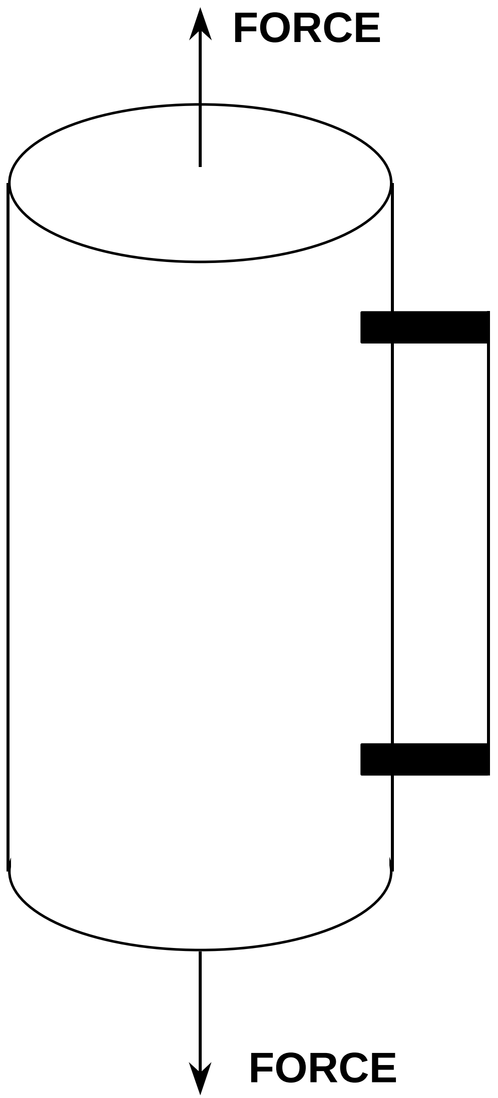
PRACTICAL DESIGN TECHNIQUES FOR SENSOR SIGNAL CONDITIONING

STRAIN GAGE BASED MEASUREMENTS

- **Strain:** Strain Gage, PiezoElectric Transducers
- **Force:** Load Cell
- **Pressure:** Diaphragm to Force to Strain Gage
- **Flow:** Differential Pressure Techniques

UNBONDED WIRE STRAIN GAGE



AREA = A
LENGTH = L
RESISTIVITY = ρ
RESISTANCE = R

$$R = \frac{\rho L}{A}$$

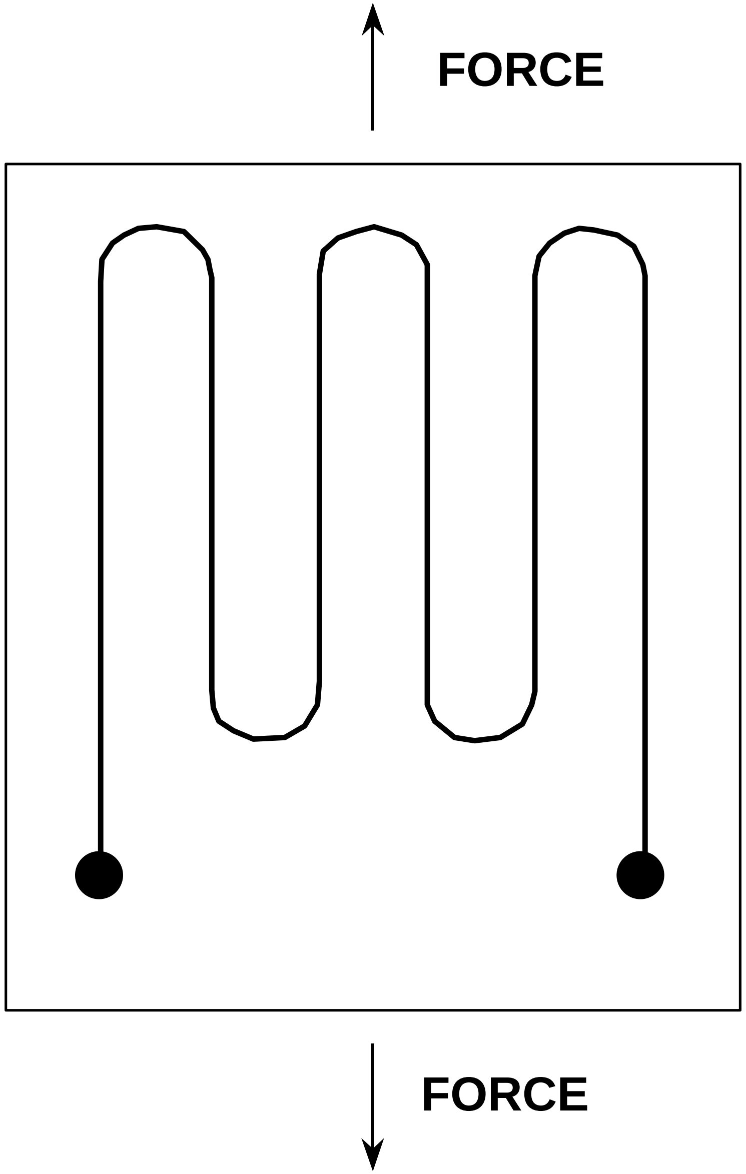
$$\frac{\Delta R}{R} = GF \bullet \frac{\Delta L}{L}$$

GF = GAGE FACTOR
2 TO 4.5 FOR METALS
>150 FOR SEMICONDUCTORS

$$\frac{\Delta L}{L} = \text{MICROSTRAINS } (\mu\varepsilon)$$

$$1\ \mu\varepsilon = 1\times10^{-6}\ \text{cm / cm} = 1\ \text{ppm}$$

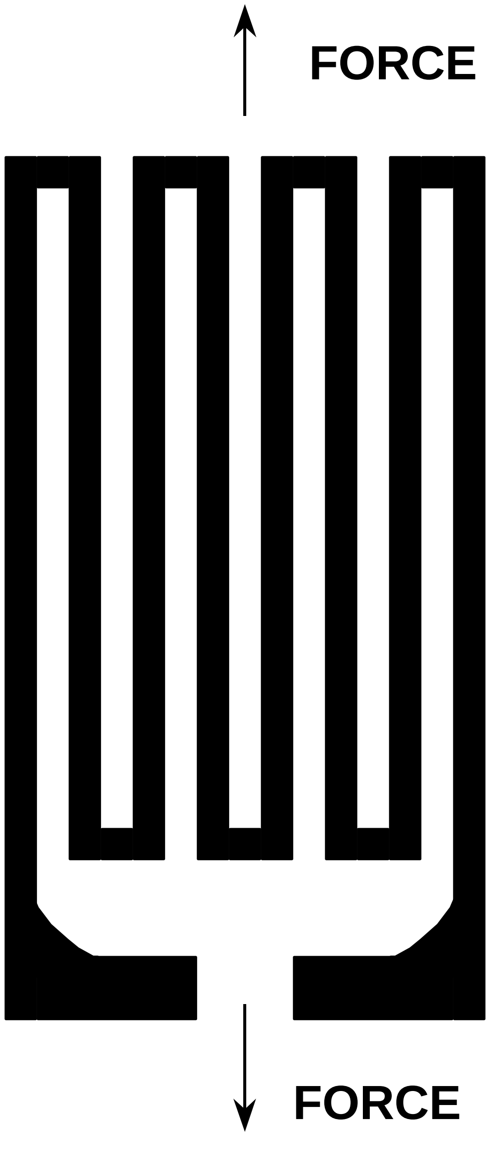
BONDED WIRE STRAIN GAGE



- SMALL SURFACE AREA
- LOW LEAKAGE
- HIGH ISOLATION

a

METAL FOIL STRAIN GAGE



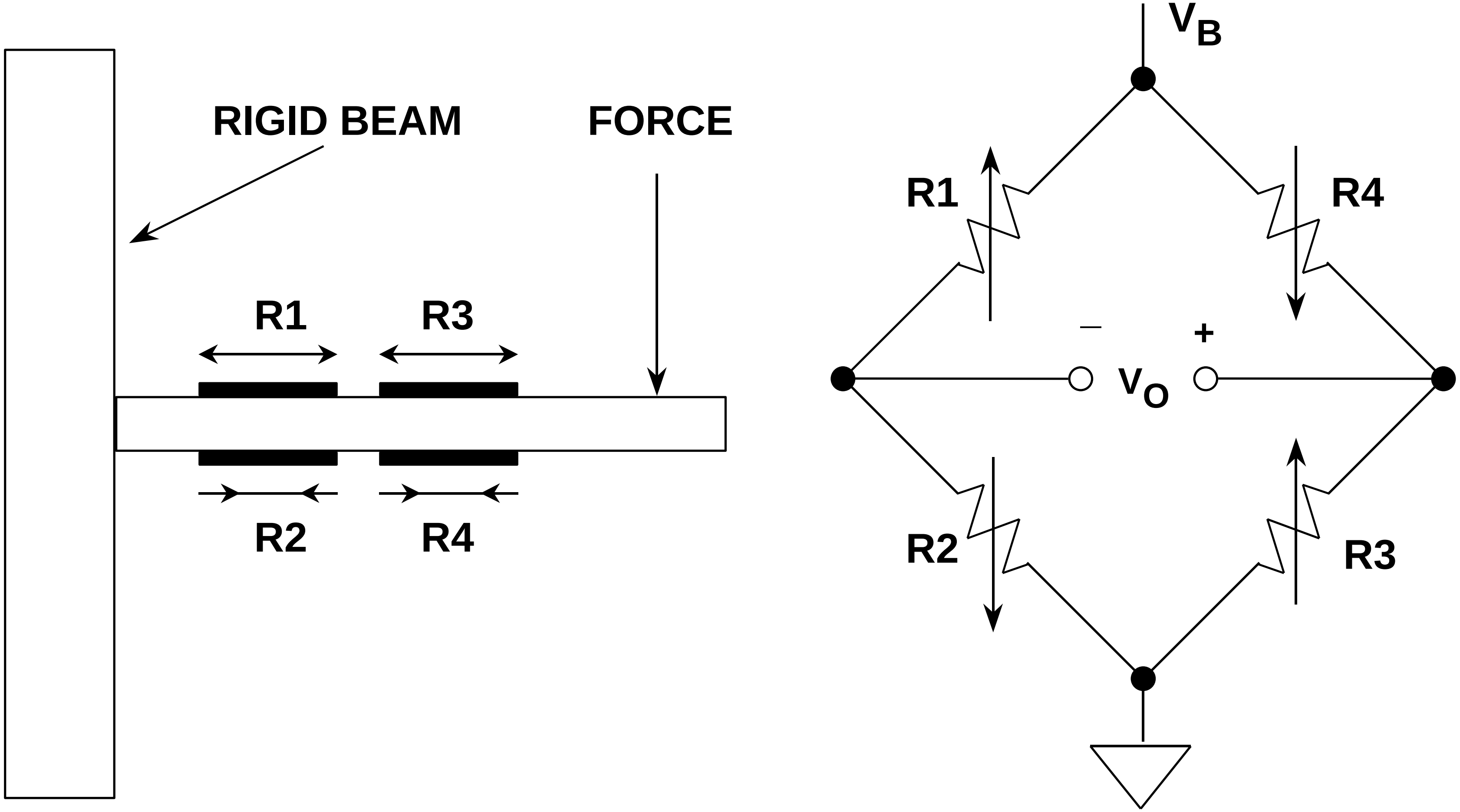
- PHOTO ETCHING TECHNIQUE
- LARGE AREA
- STABLE OVER TEMPERATURE
- THIN CROSS SECTION
- GOOD HEAT DISSIPATION

a

COMPARISON BETWEEN METAL AND SEMICONDUCTOR STRAIN GAGES

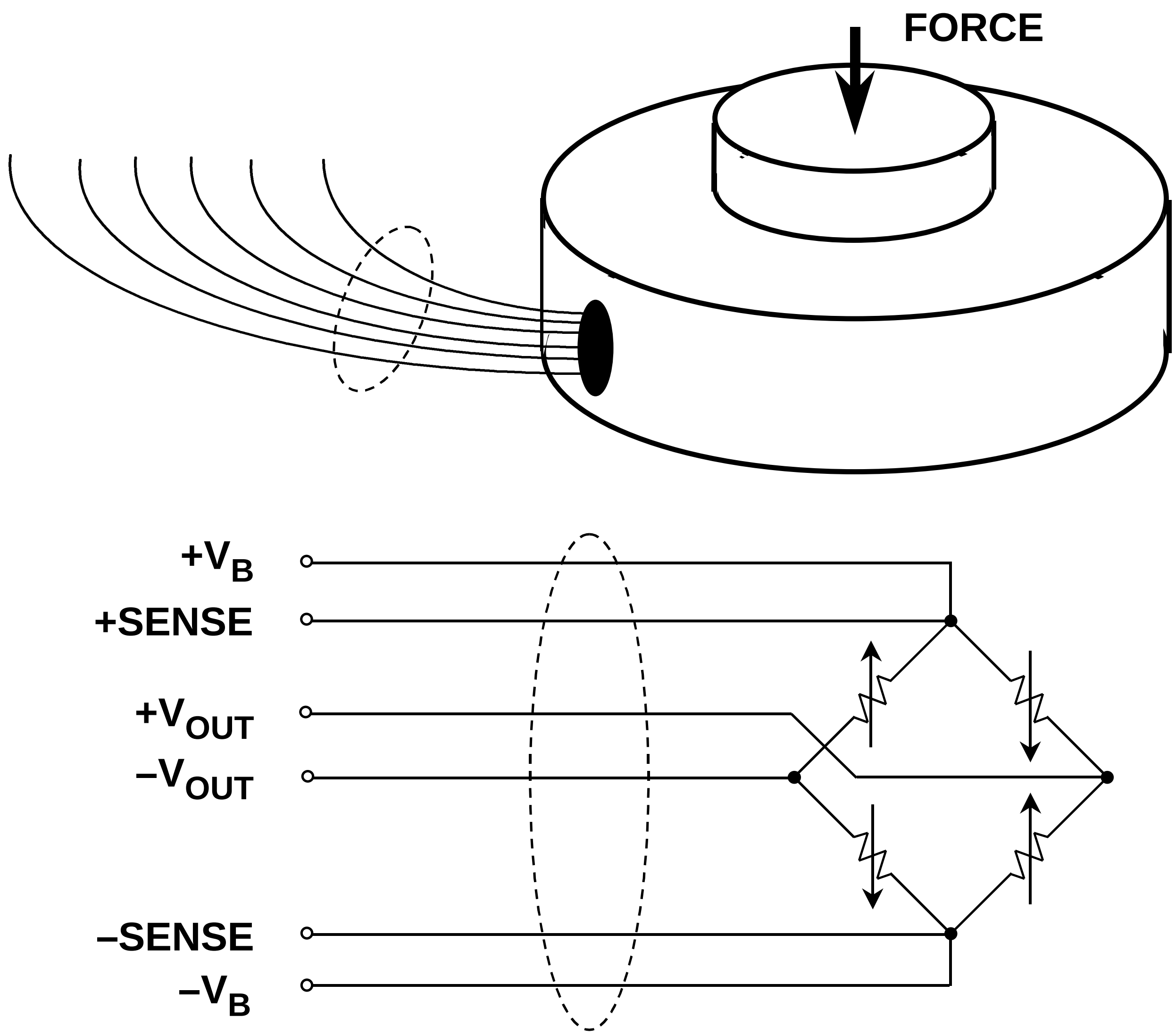
PARAMETER	METAL STRAIN GAGE	SEMICONDUCTOR STRAIN GAGE
Measurement Range	0.1 to 40,000 $\mu\varepsilon$	0.001 to 3000 $\mu\varepsilon$
Gage Factor	2.0 to 4.5	50 to 200
Resistance, Ω	120, 350, 600, …, 5000	1000 to 5000
Resistance Tolerance	0.1% to 0.2%	1% to 2%
Size, mm	0.4 to 150 Standard: 3 to 6	1 to 5

STRAIN GAGE BEAM FORCE SENSOR



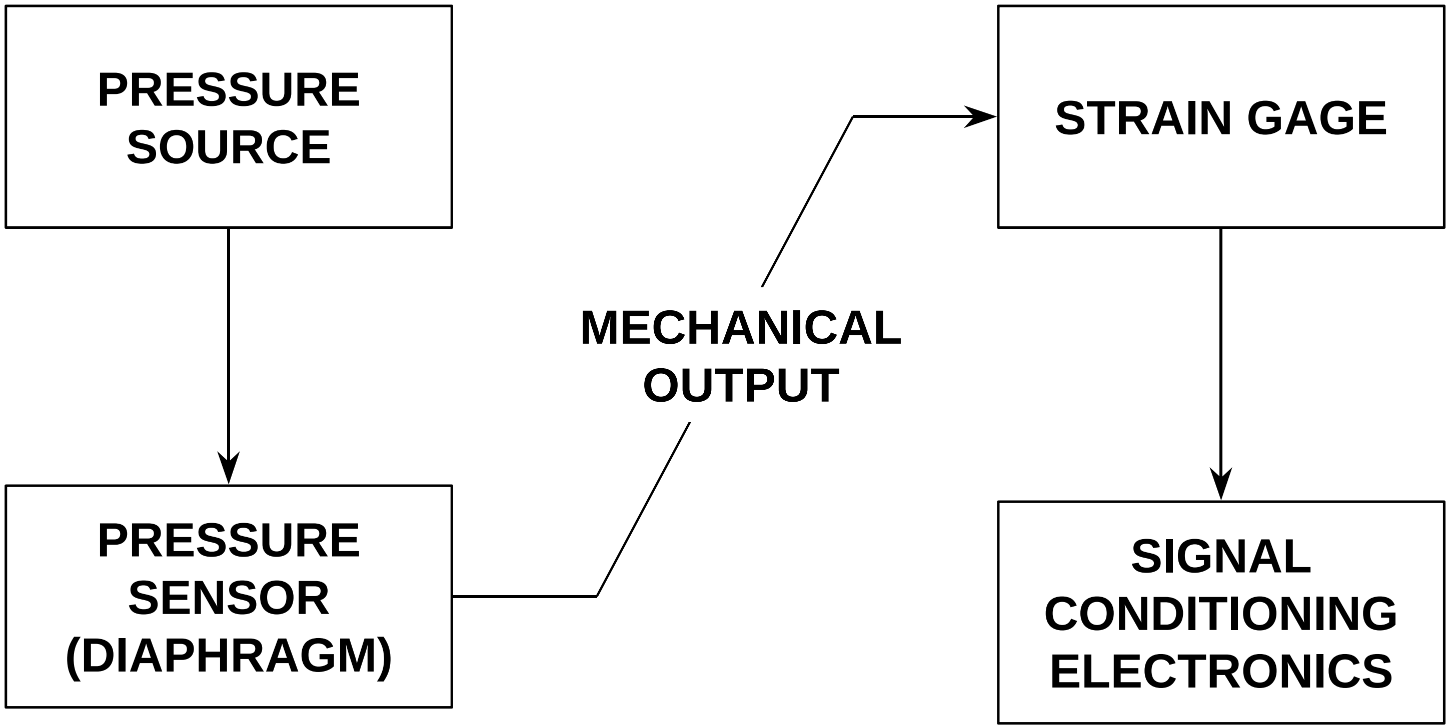
a

6-LEAD LOAD CELL

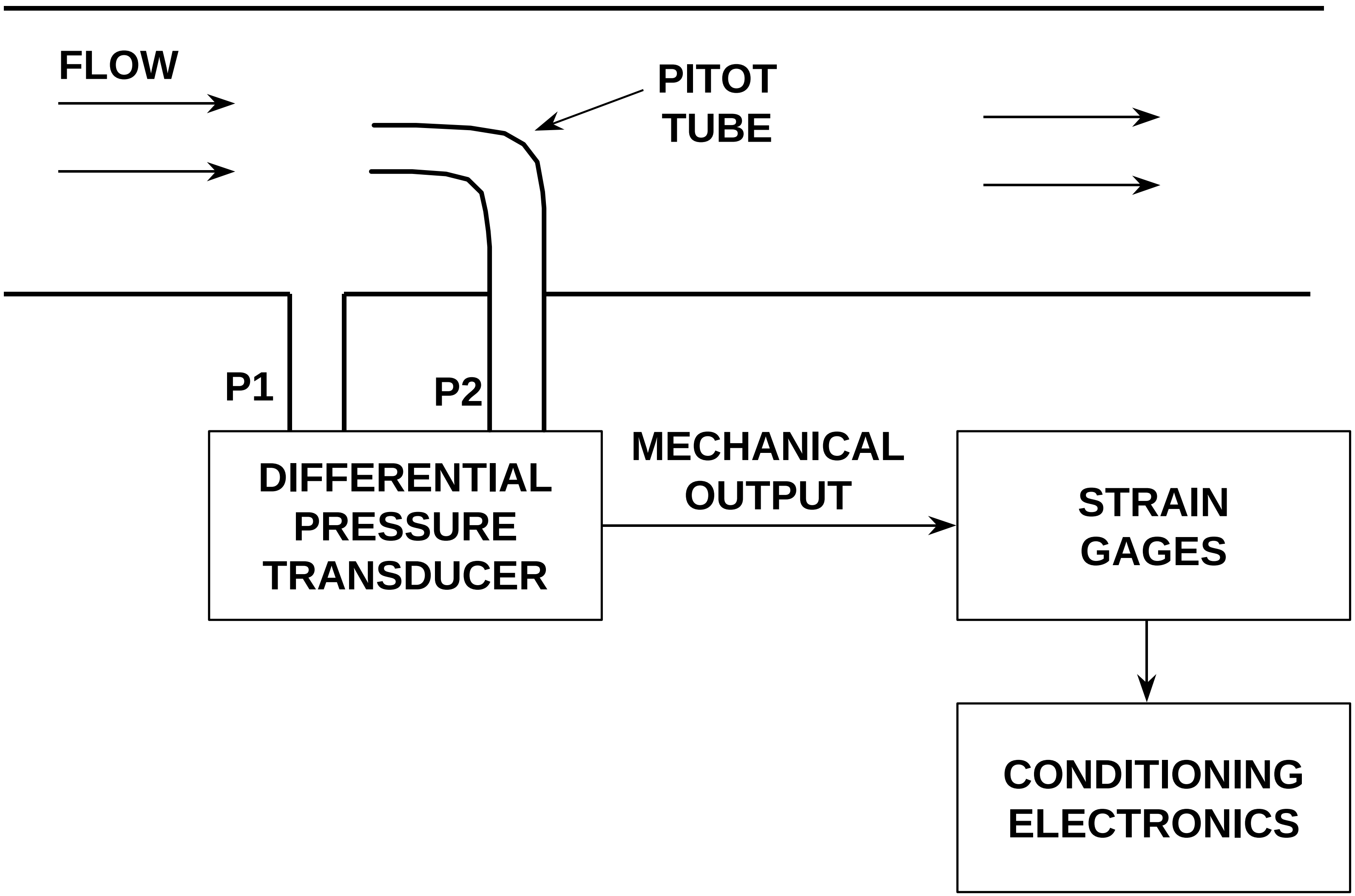


a

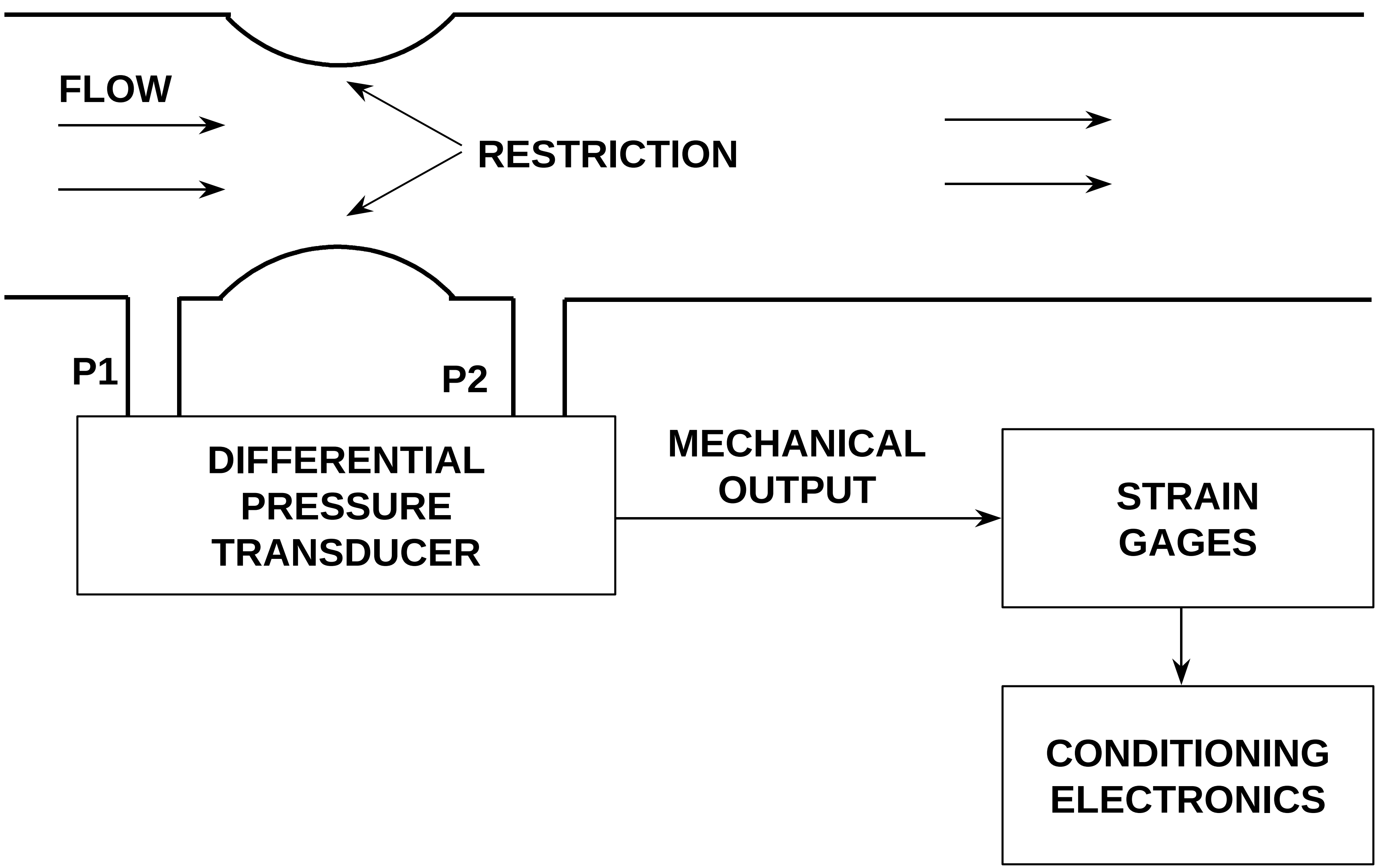
PRESSURE SENSORS



PITOT TUBE USED TO MEASURE FLOW RATE

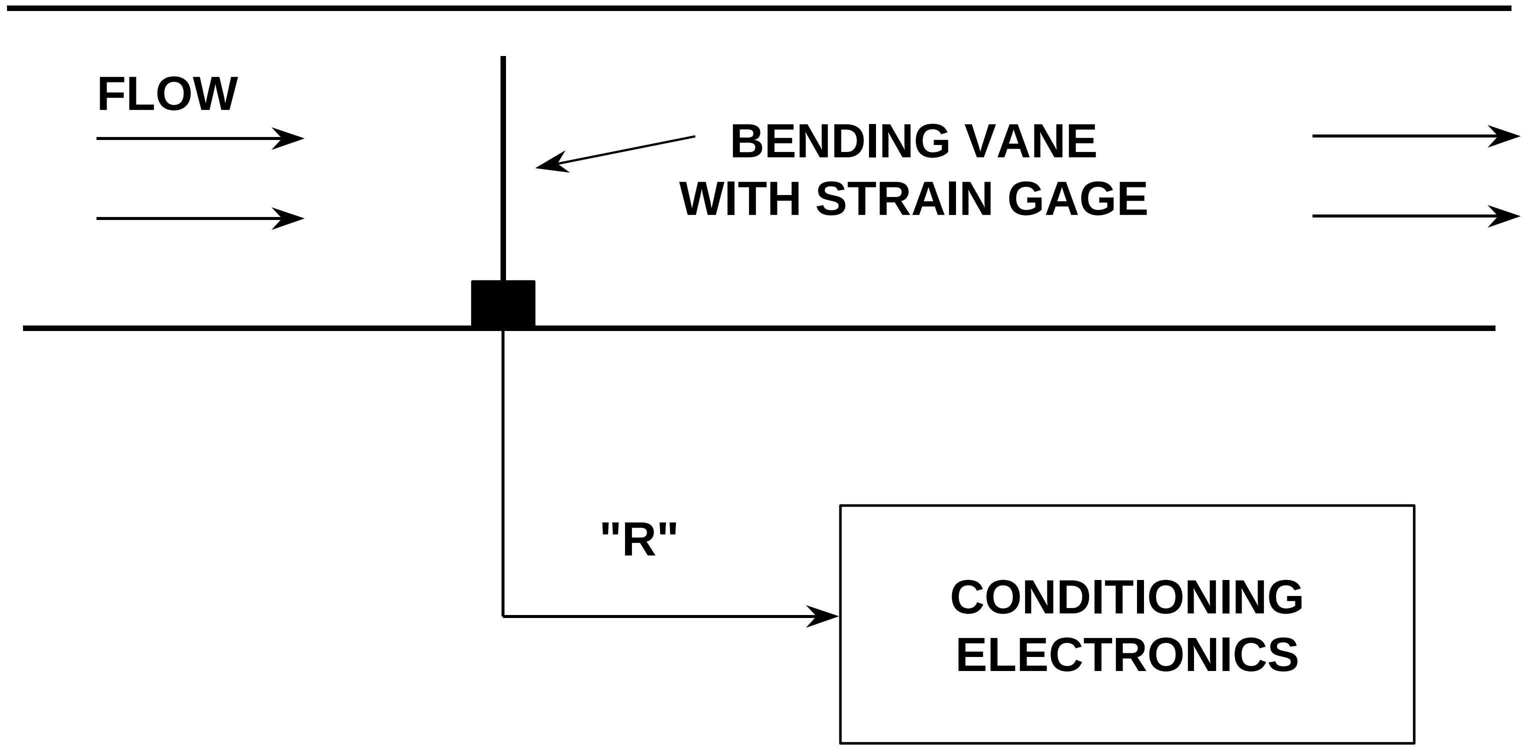


MEASURING FLOW RATE USING THE VENTURI EFFECT

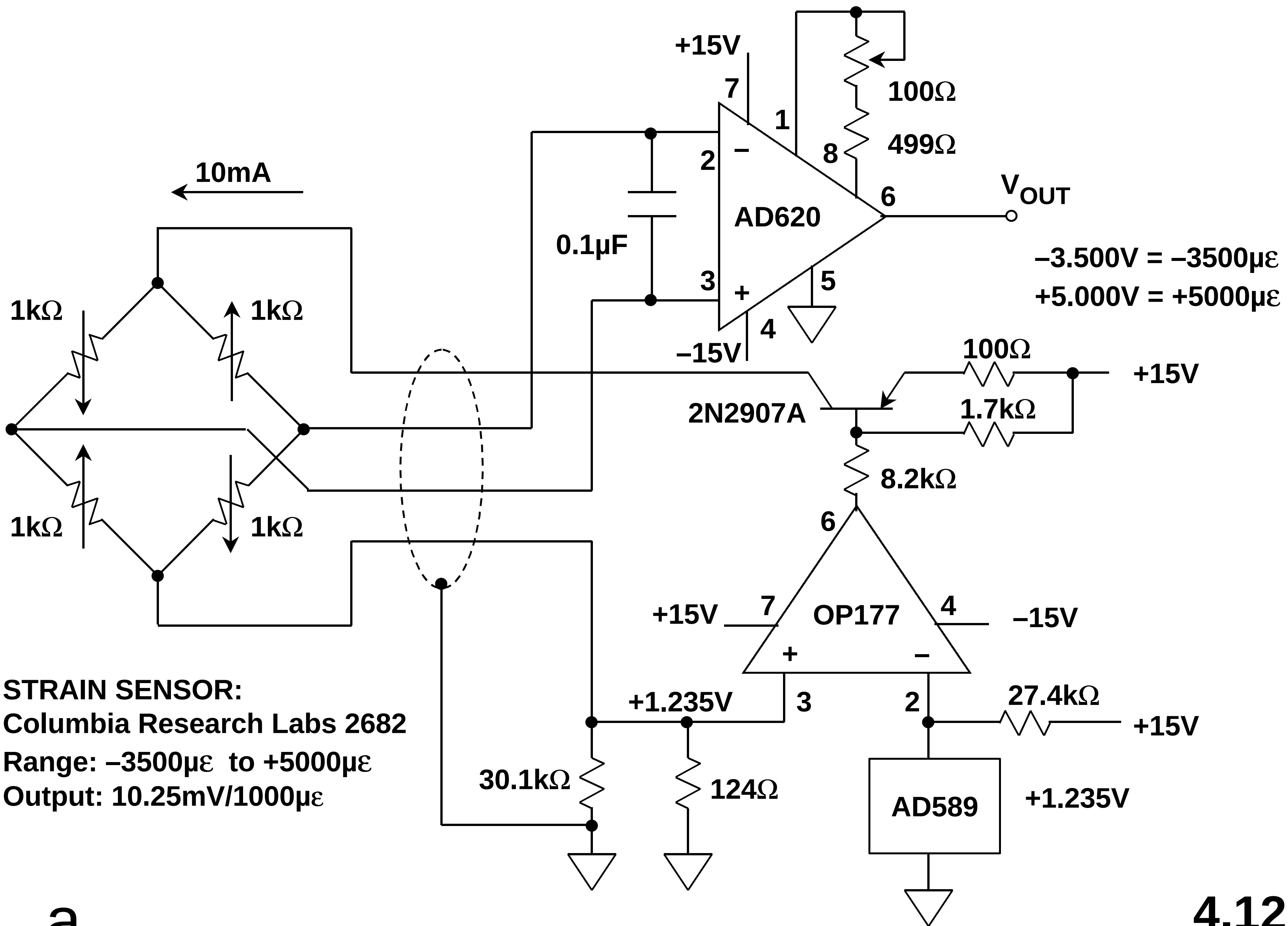


a

BENDING VANE WITH STRAIN GAGE USED TO MEASURE FLOW RATE



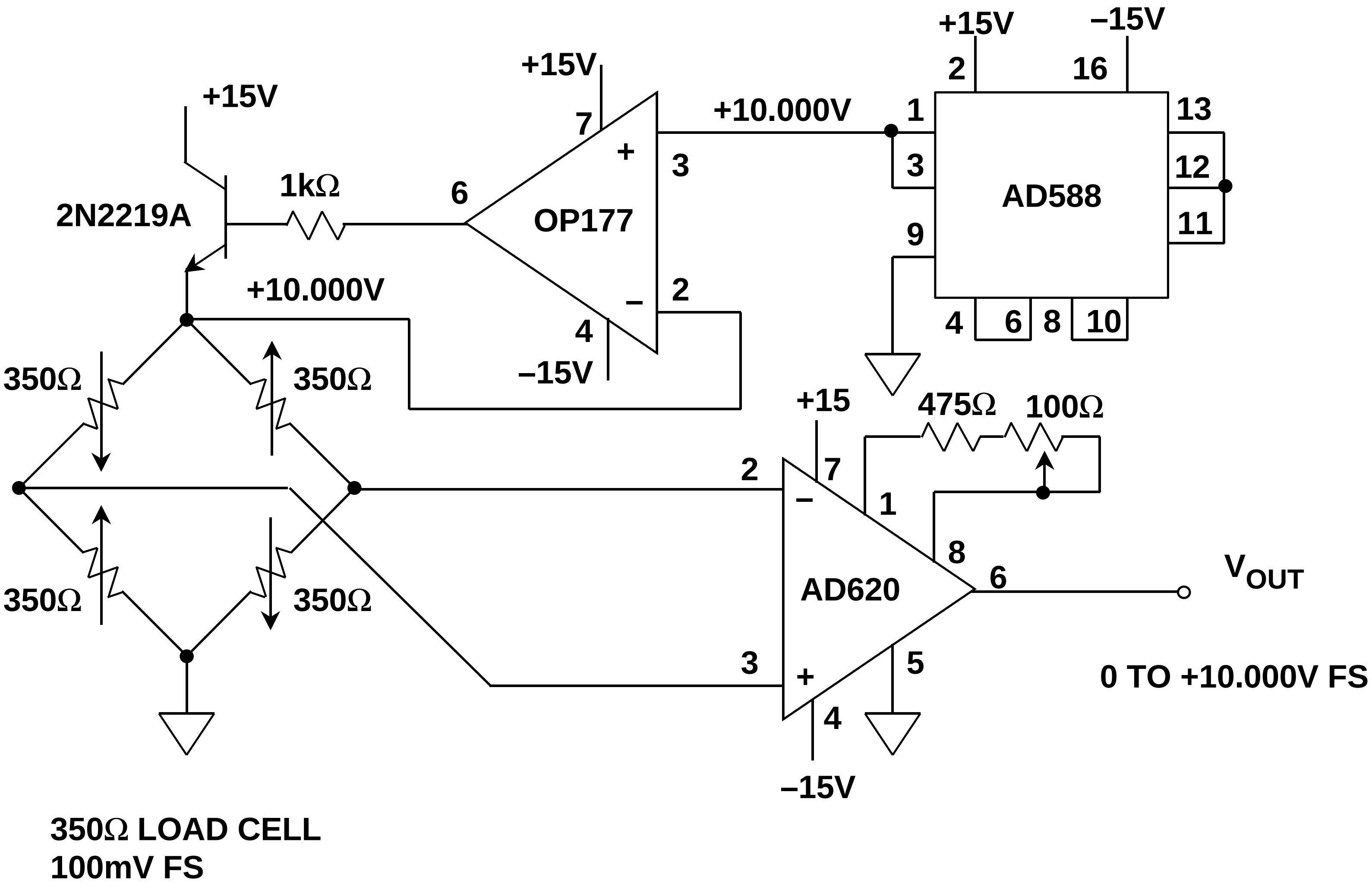
PRECISION STRAIN GAGE SENSOR AMPLIFIER



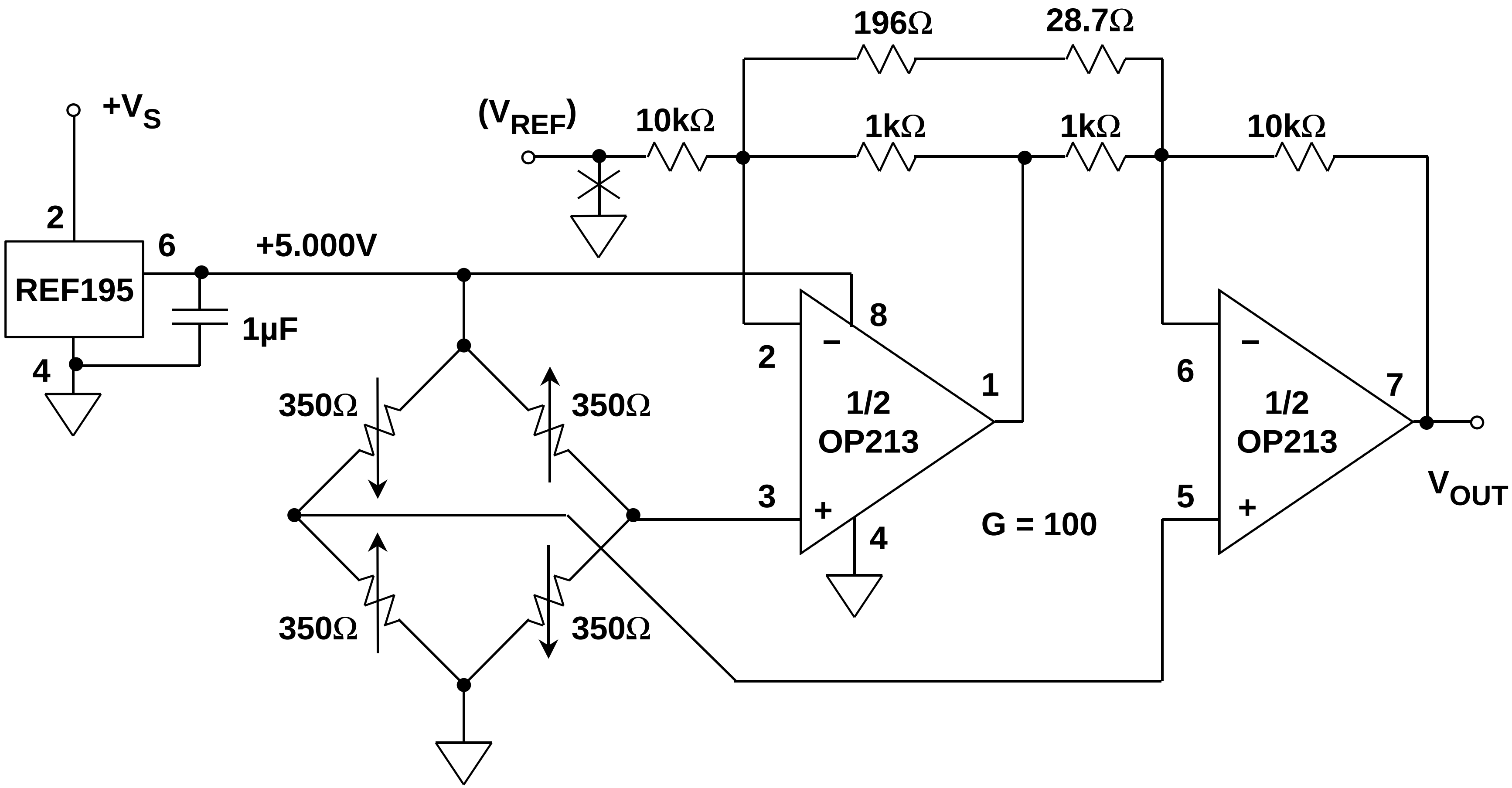
STRAIN SENSOR:
Columbia Research Labs 2682
Range: –3500µε to +5000µε
Output: 10.25mV/1000µε

a

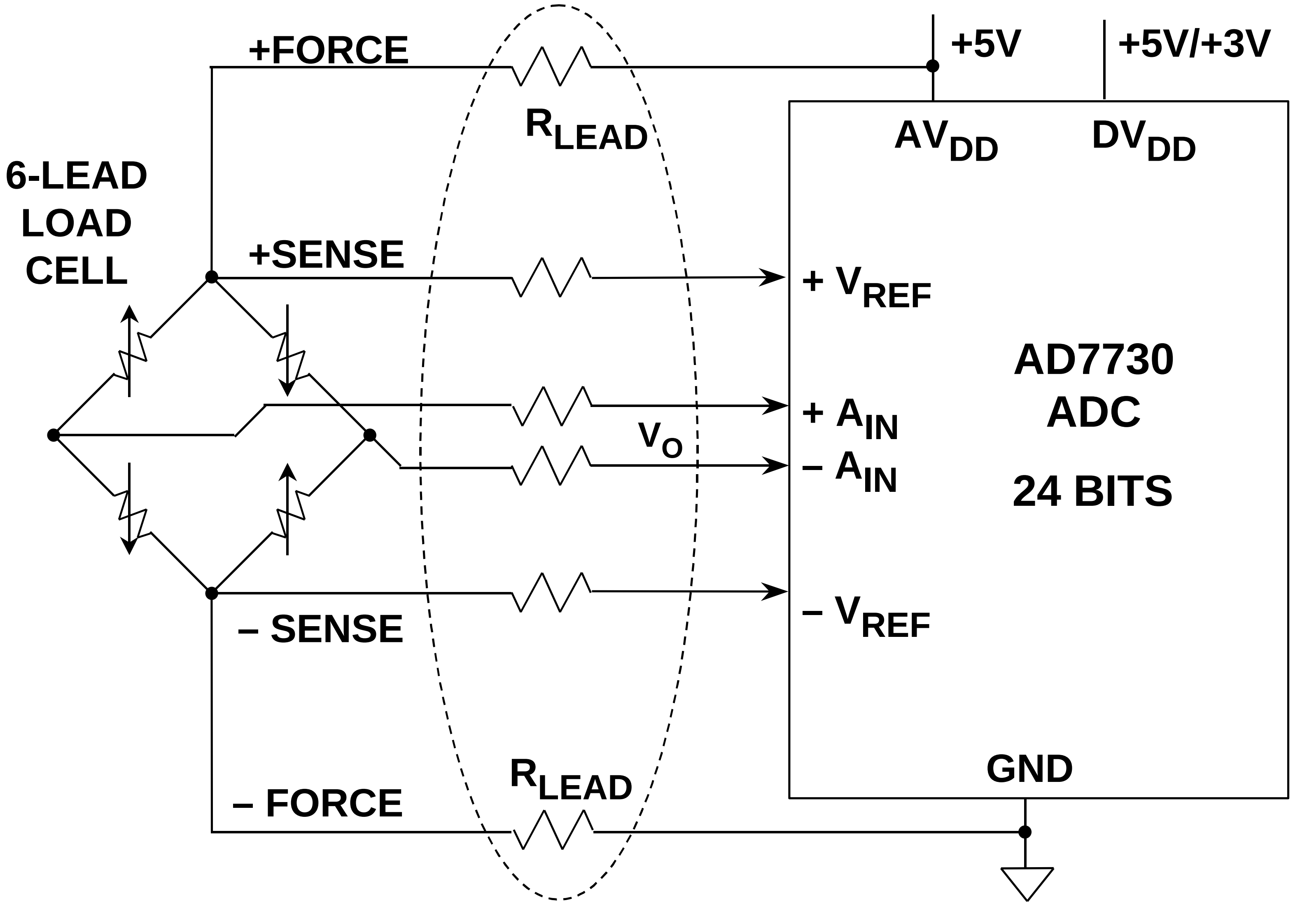
PRECISION LOAD CELL AMPLIFIER



SINGLE SUPPLY LOAD CELL AMPLIFIER



LOAD CELL APPLICATION USING THE AD7730 ADC



a

PERFORMANCE OF AD7730 LOAD CELL ADC

- **Assume:**

  Fullscale Bridge Output of ±10mV, +5V Excitation

  "Chop Mode" Activated

  System Calibration Performed: Zero and Fullscale

- **Performance:**

  Noise RTI: 40nV rms, 264nV p-p

  Noise-Free Resolution: ≈ 80,000 Counts (16.5 bits)

  Gain Nonlinearity: 18ppm

  Gain Accuracy: < 1µV

  Offset Voltage: <1µV

  Offset Drift: 0.5 µV/°C

  Gain Drift: 2ppm/°C

  Note: Gain and Offset Drift Removable with System Recalibration