G-2 ORDER PARTS INSIDE

Fermilab

Physics Department
Mechanical Department Engineering Note

Number: MD-ENG-Tentative Date: 6-2-2014

Project Internal Reference: Mu2e Straw Tube Co2 Leak Detector

Project: Mu2e

Title: Fabrication of Cu Tubing and Co2 Detector Box

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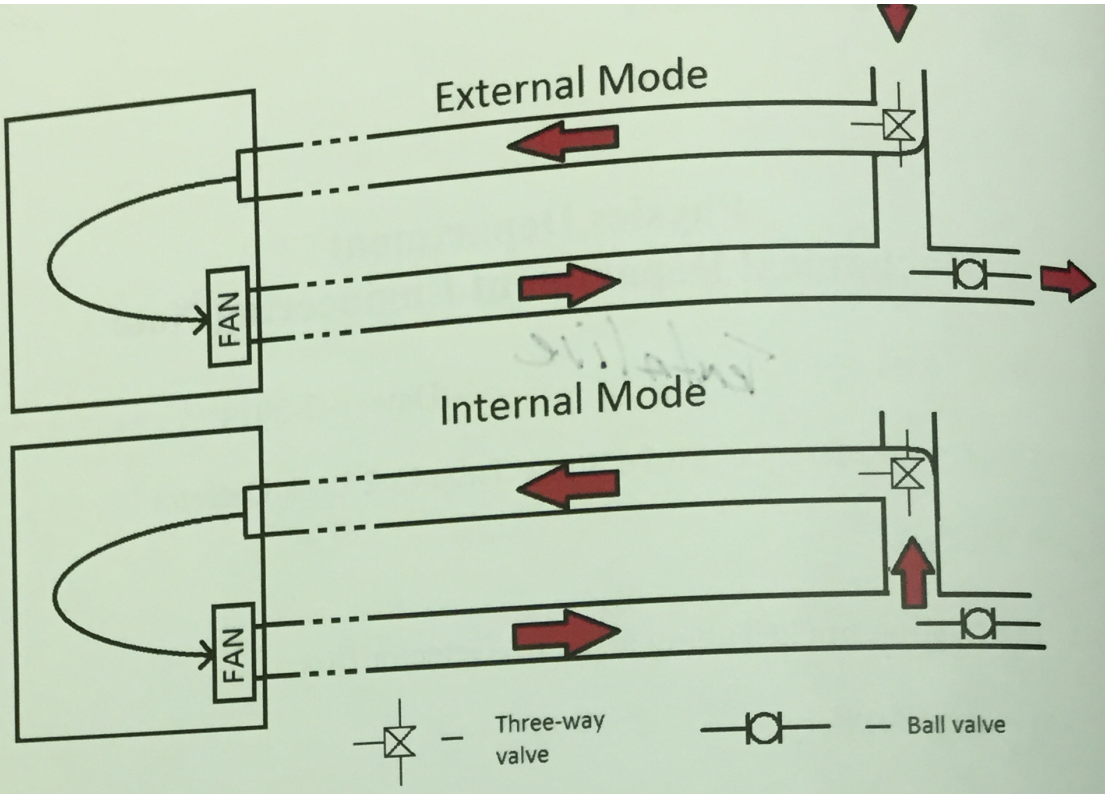
Key Words: Cu Tubing, Co2 Detector

Abstract Summary: DOE/FNAL/Mu2e Straw Tube detectors operate with Ar/Co2 gases in its straw chamber, a type of Gaseous ionization detector. It is a long tube with a wire down the center and a gas blend of Ar/Co2, which becomes ionized when a particle passes through. A potential difference in High Voltage is maintained between the wire and the walls of the tube, so that once the gas is ionized, electrons move in one direction and ions in the other. This produces a current which indicates that a particle has passed through the chamber. Many straws together can be used to track particles in a straw tracker.

The Mu2e tracker provides the primary momentum measurement for conversion electrons. The tracker must identify and measure 105 MeV/c electrons while rejecting backgrounds, and it must provide this functionality while situated in the warm, evacuated bore of a superconducting solenoid that provides a uniform magnetic field of 1 Tesla.

CD-1 Review of Mu2e



G-2 ORDER
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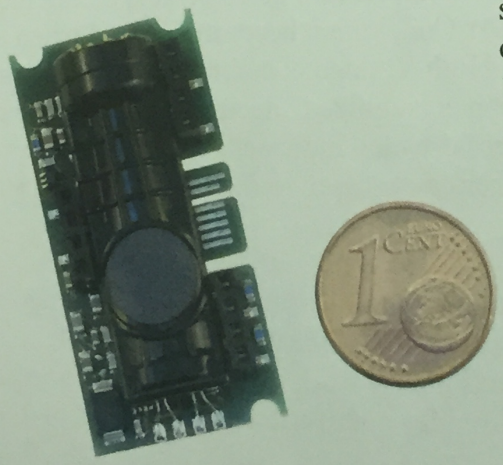
Nondispersive infrared technology, 891 sensor has an adjustable Co2 concentration range of 0–2000/ 5000/ 10000 ppm



Images Courtesy: David Rivera, Rice University
Aug 19 2013
dor1@rice.edu

A means of checking bulk assembled Straws are required to test for Permeability of wall construction. Ar 25cm3, Co2 240 cm3 in Mylar compared to Kapton Ar 1.5_10_11 , Co2 6843cm3. Nuclear Instruments and Methods in Physics Research A 615 (2010) 267–271

Copper Tube Construction

Bronze Three way Ball Valve modification

A crude prototype copper tube leak detector was constructed in 2013 and tested.
Results were favorable, indicating Co2 permeability of bulk straws, under a low pressure condition.

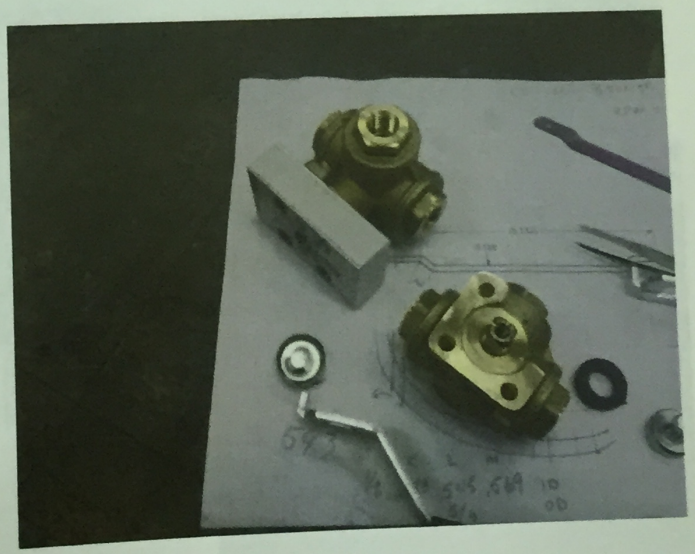
This testing however does not indicate where along the tube assembly the device is leaking.

A more suitable device is a Dual Thermal Column Gas Leak detector which can be used once straw tubes are installed in the HARP assembly. This method will locate exact leak location.

Three-way bronze ball valve ordered is a National Pipe Thread device. Copper solder fittings were requested and the valve will be modified to accept this assembly method.

An aluminum jig was fabricated to facilitate a secure mounting in a vertical milling machine.

Valve actuator; handle and hardware are removed during the process.



Bronze Three way Ball Valve modification

After bronze ball valve is mounted to aluminum fixture the valve is positioned to mill a flat across the casting at three points.

This will produce a gripping area in the milling machines hardened steel vice.

A guide pin of the OD of the NPT threads is used as an alignment jig. The vertical feed stock lowers three-way valve into mills vice and then is secured. This method aligns valves vertical axes to mill's spindle CL on next milling step.

Copper Tube Construction

Bronze Three way Ball Valve modification

Mill operator then changes alignment pin to end mill. A stop is inserted in mills vice to speed up this set up.

The table lift is used in this procedure to safely mill the bronze casting. The end mill will climb up the end mill if spindle feed is used.

A go-no go gauge is used to test fit milling process. The gauge is a piece of copper tubing that should fit snuggly into bore of bronze ball valve, but not bind.

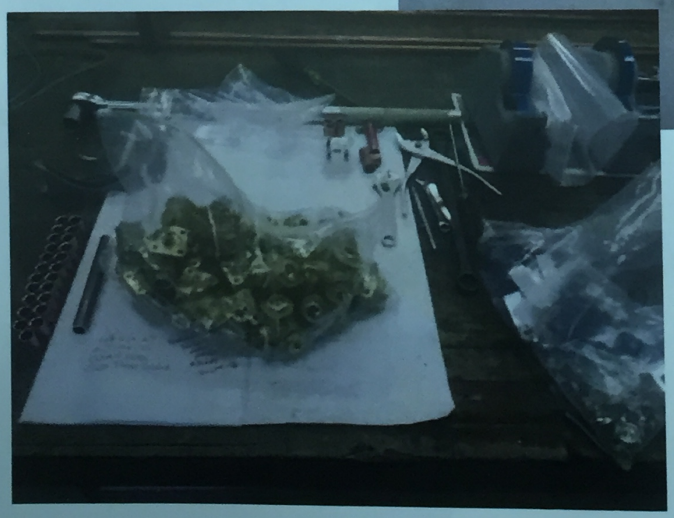
A line is placed on the tube to also indicate the proper depth.

Copper Tube Construction

Bronze Three way Ball Valve modification

Valve will need to be taken apart to properly clean bronze chips from the milling process. Ultrasonic cleaner is used during this step.

Valve parts are then reassembled and tightened to proper torque. Mill has faced flats on these surfaces, to aid reassembly.

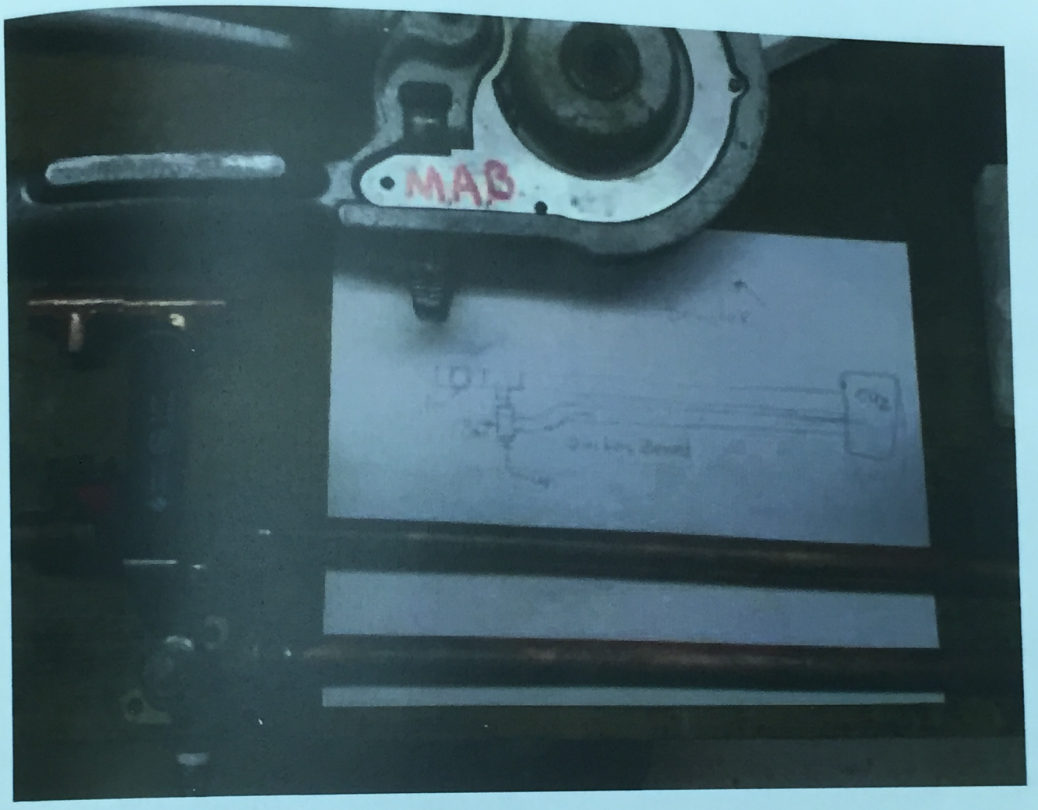


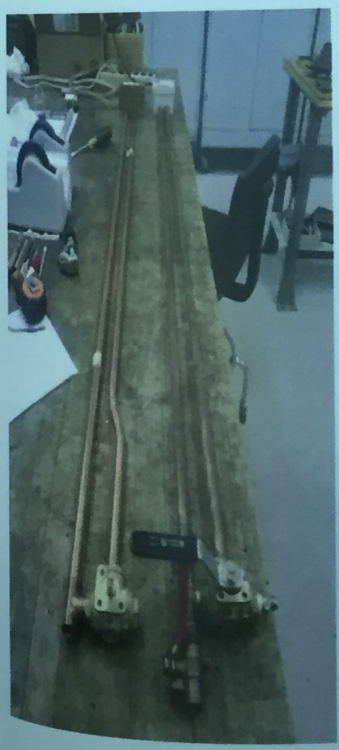
Parts are test fitted to check assembly. Short tubes have been cut on lathe and polished, as seen in image ~~left.~~ ABOVE

After ultrasonic cleaning and reassembly valves are stored in a bag to minimize corrosion.

Copper Tube Construction

Copper tube preparation





A tube bender is prepared to bend a "dog leg" in the copper pipe to keep the two copper tubes parallel to each other.

This minimizes the stress on copper fittings as seen in above image and image left, of prototype.

Prototype's detector gas box was epoxied.

Small die cast boxes were ordered, copper tubing will need to be terminated with soft solder to insure gas integrity.

Soldering Copper tubing

Bronze Ball Valve

Knowledge of soft soldering techniques is required to perform this task.

A soft soldering Jig Station was assembled to aid in alignment of the copper tubing.

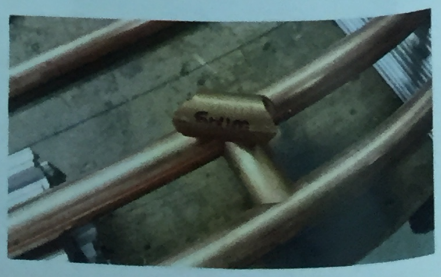
Dog leg tubing is pre-formed. Length of both ends are a tad longer and will be cut to proper size during sizing of the assembly to insure uniformity of each leak station.

Once Ball Valve end of assembly is sized correctly Solder Paste is added to fittings. A clamp is then placed over the length of copper tubing and held securely.

Long length of tubing is then aligned parallel along Jig Station with Cu tube Shims, as seen in images right. These tube jigs are not soldered and will be removed after fabrication.

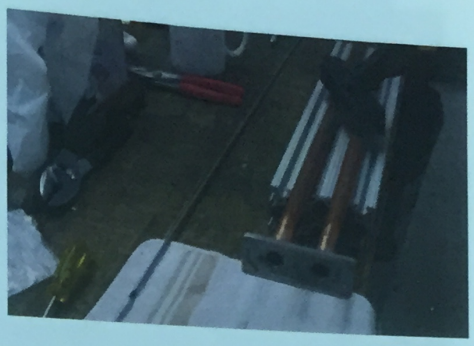
After parallelism adjustments are checked, clamps are placed at each clamp station.

End pieces will be trimmed to length in the next step with the Brass detector box parts and prepped for soldering.



Soldering Copper tubing
Finishing End Cap

Length of tubing needs to be uniform. Cut both tube to length and fit Brass end pieces to have the Cu tubing even to Brass end piece.



Brass end piece and die cast gas box is machined together and witness numbered.
To insure proper fit, please keep these together.

Once Cu tube is at correct length, apply Solder Paste and reassemble.

In order to solder, remove die cast end plate as it would act as an heat sink, warp and damage plastic gas seal.

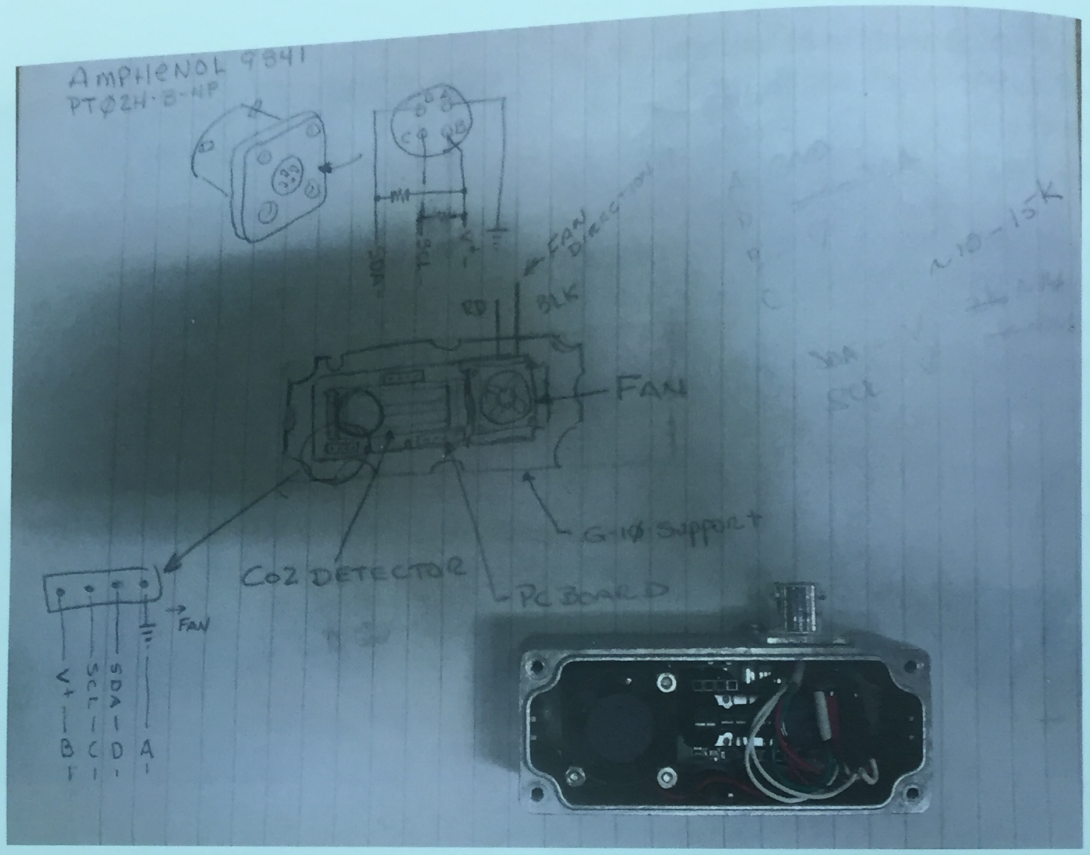
Image left shows proper soldering of the Brass end piece. Once solder Paste is cleaned off and a file run across face of Brass end piece to remove high points. This surface must be flat to the die cast part.

Clean both surfaces with alcohol and dry.

RTV is applied and the three 4-40 screws are then used to assemble to pull die cast gas box end piece to the Brass.

This is a critical gas seal, double check RTV and then wipe off excess sealant.

Co2 Detector Box



G-2 OLDER → EE891 CO2 SENSOR IN Shipping Package

Co2 Detector is a packaged item and stored in a vacuum form tray. Each die cast box Co2 Detector is hand assembled on a 1/16" G-10 board.

The G-10 is formed to snugly fit at base of Die Cast box. Parts are tightly arranged in order to fit. No room for error so follow assembly procedure.

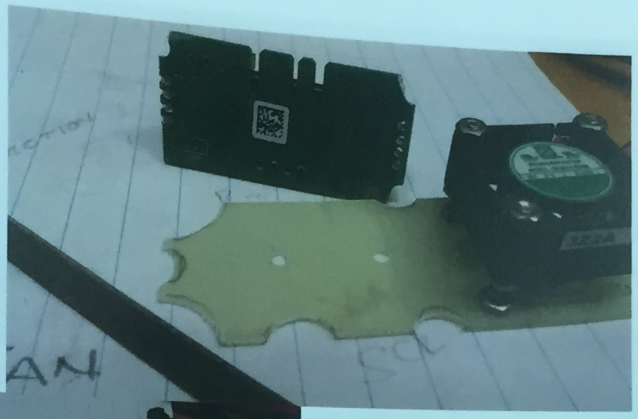
Mark each G-10 strip by over laying atop die cast box the cut outs. FOR
Cut out is performed on a Rotex die punch. Follow diagram seen above image. Test fit often.

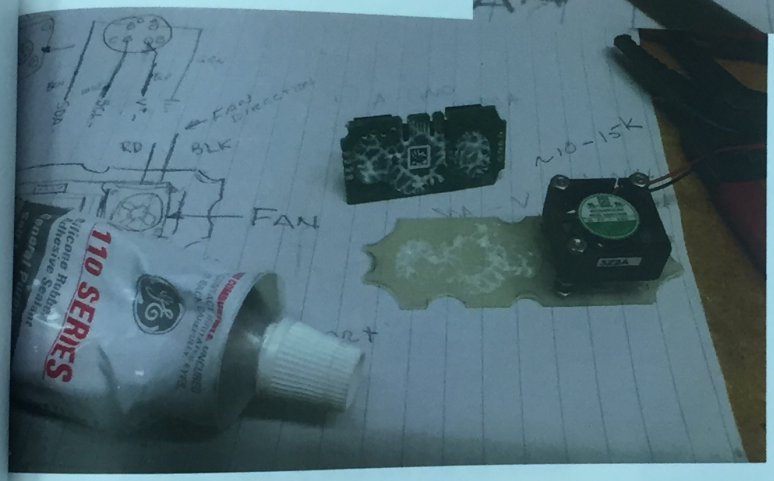
Co2 Detector Box

Detector assembly

After G10 is sized and fits correctly, start with fan installation.

Three 2-56 machine screws and nuts provide stand off. G10 has a hole punch beneath fan to insure gas exchange in die cast box.





Co2 detector has two snap mounts on bottom of detector PC Board,

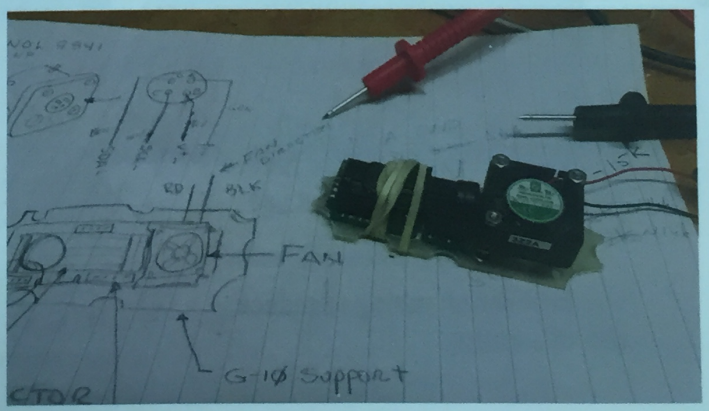
Transfer these locations to thin G-10 mounting board.

Beneath Detector PC Board, solder Pads and leads need to be files flat to insure RTV adhesive can hold the two together.

Once solder pads are filed flat, clean with alcohol to remove bits of conductive solder. These PC Boards are newer in design and are soldered with silver/tin and not lead/tin

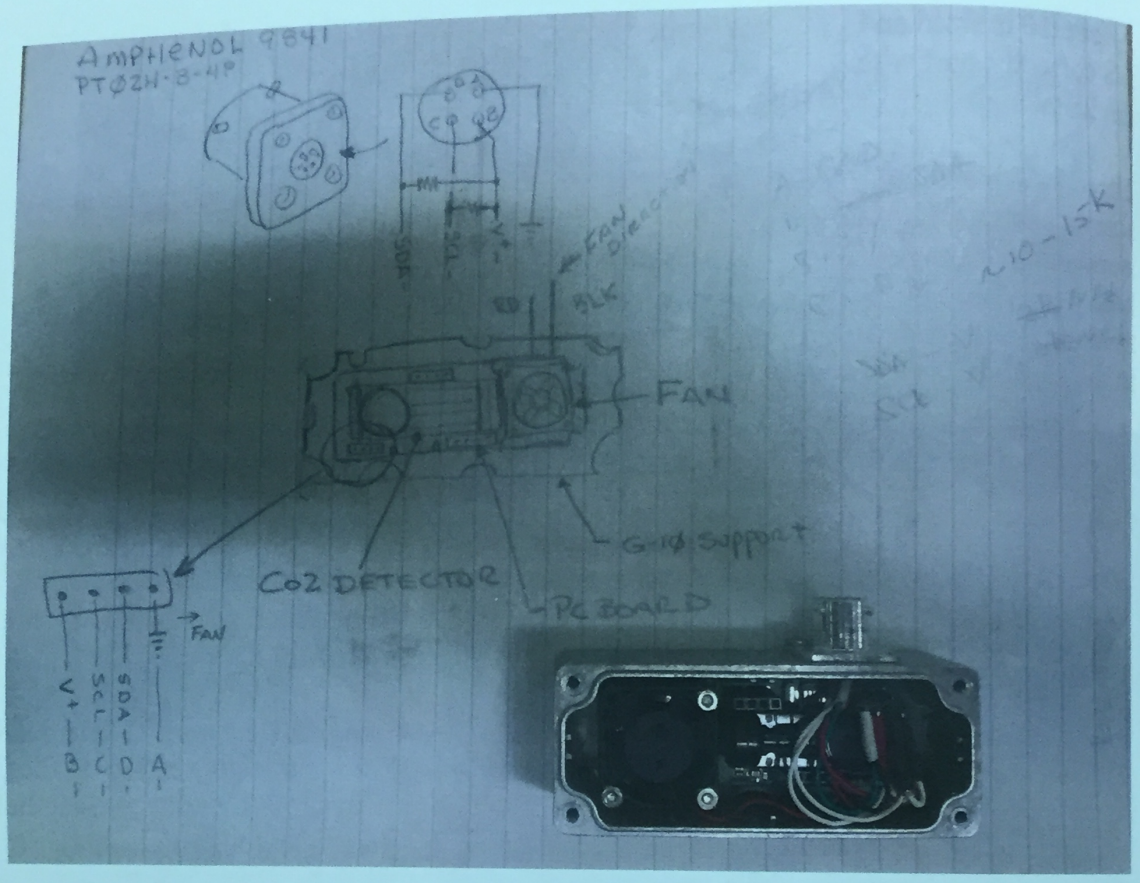
Once RTV is applied as shown in image above, click two snap mounts into thin G-10 board to align.

A rubber band is used to secure parts during RTV cure.



Co2 Detector Box

Wiring



Above image shows the wiring schematic pin to pin.

With die cast detector box limited space, start with four pin Amphenol 9841 connector placed in a secure mount, to solder.

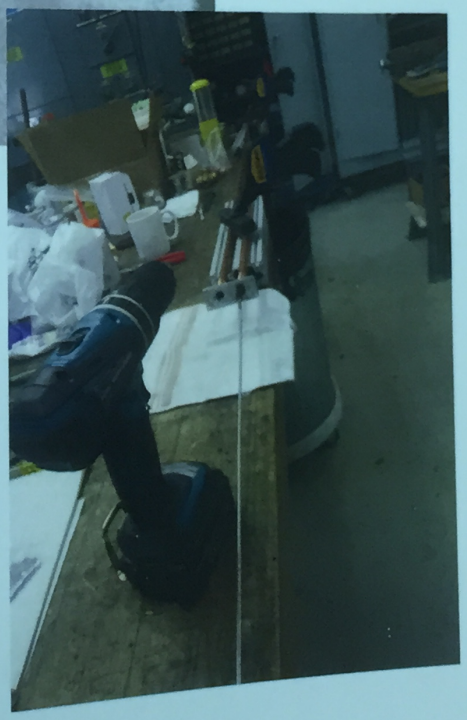
33awg wire was chosen to reduce packing area of the die cast gas box.

Use heat shrink tubing to reduce risk of shorting.

Sautec F-Post 4-Pin are used to connect to Co2 detector board. wires are covered w/ heat shrink tubing.

Preparing Copper tubing assembly

Cleaning ID of tube



Before Straw Tube Co2 Detector can be assembled, inside of copper tubing must be cleaned out of debris from tube storage, assembly contamination, etccc.

A tube cleaner was fashioned to be used on a battery operated drill.

Brush diameter if too small can be bent as in image above to accomplish full cleaning.

With Copper tube assembly secured in table jig, attach compressed air to flow at opposite end of tube. Run brush full length, back and forth several times.

Repeat for second tube.