Direct Reading 6 component Balance
Lift = L_1 + L_2 + L_3
Drag = D_1 + D_2
Pitch = L_3 \alpha
yaw = (D_1 - D_2) \beta
Roll = (L_1 - L_2) \beta

Lift = L_1 + L_2 + L_3
Drag = D
Side = S_1 + S_2
Pitch = L_3 \alpha - D \epsilon
yaw = S_2 \alpha
Roll = (L_1 - L_2) \beta
Alternate Bid

6. Bidders shall quote price on item No 6, consisting of the original specifications modified and altered, as follows:

(a) The contractor shall furnish one (1) set of levers, linkages, lever supports, and scale cabinets; from the floating frame to the scale head ending with the knife edges at the ends of the levers which attach to the stibyard masts. This item shall not include scale heads, printers, compensators, compensator stands, unit weights and control panel.

(b) The lever ratios employed in each scale shall be according to the following schedule:

<table>
<thead>
<tr>
<th>Scale</th>
<th>Sensor Ratio</th>
<th>Total Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left front lift</td>
<td>2000 to 1</td>
<td>1 ± 8000 lb</td>
</tr>
<tr>
<td>Right &quot; &quot;</td>
<td>2000 to 1</td>
<td>1 ± 8000 lb</td>
</tr>
<tr>
<td>Rear lift</td>
<td>1000 to 1</td>
<td>1 ± 4000 lb</td>
</tr>
<tr>
<td>Side force</td>
<td>500 to 1</td>
<td>1 ± 2000 lb</td>
</tr>
<tr>
<td>Manometers</td>
<td>200 to 1</td>
<td>1 ± 800 lb</td>
</tr>
<tr>
<td>Right drag scale No.1</td>
<td>500 to 1</td>
<td>1 ± 2000 lb</td>
</tr>
<tr>
<td>Right &quot; &quot; No.2</td>
<td>200 to 1</td>
<td>1 ± 800 lb</td>
</tr>
<tr>
<td>Left &quot; &quot; No.1</td>
<td>500 to 1</td>
<td>1 ± 2000 lb</td>
</tr>
</tbody>
</table>
(C) The lever shall be capable of transmitting both positive and negative forces from the floating frame to the steyyard rod. Since the scale head capacity to be used with this arrangement system is plus and minus four (4) pounds no unit weights are contemplated for this system. The same specifications covering balancing tare weights, setting the zero, and locking the system shall apply also to this item.

(d) The cabinet shall be provided with a base top arranged to receive the balance head outlined in NACA drawing No—

(e) The contractor shall demonstrate the accuracy and precision of the

(f) Although the use of unit weights in the usual sense are not contemplated for this system, a series of weights shall be provided for the purpose of reloading the scale head rim either direction for the purpose of conveniently checking its accuracy and also to increase its capacity if necessary.
Eight. Means for conveniently adding eight unit weights in the positive direction and eight weights in the negative direction to the so proportioned and located in the lever system as to obtain full scale deflection. Four pounds tension or compression in the steelyard rod through adding all eight weights. Eight weights shall be furnished with each scale.

(f) The contractor shall demonstrate the accuracy of the lever system install all the balance parts furnished by him and shall demonstrate the accuracy of the levers according to the requirements set forth in the original specifications by any means satisfactory to the government, such as through the use of an improvised dial or beam head supplied by him.
<table>
<thead>
<tr>
<th>Unit Wts.</th>
<th>Max. Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>750</td>
</tr>
<tr>
<td>500</td>
<td>1250</td>
</tr>
<tr>
<td>1000</td>
<td>2500</td>
</tr>
<tr>
<td>2000</td>
<td>4750</td>
</tr>
<tr>
<td>4000</td>
<td>7750</td>
</tr>
<tr>
<td>500</td>
<td>1500</td>
</tr>
<tr>
<td>1000</td>
<td>2500</td>
</tr>
<tr>
<td>2000</td>
<td>4500</td>
</tr>
<tr>
<td>4000</td>
<td>8500</td>
</tr>
<tr>
<td>8000</td>
<td>16500</td>
</tr>
</tbody>
</table>

200 Wts.

<table>
<thead>
<tr>
<th>Wts</th>
<th>Caps</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>200</td>
<td>500</td>
</tr>
<tr>
<td>400</td>
<td>900</td>
</tr>
<tr>
<td>800</td>
<td>1900</td>
</tr>
<tr>
<td>1600</td>
<td>3300</td>
</tr>
</tbody>
</table>
Accuracy of balance for measuring moments
(Percents for middle of working range based on scale accuracy of \( \pm \) dial division)

<table>
<thead>
<tr>
<th>Tunnel Speed, mph</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch</td>
<td>1.0</td>
<td>0.25</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rolling</td>
<td>8.0</td>
<td>2.0</td>
<td>1.0</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Yaw</td>
<td>0.3</td>
<td>0.1</td>
<td>0.4</td>
<td>0.04</td>
<td>0.25</td>
</tr>
</tbody>
</table>

was idle

was idle

\[ \text{Pitch} \]
\[ \text{Rolling} \]
\[ \text{Yaw} \]
Moment sensitivities

Pitching
\[
\text{smallest dial division} = 1.0^\circ \quad \text{accuracy} 0.5^\circ \\
\text{lever arm} = 10 \text{ ft.} \\
\text{Moment accuracy} = 5 \text{ ft-lb.}
\]

Rolling
\[
\text{smallest dial division} = 2.5^\circ \quad \text{accuracy} 1.25^\circ \\
\text{lever arm} = 20 \text{ ft.} \\
\text{Moment accuracy} = 25 \text{ ft-lb.}
\]

Yaw
\[
\text{smallest dial division} = 0.5 \text{ lb. and } 1 \text{ lb} \\
\text{lever arm} = 20 \text{ ft.} \\
\text{Moment accuracy} = 5 \text{ ft-lb. and } 1 \text{ ft-lb.}
\]
Desired moment accuracy.

\[ C_e = \frac{\text{rolling moment}}{g \cdot b} \]

\[ b = 14.9 \]
\[ s = 41.5 \]

\[ C_e = 0.0002 \] represents 1% of working range on 1/20 gage inch force plate 25

rolling moment = 0.0002 \times 9 \times 14.9 \times 41.5

d for 100 m.p.h.

\[ = 3.1 \]  \pm \text{lb. @ 100 m.p.h.} \]
\[ 12.4 \quad " \quad @ 200 " \]
\[ 27.9 \quad " \quad @ 300 " \]
\[ 49.5 \quad " \quad @ 400 " \]
\[ 77.5 \quad " \quad @ 500 " \]

\[ C_m = \frac{\text{yawing moment}}{g \cdot b} \]

\[ k_m = \text{yawing moment} = 0.002 \] represents 1% for instability range

Same results as for \( C_e \)
\[ C_m = \frac{\text{pitching moment}}{g \cdot S_c} \]

\[ C_m = 0.002 \]

\[ \text{pitching moment} = 0.002 \times 25.6 \times 41.5 \times 3 = 6.35 \]
Max. Forces on 16 ft Tunnelalance

- Basis: 500 mph; q = 640 ft/lb
- Wing: 16' x 5' = 80 sq ft
  - $C_L_{max} = 1.5$; Lift = 77,000 #
  - $C_L = 0.5$; Lift = 25,000 #

Drag:
- Noodle: 52" dia; drag @ 100 mph = 40 #
- $C_L$ = 0.5
- $C_L$ = 0.5; drag @ 500 mph = 1000 #
- $C_L$ = 0.5; drag @ 500 mph = 1250 #
- Total wing+ Noodle = 2250 #

Static Thrust for 2000 HP engine = 8000 #

Yawing Moment
Part of plant head system

Power supply: £3,500
Balance units: £10,500
Duplicating equipment: £12,000
Amplifiers: £12,000
Regulators: £6,000

Mechanical & electrical: £5,000
Welding machine: £5,000
Effective balance considerations

Drag scale: \[ \frac{8000 \text{# thrust}}{4000 \text{# drag}} = 2 \]

12000 #