> , contents in port and stbd. tanks.         |
| 4                                | Q                               | port and stbd. wing tanks.  |
| 5                                | T P Q                           | temperature and pressure in stbd. tank only.<br>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                               | <u>T</u>                        | <u>pressurization air entering tank.</u>  |

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(Continued/...

2. SUMMARY**CONFIDENTIAL**  
**UNCLASSIFIED**2.1 Temperature

| Instrument | Range<br>(°F) | Accuracy<br>(F°) | Accuracy<br>(% of Range) | Recording<br>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<br>(psia) | Accuracy<br>(psi) | Accuracy<br>(% of Range) | Recording<br>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/...

**UNCLASSIFIED**

(Continued/...

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

| Instrument | Range<br>(Gals.) | Accuracy<br>(Gals.) | Accuracy<br>(% of Range) | Recording<br>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.

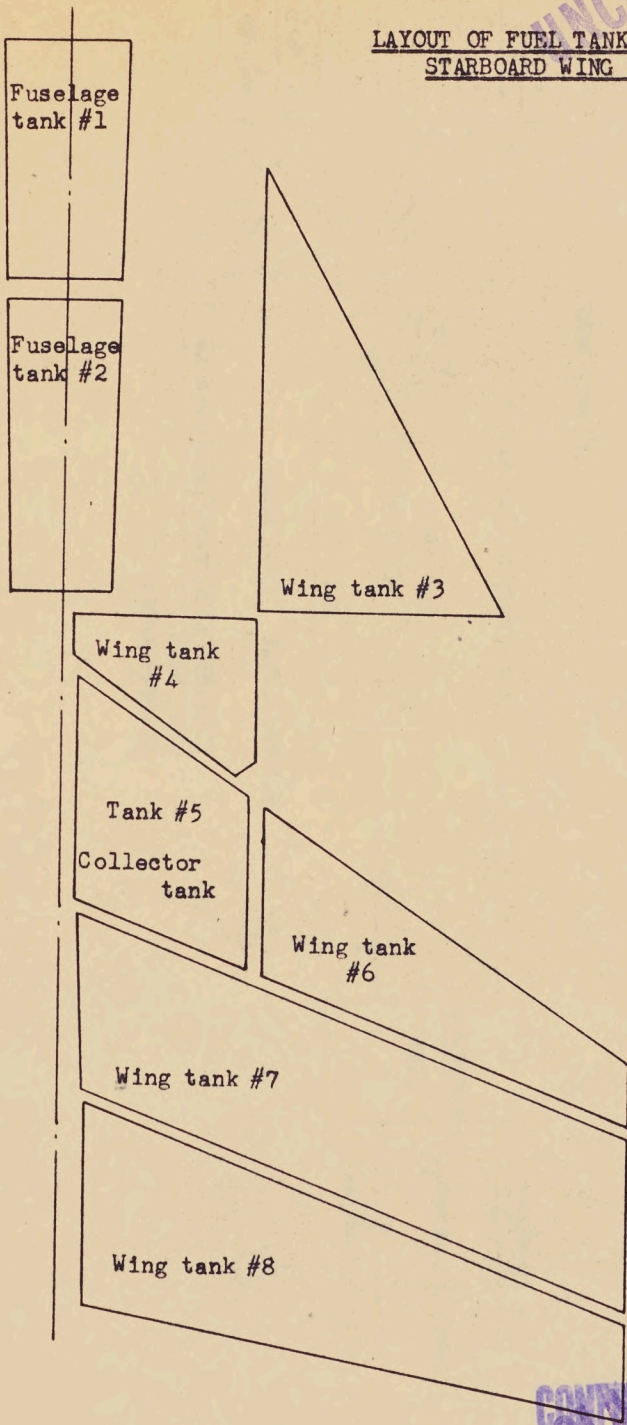
The range of flows to be covered is as follows (for J.75 engine):

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.

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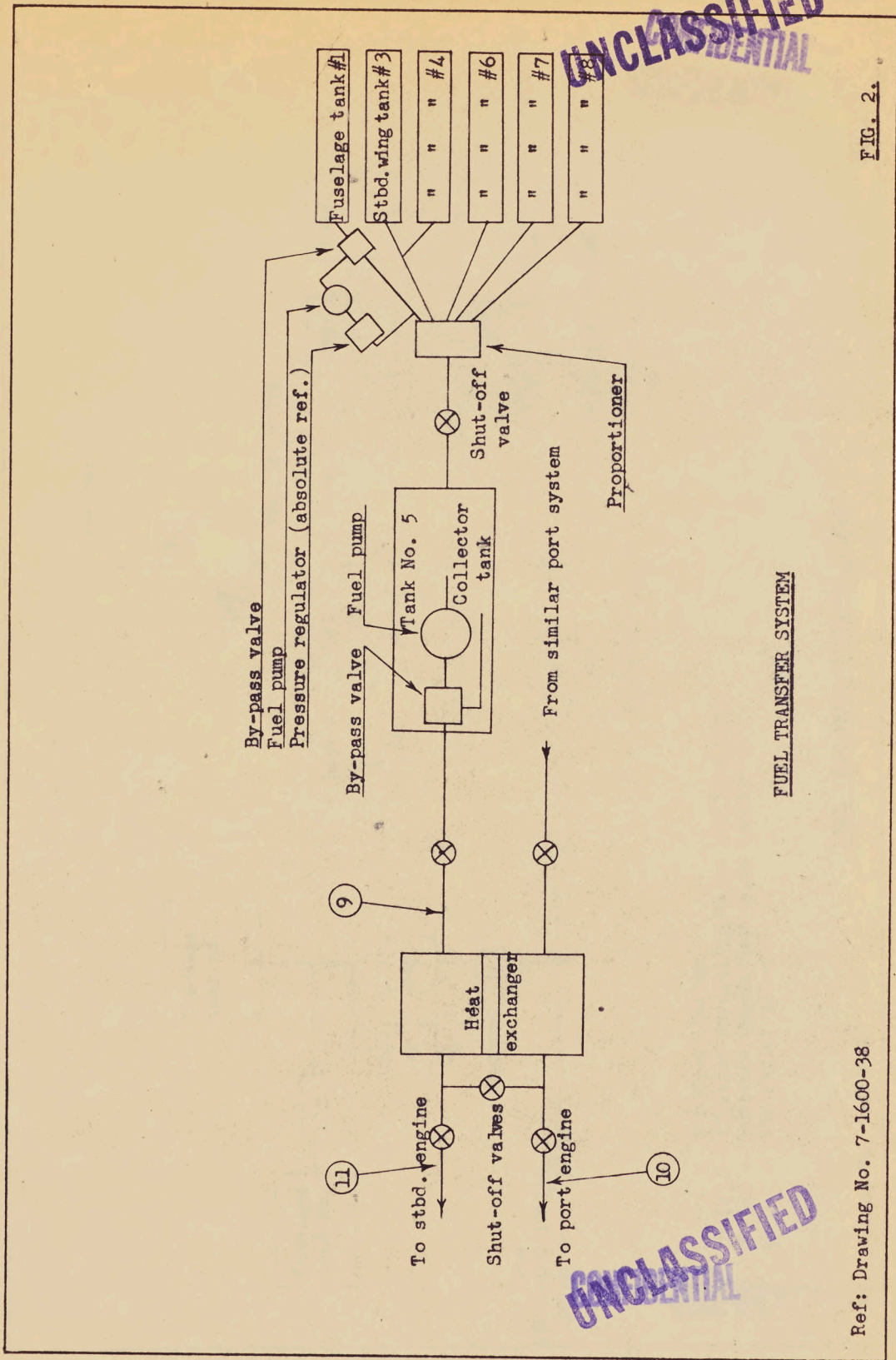
LAYOUT OF FUEL TANKS SHOWING  
STARBOARD WING ONLY



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FIG. I

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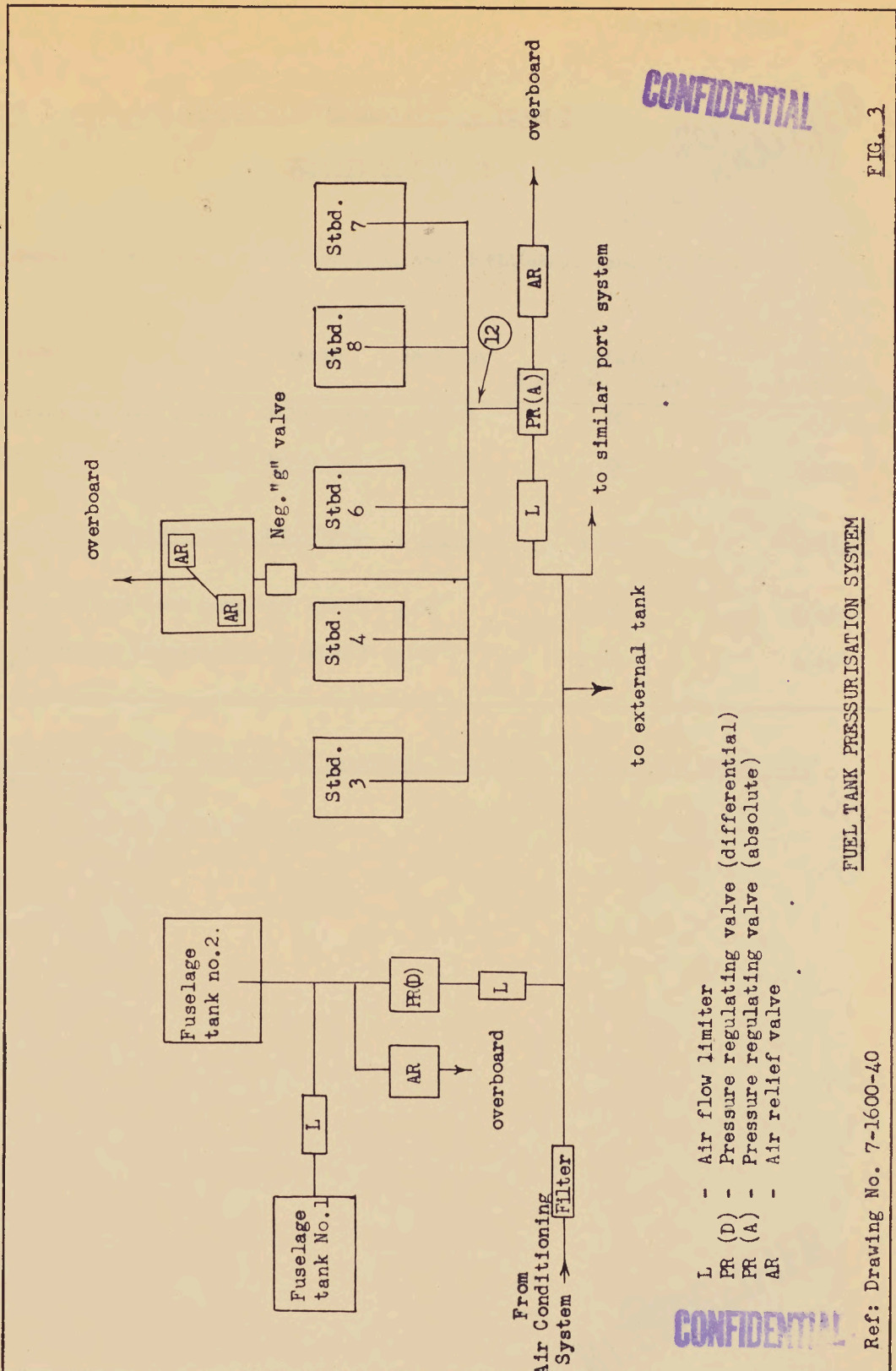


FUEL TRANSFER SYSTEM

FIG. 2.

Ref: Drawing No. 7-1600-38

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FIG. 3

FUEL TANK PRESSURISATION SYSTEM

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

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Ref: Drawing No. 7-1600-40

November, 1956.

CF-105 - INSTRUMENTATION - ISSUE 7UTILITY HYDRAULICSCONFIDENTIAL  
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Items underlined are added since Issue 5, Ref. 6302/22/J, Jan. 3, 1956.

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

v 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.

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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

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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.

JDH/h

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

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

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March, 1957.

CF-105 - INSTRUMENTATION - ISSUE 8

AIR CONDITIONING SYSTEM

Items underlined are changed from Issue 7, Ref. 4028/02A/J, November 20, 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.

$\Delta P$  -  $P_t - P_s$ .

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

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(Continued.....)

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2. SUMMARY

2.1 Temperature

| Instrument | Range<br>(°F) | Accuracy<br>(F°)                | Accuracy<br>(% of Range) | Recording<br>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<br>(psia) | Accuracy<br>(psi) | Accuracy<br>(% of Range) | Recording<br>Frequency |
|----------------------------------|-----------------|-------------------|--------------------------|------------------------|
| P <sub>s</sub> 1                 | 0-360           | ±10               | 2%                       | 1/sec                  |
| P <sub>s</sub> 2                 | 0-100           | ±1                | 1%                       | 1/sec                  |
| P <sub>s</sub> 3                 | 0-100           | ±1                | 1%                       | 5/min                  |
| P <sub>s</sub> 5 ( <u>rake</u> ) | 0-20            | ±0.2              | 1%                       | 5/min                  |
| P <sub>s</sub> 7                 | 0-20            | ±0.2              | 1%                       | 5/min                  |
| P <sub>s</sub> 8                 | 0-20            | ±0.1              | 0.5%                     | 1/sec                  |
| P <sub>s</sub> 9 ( <u>rake</u> ) | 0-20            | ±0.2              | 1%                       | 5/min *                |
| P <sub>s</sub> 10( <u>rake</u> ) | 0-20            | ±0.2              | 1%                       | 5/min *                |

\* Note: Either static or total may be measured.

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2.3 Total Head Pressure

| Instrument     | Range      | Accuracy<br>(psi) | Accuracy<br>(% of Range) | Recording<br>Frequency |
|----------------|------------|-------------------|--------------------------|------------------------|
| $\Delta P_3$   | 0-5 psi    | $\pm 0.25$        | 5%                       | 5/min                  |
| $P_{t4}$       | 0-100 psia | $\pm 1$           | 1%                       | 5/min                  |
| $\Delta P_7$   | 0-1 psi    | $\pm 0.05$        | 5%                       | 5/min                  |
| $P_{t9}$ rake  | 0-30 psia  | $\pm 0.3$         | 1%                       | 5/min *                |
| $P_{t10}$ rake | 0-30 psia  | $\pm 0.3$         | 1%                       | 5/min *                |

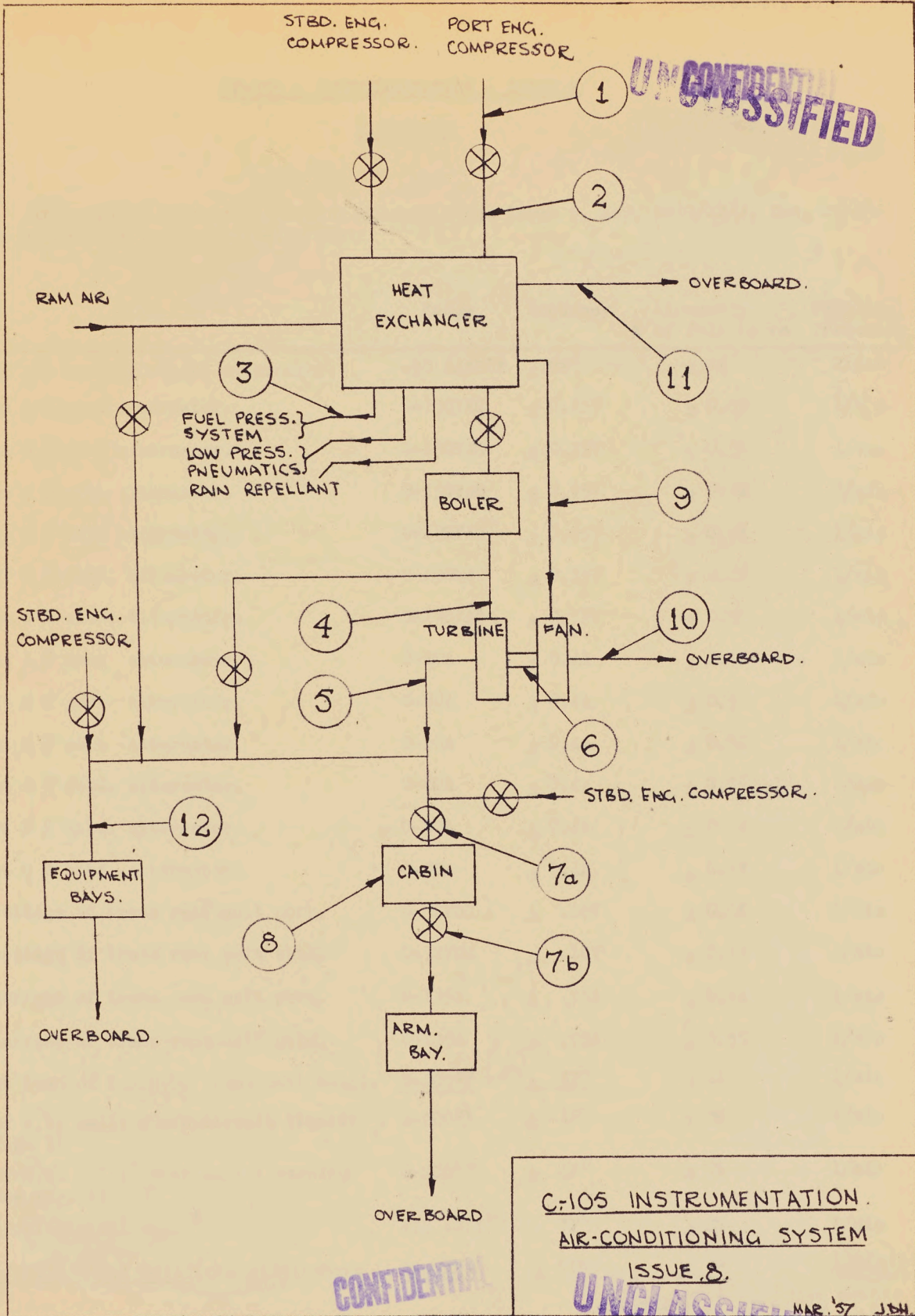
\* See note Page 23.

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 AIRResearch.

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

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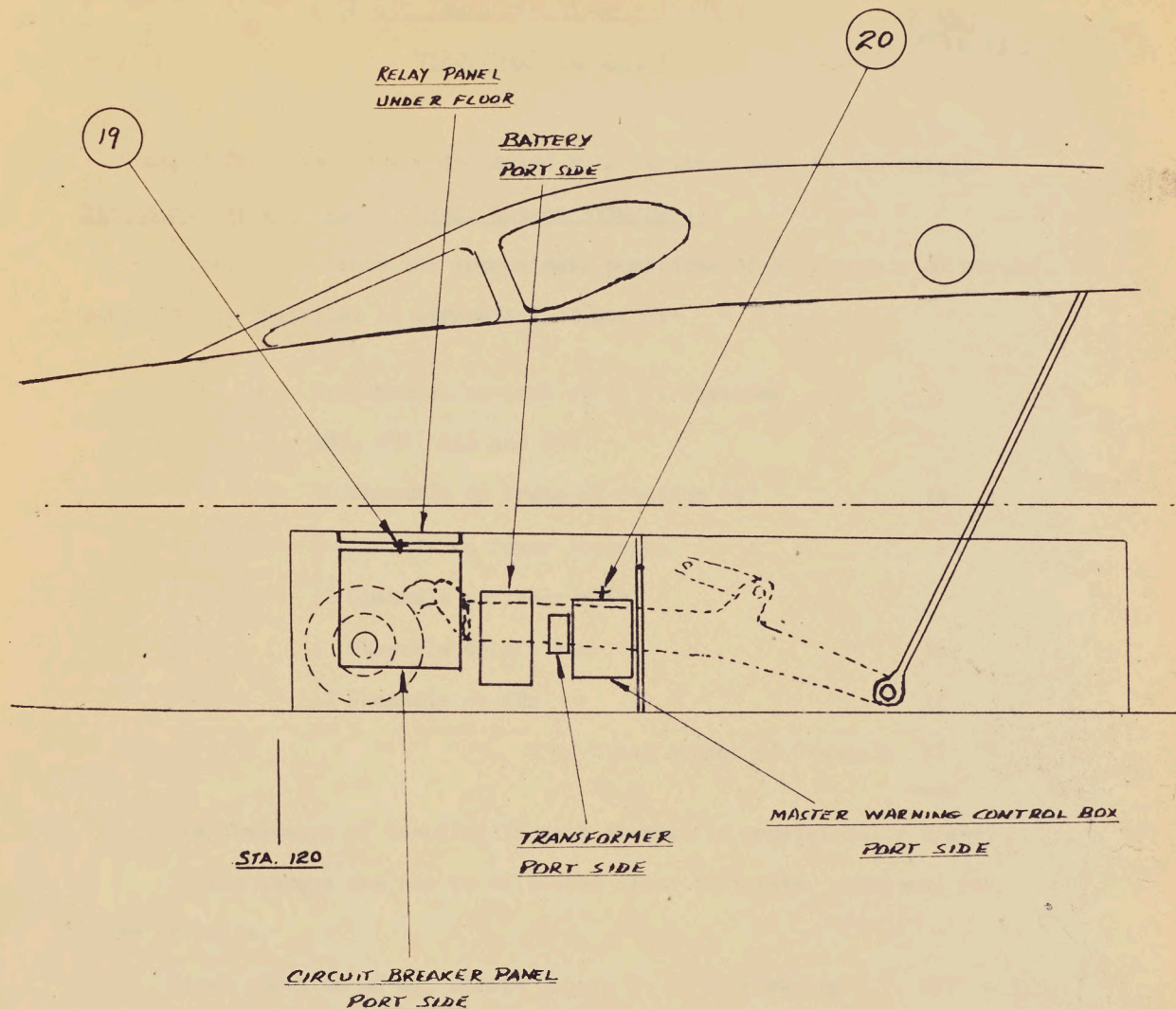
Items which have been added or changed since Issue 5, Ref. 6219/22/J, Dec. 27/55 are underlined in the following list:

| Item  | Range                     | Accuracy                | Accuracy<br>% of full range | Sampling<br>Frequency                                 |
|---|---------------------------|-------------------------|-----------------------------|---|
| 1. Temp of aft bearing - port alternator.                       | -70 +450 <sup>o</sup> F   | ±10F <sup>o</sup>       | ± 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).                   | <u>0-200<sup>o</sup>F</u> | ± <u>4F<sup>o</sup></u> | ± 2%                        | 1/min   |
| 19. Temp of N.W. well, above circuit breaker<br>(See Fig. 1)    | 0-200 <sup>o</sup> F      | ± 4F <sup>o</sup>       | ± 2%                        | 1/min   |
| 20. Temp of N.W. well, above master warning<br>box (See Fig. 1) | 0-200 <sup>o</sup> F      | ± 4F <sup>o</sup>       | ± 2%                        | 1/min   |
| 21. Temp of electrical bay. *                                   | -70 +275 <sup>o</sup> F   | ± 7F <sup>o</sup>       | ± 2%                        | 1/min   |
| 22. <u>Temp of main wheel well (one side) above<br/>brakes.</u> | <u>0-450<sup>o</sup>F</u> | ± <u>9F<sup>o</sup></u> | ± 2%                        | 1/min (after<br>retracting<br>wheels for<br>15 mins.) |

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

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SKETCH OF NOSE WHEEL WELL

SHOWING ELECTRICAL EQUIPMENT AND

POSITION OF THERMOCOUPLES

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October, 1956.

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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<br>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   | <u>12</u> |
| Total number of Channels  | <u>52</u> |

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  $\pm 0.25$  g, and the instruments should be capable of recording frequencies up to 60 cycles/sec.

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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.

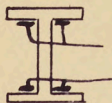
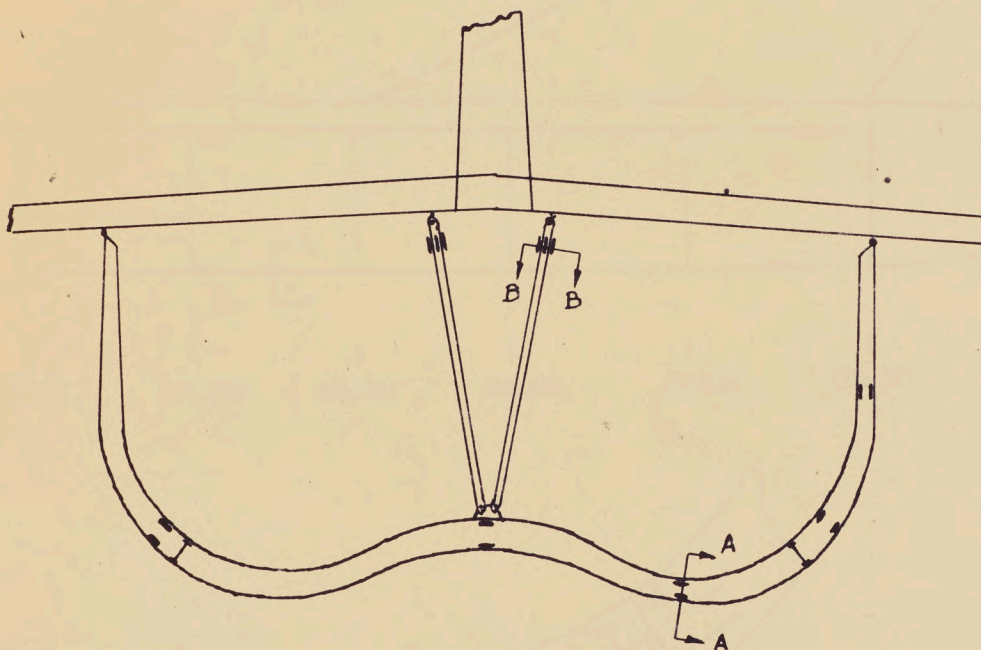
During a specific flutter programme, the requirement for telemetry of accelerometers may be greater, the number required being dependent on the availability of telemetry channels.

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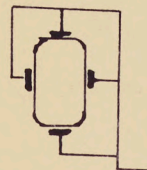
C/S FRAME & STRUTS AT STATION 697

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ALSO STRAIN GAUGE STRUTS AT STATIONS - 485, 591, 7-644



SECTION A-A



SECTION B-B

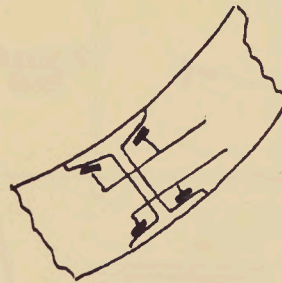
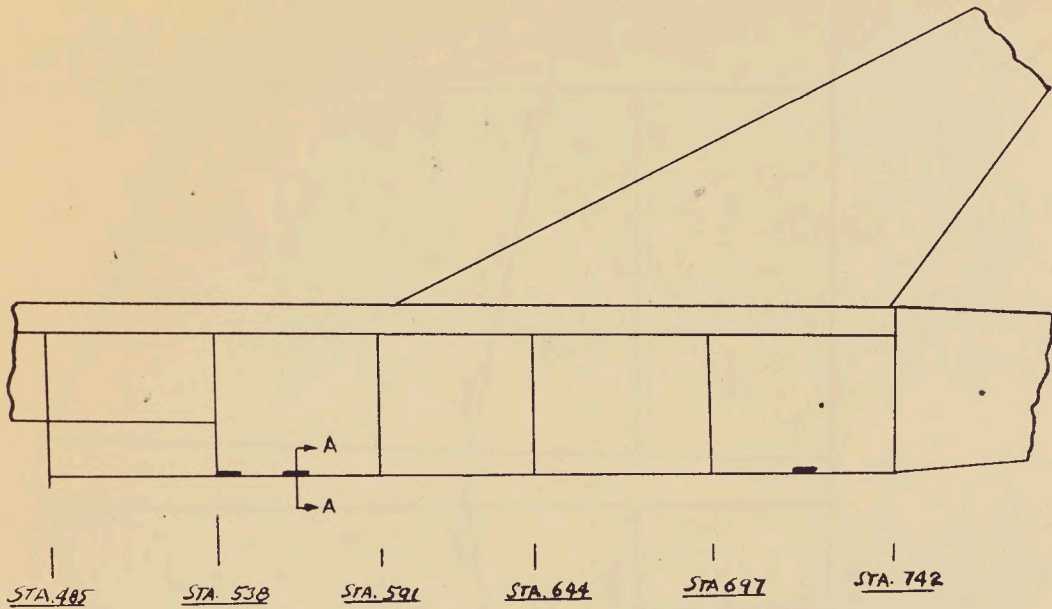
NUMBER OF CHANNELS ON FRAME - 10

TOTAL NUMBER OF CHANNELS ON STRUTS - 8

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FIG. 1

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SECTION A-A

LOWER LONGERON - ONE SIDE ONLY

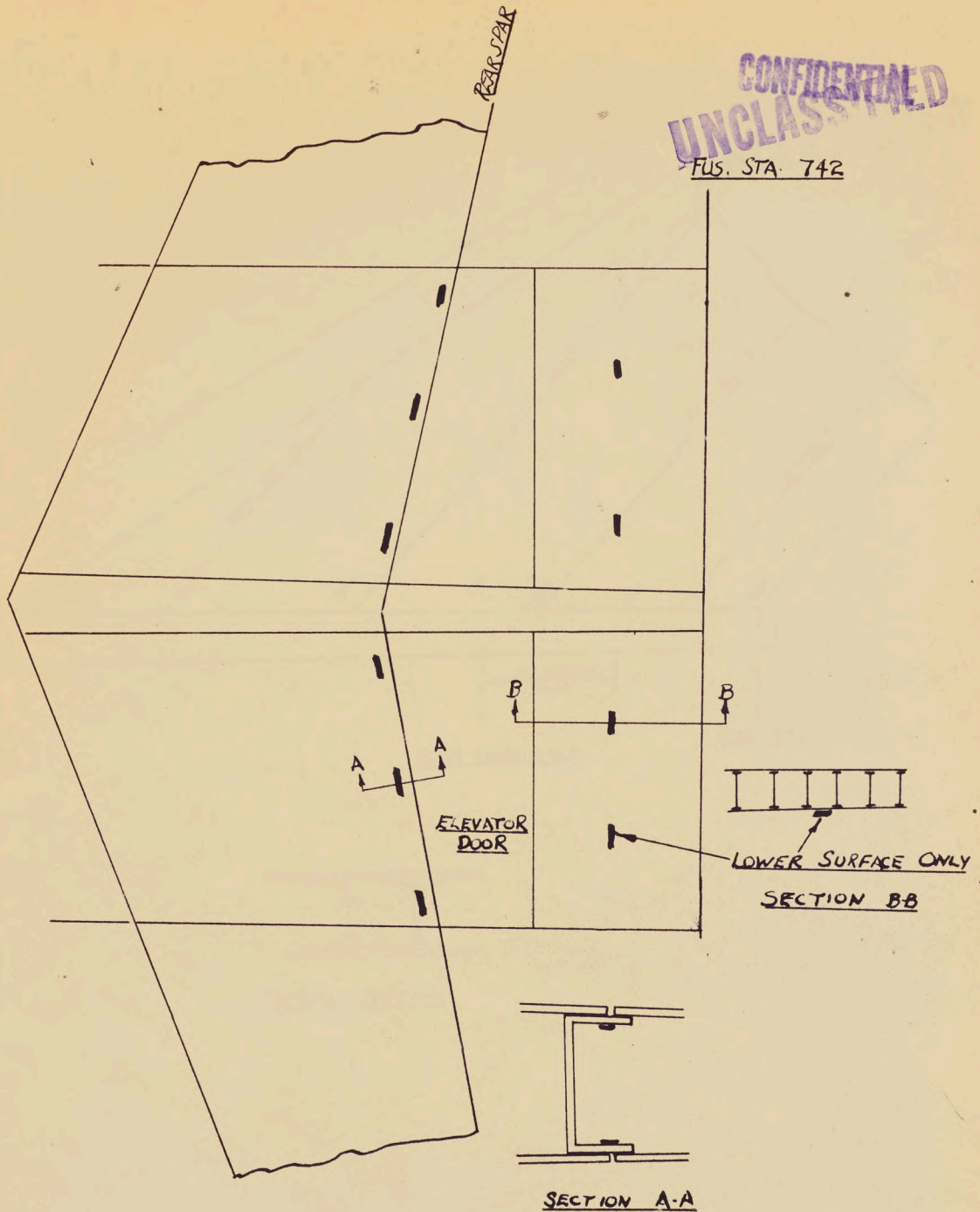
NUMBER OF CHANNELS - 6

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FIG. 2

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FUS. STA. 742



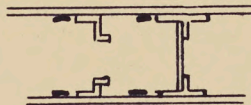
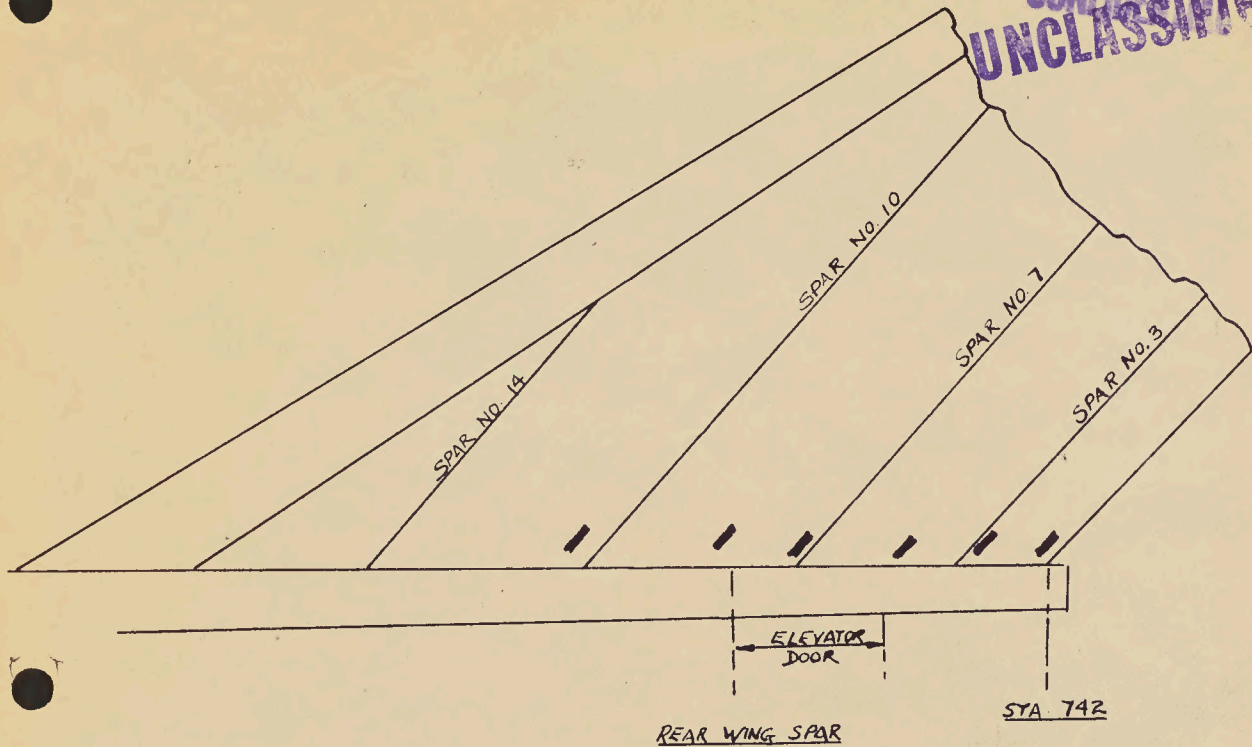
INNER WING & AFT BOX

TOTAL NUMBER OF CHANNELS - 16

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FIG. 3

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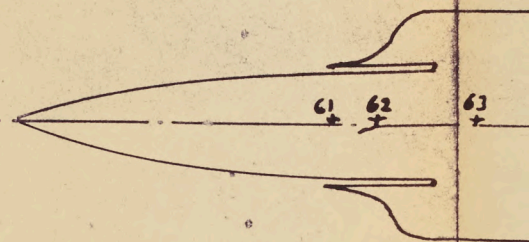
TYPICAL SECTION

EIN

NUMBER OF CHANNELS - 12

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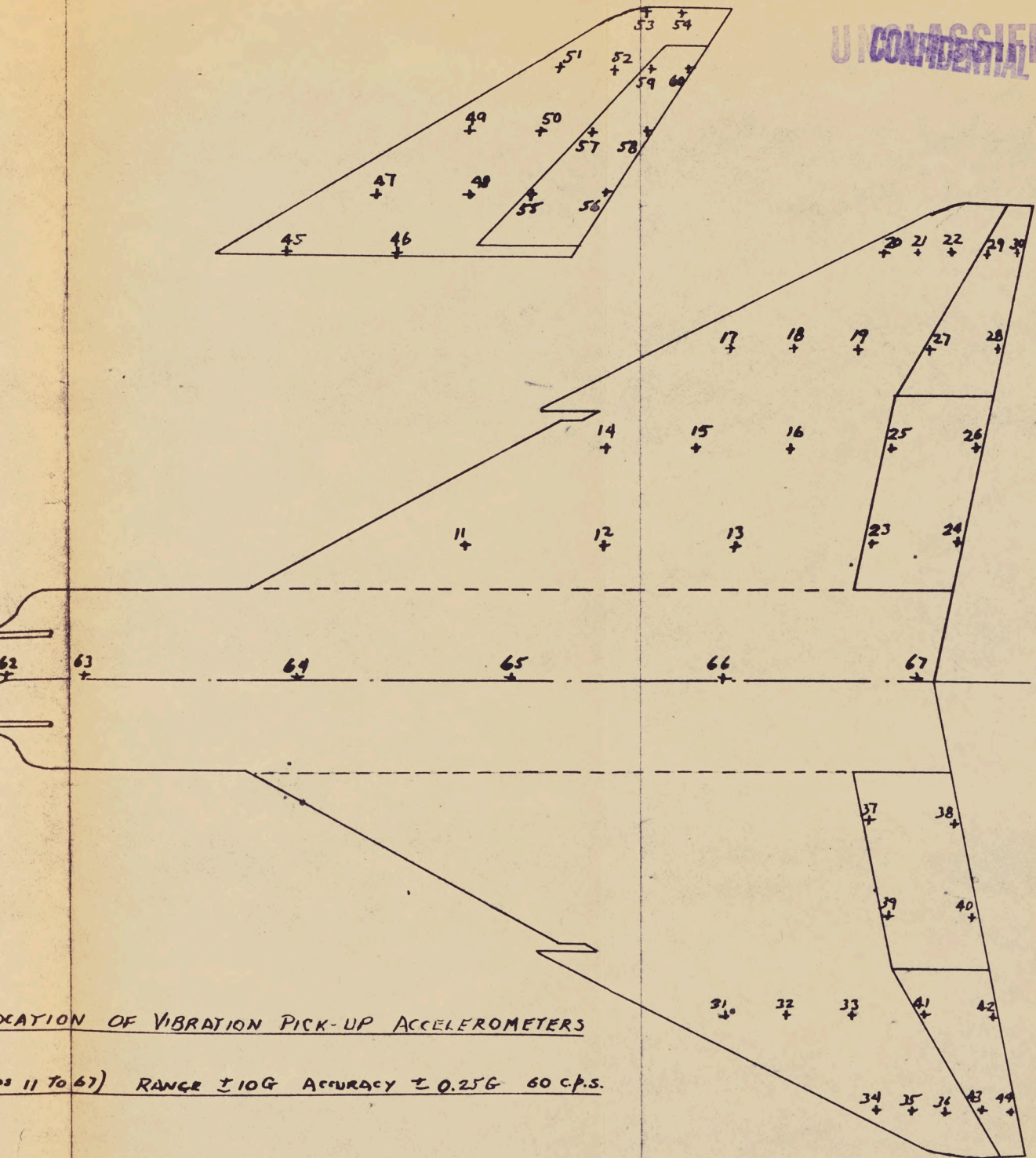
FIG. 4



SKETCH SHOWING LOCATION OF

57 ACCELEROMETERS (Nos 11 To 67)

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LOCATION OF VIBRATION PICK-UP ACCELEROMETERS  
 (11 To 67) RANGE  $\pm 10G$  ACCURACY  $\pm 0.25G$  60 C.P.S.

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FIG. 5

CF-105 - INSTRUMENTATION - ISSUE 7

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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<br>% of full range | Sampling<br>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

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INTER-DEPARTMENTAL MEMORANDUM

Date December 21, 1956.  
To Mr. S.E. Harper  
From John Morris  
Subject CF105, INSTRUMENTATION, ISSUE NO. 7

Reference: 4510/02B/J

In section 1 "Stability and Control" of CF105 Instrumentation - Issue No. 7, an X mark, indicating that provision should be made for telemetry, 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 amended to read as follows:

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

DNV/rs

*John Morris*  
John Morris,  
Assistant Chief Aerodynamicist.

|            |                 |                |                   |
|------------|-----------------|----------------|-------------------|
| cc Messrs: | J.C. Floyd      | S. Kwiatkowski |                   |
|            | R.N. Lindley    | I. Craig       |                   |
|            | J.A. Chamberlin | G. Shaw        |                   |
|            | G. Hake         | W.S. Sload     | A. Crust (9)      |
|            | F. Brame        | E. Duret       | R. Young (2)      |
|            | F.P. Mitchell   | J.C. McKillop  | Aero Files        |
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|            | H. Malinowski   | S. Brown       |                   |
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