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SDC
SOLENOIDAL DETECTOR NOTES

REPORT: HEATING OF MUON TUBE

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Report: Heating of Muon Tube

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For the heat shrinking process of securing the end caps into the muon tubes, we explored the option of using conventional heating as an alternative method to infrared or induction heating.

To test the feasibility of heating the tubes this way, we first heated a piece of aluminum of comparable thickness to the muon tube (1.6 mm) on a brass hot plate for several different durations and recorded the aluminum's final temperature using a calorimeter (Fig. 1). Doing this, we found that, with the hot plate held at 150 °C, it took about 10 seconds to heat the aluminum to 120°C (Fig. 2) We also experimented with using a .01" sheet of silicon between the hot plate and the aluminum to make a better fit between the surfaces, but found that this method was unsuitable as it took three times as long to heat the aluminum to the desired temperature.

The clamp we prototyped was made up of eight segmented brass blocks, each heated by a 30 watt cartridge heater, held together in the shape of the tube (that is the ID of the clamp was equal to the OD of the tube) by a springy belt of phosphore bronze (Fig. 3 and Fig. 4). [Note: the prototype in Fig. 3 was designed for the old, 7.5 cm tubes. Everything will be scaled up for the new tubes.] The reason for segmenting the brass heating surface was to maximize the surface area of the clamp that made contact with the muon tubes to accommodate the variations in the ODs of the muon tubes. By segmenting the heating pad and pulling them snugly against the muon tube, any gaps are minimized. Table 1 shows how the maximum gap between tube and clamp varies with the number of segments per clamp.

We designed a unit using last-word indicators to measure, from the inside, the expansion of the tube and tested our prototype design. We found that, with the heating blocks held at 150 °C (100 watts total), it took ≈10 seconds for the tube to expand by .006". This expansion, we measured, was uniform and corresponded to a temperature of 120 °C. Heating time and/or final temperature (expansion) can, of course, easily be varied.

Instead of the hinged clamp depicted in Figure 3, this heating device will be split into two, well insulated, clam shells that are pushed onto the tube from the side with pneumatic arms (Fig. 5). The two clam shells will be kept heated, out of the way, and if necessary, will rest in protective housings.

We estimate the cost of constructing the clamp assembly for the 93 mm tubes (minus the pneumatic arms) to be $400 plus 12 hours of machine time.

Fig. 1

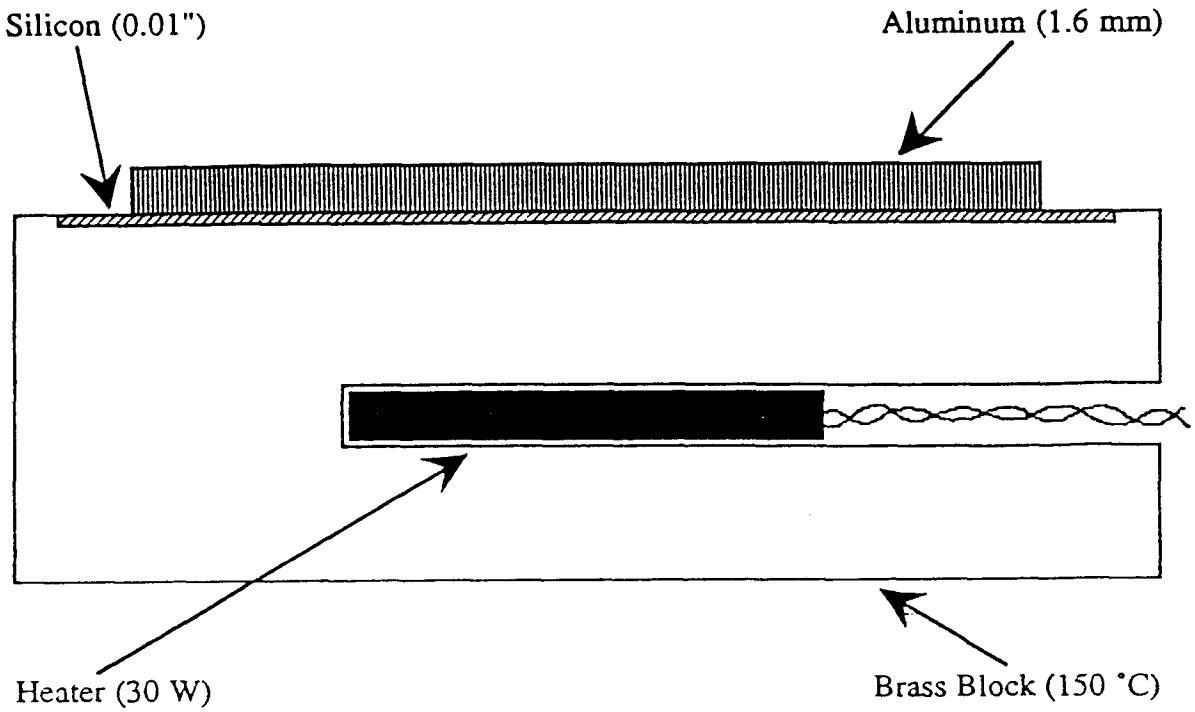

Silicon (0.01")
Aluminum (1.6 mm)
Heater (30 W)
Brass Block (150 °C)

Fig. 2

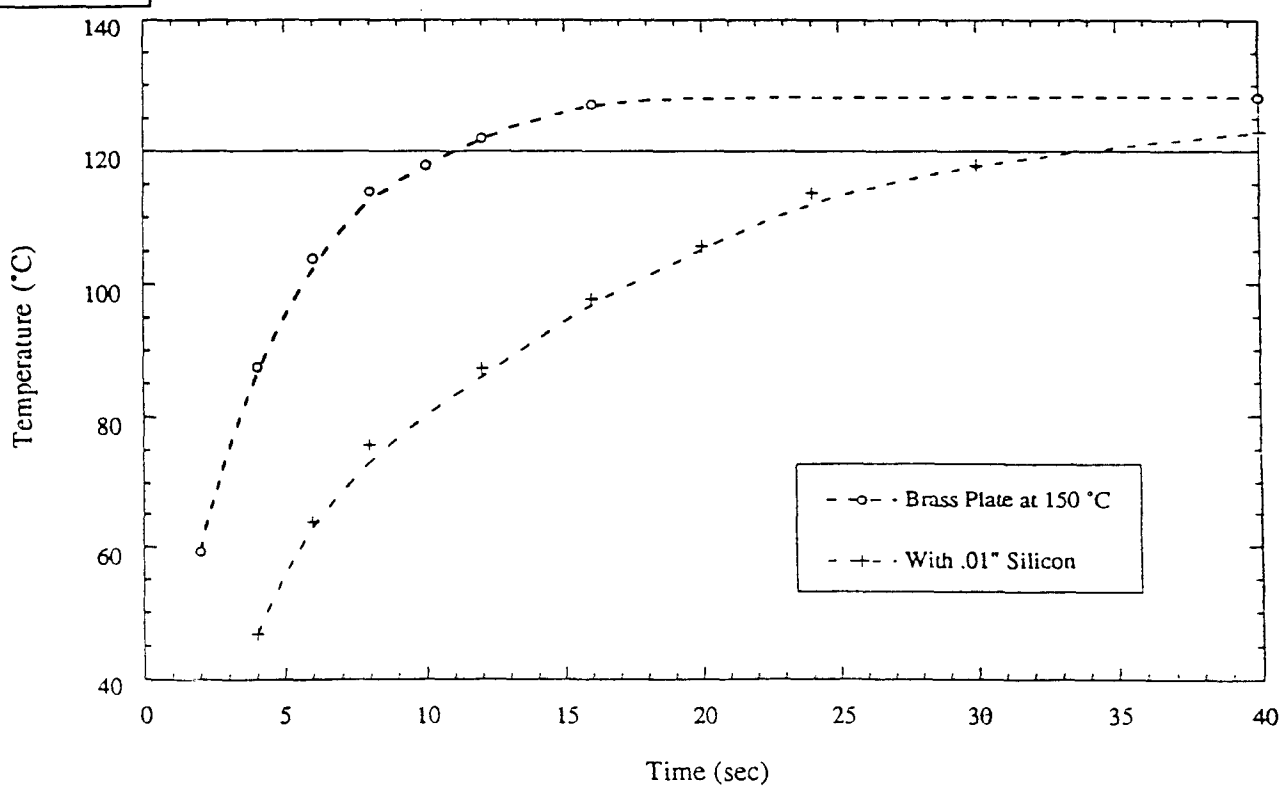
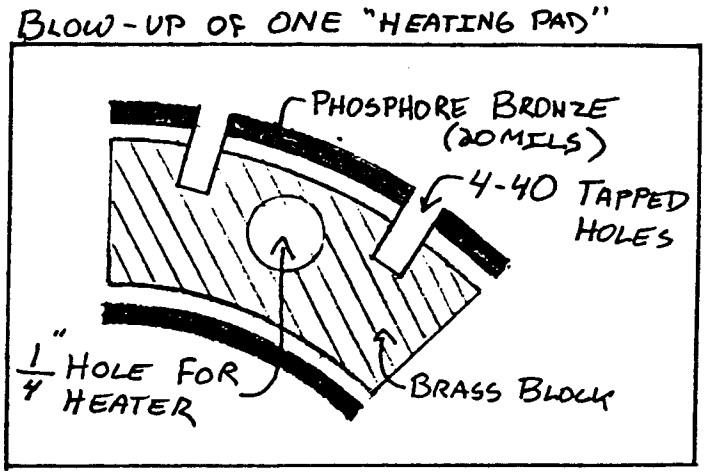
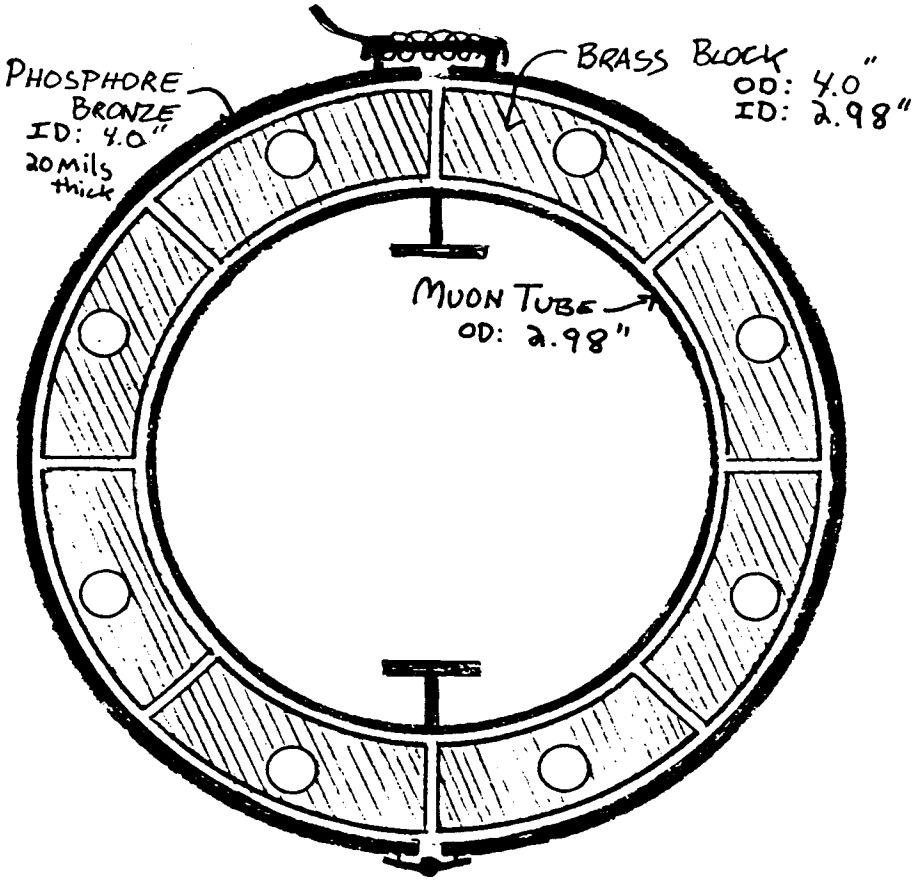

Heating of 1.6 mm Aluminum Plate
Temperature (°C)
Time (sec)
140
120
100
80
60
40
0
5
10
15
20
25
30
35
40
Brass Plate at 150 °C
With .01" Silicon

Fig. 3





Note: The gap shown between the muon tube and the brass blocks as well as that between the brass blocks and the phosphore bronze belt have been exaggerated for clarity.

Fig. 4

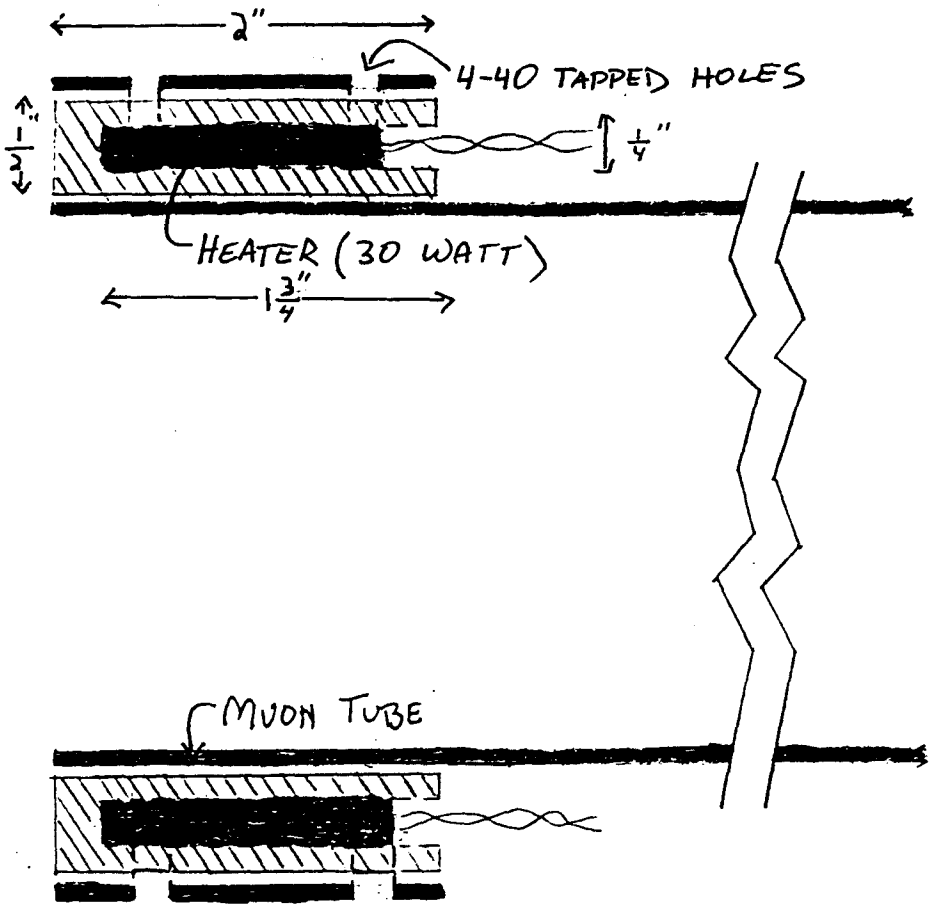
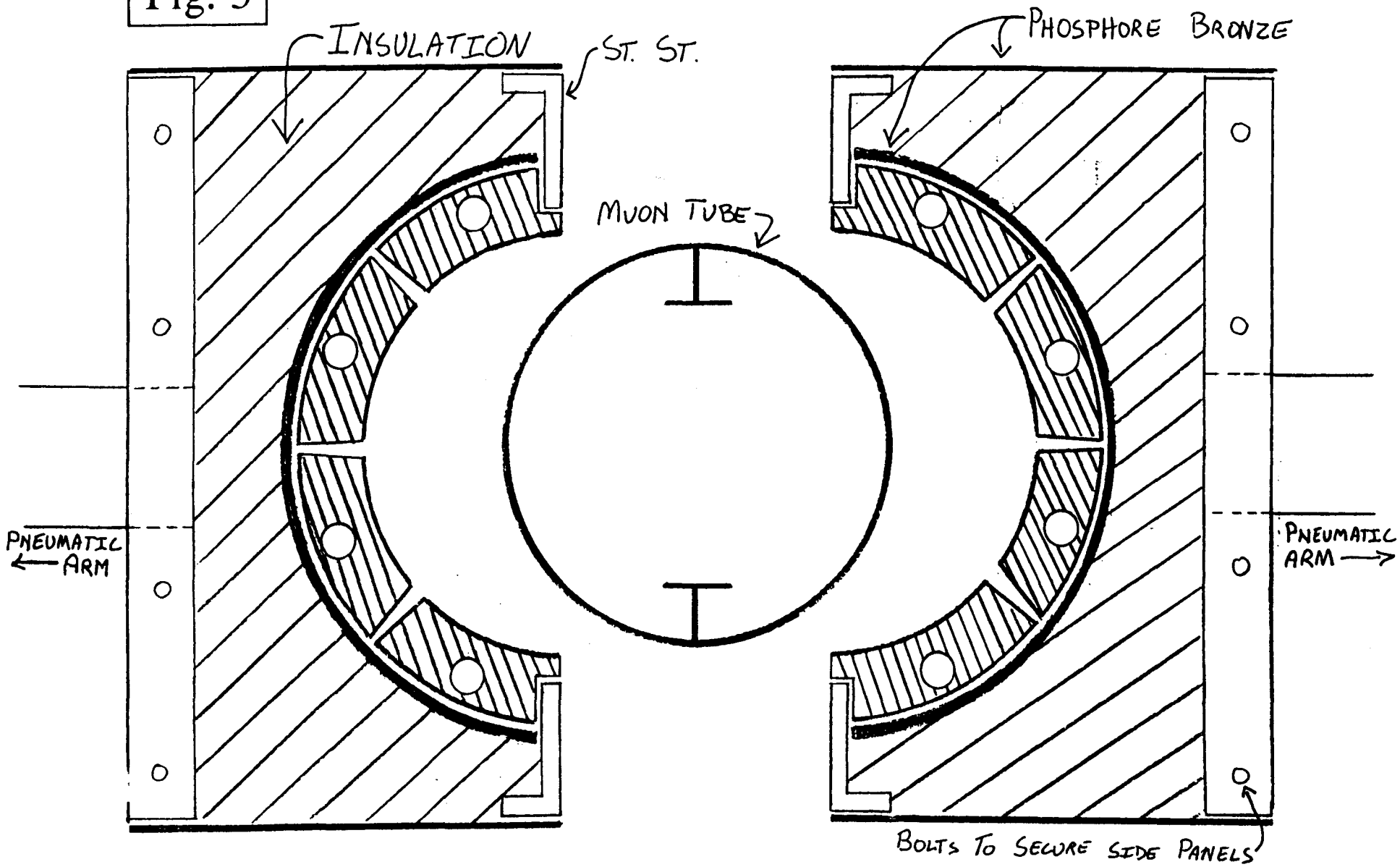


Table 1

# of segments	max gap / $\lvert R_{tube} - R_{clamp} \rvert$
4	.7
8	**.146**
16	.034
32	.0086

Fig. 5


INSULATION
ST. ST.
PHOSPHORE BRONZE
MUON TUBE
PNEUMATIC ARM
PNEUMATIC ARM
BOLTS TO SECURE SIDE PANELS