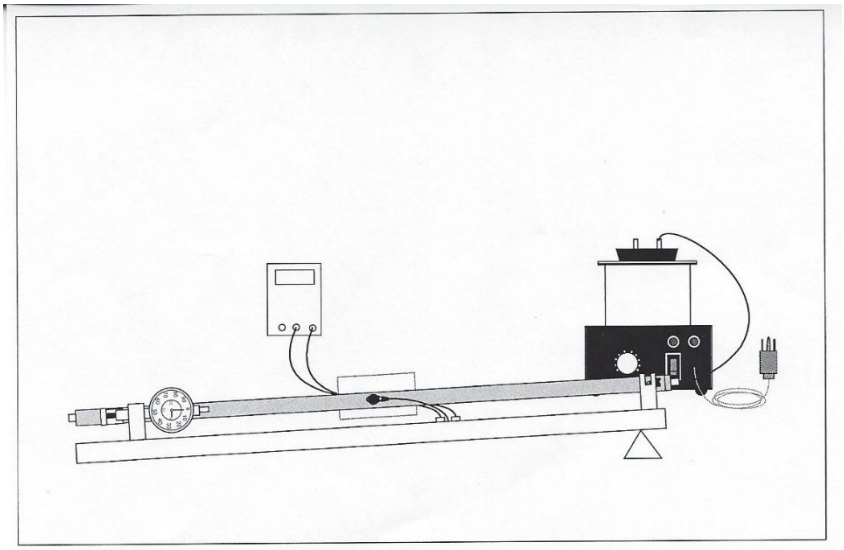
Thermal Expansion

Purpose: To find the coefficent of thermal expansion for copper, steel and aluminum

Equipment: Thermal expansion apparatus with three rods, foam cover and tubing
Metersticks
Pasco steam generator
Wood block
Hand-held DMM with banana leads
Small cup to collect condensation

Setup:



Here you can see that the apparatus is raised on the end opposite the micrometer. Also, the steam generator is connected at the end opposite the micrometer. The foam block is around the thermistor connector.

Background: Most materials expand when heated through a temperature range that does not produce a phase change. The added heat increases the average amplitude of vibration of the atoms in the material which increases the average separation between the atoms.

If an object is length L at some initial temperature T_i is heated to temperature T_f, the increase in length $\Delta L = L_f - L_i$ is characteristic of the composition of the object. The coefficient of linear expansion α is given by:

$$\alpha = \frac{\Delta L}{L \Delta T}$$

Procedure:

1. Measure L, the length of the copper tube at room temperature. Measure from the inner edge of the stainless steel pin on one end, to the inner edge of the angle bracket at the other. Record your value with uncertainty.
2. Fill the steam generator about 2/3 full of water and turn it on with the dial at 7. Do not connect it, just let it warm.
3. Mount the copper tub in the expansion base as shown. The stainless steel pin on the tube fits into the slot and the bracket should be snug against the spring arm of the dial gauge.
4. Attach the thermistor lug to the thumbscrew to insure maximum contact with the tube. Put the foam insulator over the thermistor lug.
5. Connect an ohmmeter to the banana plug connected labeled THERMISTOR.
6. Measure and record R_i for the resistance at room temperature.
7. Place the wood block under the end of the expansion base opposite the gauge and a cup to collect condensation at the other.

8. Turn the outer casing of the dial gauge to align the zero point on the scale with the long indicator needle. As the tube expands, the indicator needle will move counterclockwise.
9. Connect the steam generator using the black tubing provided. Watch *R* and the dial. When the thermistor resistance stabilizes, record R_{hot} and ΔL. Each increment on the dial gauge is αequivalent to 0.01 mm of tube expansion.
10. Repeat for steel and aluminum.

Analysis:
Using the conversion for the thermistor resistance, Find the temperature of the rod initially and finally. The uncertainty stated by Pasco for the thermistor is ±0.2ºC.

Calculate α for each of the rods and the absolute uncertainty using the partial derivative method.

Are your values within uncertainty of the accepted values?

$\alpha_{cu} = 17.6 \times 10^{-6}$ /ºC
$\alpha_{steel} = 11.3$ to 13.5×10^{-6} /ºC
$\alpha_{al} = 23.4 \times 10^{-6}$ /ºC

THERMISTOR CONVERSION TABLE:

Temperature versus Resistance

Res. (Ω)	Temp. (°C)	Res. (Ω)	Temp. (°C)	Res. (Ω)	Temp. (°C)	Res. (Ω)	Temp. (°C)
351,020	0	95,447	26	30,976	52	11,625	78
332,640	1	91,126	27	29,756	53	11,223	79
315,320	2	87,022	28	28,590	54	10,837	80
298,990	3	83,124	29	27,475	55	10,467	81
283,600	4	79,422	30	26,409	56	10,110	82
269,080	5	75,903	31	25,390	57	9,767.2	83
255,380	6	72,560	32	24,415	58	9,437.7	84
242,460	7	69,380	33	23,483	59	9,120.8	85
230,260	8	66,356	34	22,590	60	8,816.0	86
218,730	9	63,480	35	21,736	61	8,522.7	87
207,850	10	60,743	36	20,919	62	8,240.6	88
197,560	11	58,138	37	20,136	63	7,969.1	89
187,840	12	55,658	38	19,386	64	7,707.7	90
178,650	13	53,297	39	18,668	65	7,456.2	91
169,950	14	51,048	40	17,980	66	7,214.0	92
161,730	15	48,905	41	17,321	67	6,980.6	93
153,950	16	46,863	42	16,689	68	6,755.9	94
146,580	17	44,917	43	16,083	69	6,539.4	95
139,610	18	43,062	44	15,502	70	6,330.8	96
133,000	19	41,292	45	14,945	71	6,129.8	97
126,740	20	39,605	46	14,410	72	5,936.1	98
120,810	21	37,995	47	13,897	73	5,749.3	99
115,190	22	36,458	48	13,405	74	5,569.3	100
109,850	23	34,991	49	12,932	75		
104,800	24	33,591	50	12,479	76		
100,000	25	32,253	51	12,043	77		

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