Survey Meter-to-Laboratory Counting Instrument Transformation

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Introduction

The Model CD 700 Geiger-Mueller survey meter, which is often made available to teachers as a surplus item left over from the Cold War, is a very useful and sensitive radiation detection instrument. Geiger-Mueller (G-M) survey meters are equipped with an analogue meter as the indicating device and an output jack from which individual detection events may be perceived audibly by clicks in headphones. As they are provided to teachers, often they are supplied with an audio amplifier which allows the detection events to be heard by an entire class.

As useful as these instruments are, a great deal of their capability is lost because of their inability to collect data in numerical, or digital, form, which would allow a detailed analysis of the radiation being studied. This document is presented as a guide to the transformation of the survey meter into a radiation counting instrument capable of serving in a laboratory to provide accurate and reproducible data on radiation intensities under a variety of experimental conditions.

The transformation involves the purchase of certain readily available items and materials, access to tools, and a certain amount of craftsmanship to put it all together. The overall cost should be well under $100, primarily for the electronic counting module, with less than eight hours of labor for the fabrication and assembly. In addition to a digital counting module, the transformation includes a wooden stand (to position the meter and its Geiger tube) reproducibly adjacent to a source positioning rod and source positioning device. These three items, fabricated and assembled, are pictured in Figure A1. Figure A2 shows the survey meter properly positioned on the stand, with the Geiger tube in position.

When the meter is properly positioned in the stand, the end with the count-rate meter will be up against the stops near the source positioning rod. The G-M tube should be forward in its holder, so that the beta shield can be rotated without moving the G-M tube itself, and positioned with the beta window facing up. When in this position, the hole in the source positioning device should be directly above and centered upon the beta window of the tube. The source positioning device may thus be positioned and

locked at particular elevations above the G-M tube, using markers on the rod at several locations.

This document provides detailed fabrication instructions for the above items, assembly and wiring diagrams for the counting module, and a list of materials with purchase location and cost information.

Adding Audible Amplifier

The transformation described herein is only possible if the G-M survey meter is supplied with a supplemental amplifier to amplify the event output pulses from the meter that originally went to earphones worn by the user. A slight modification of the headphone lead allows this pulse to be fed into an audio amplifier, resulting in an audible click each time a count is registered. The amplifier used in this case is a RadioShack Model 277 1008C, which costs about $10. The amplifier has an output connection, for use with an external amplifier, and it is the signal from this output jack that is used to drive the counting module. When this output is used, the audio amplifier no longer emits the audible click. The connectors used to provide the input to the audio amplifier and those at the ends of the cable between the amplifier and the counting module are ⅛" monaural connectors, also available at RadioShack stores. The white audio amplifier is shown in Figure A2, attached to the side of the survey meter with Velcro tape, and the various connecting cables are shown. An early model of the counting module (that is not exactly like the one depicted in Figure A5a and A5b) is shown in Figure A2.

Fabrication Instructions

Stand: The stand used to position the survey meter is simply a section of 1" x 6" board (actual dimensions, 0.75" x 5.5") cut to 10" length. In order to locate the survey meter on the stand, there are four holes drilled though the base, ¼" in diameter. Quarter-inch dowel rods, 2½" long, are placed in the holes. Two holes 4 3/18" apart at the center provide for lateral positioning, and two near one end place the meter in the proper position relative to the source support rod. A ½" hole is drilled along the centerline of the stand, near one end, to accept the source positioning rod, a section of ½" dowel, cut to 16". A photograph of the assembled stand is shown in Figure A1, and Figure A3 is a drawing of the stand indicating the exact position of the various holes.

Source Positioning Rod: The rod is a ½"-diameter wooden dowel, cut to 16" length. It mounts in a ½"-diameter through-hole at one end of the stand and supports the source positioning device at various elevations above the tube. With the rod fully inserted in

the stand, the top of the tube coincides with a distance of about 6½" from the top of the stand, which is ¾" thick. Thus, from the bottom of the rod to the elevation of the top of the Geiger tube is 7¼". The source positioning device at its lowest level, in contact with the tube, locates a source at ⅛" above the tube. The device itself is ¾" thick.

Combining all of these dimensions, if one puts a mark on the rod 8¼" up from the bottom, and aligns the top of the source positioning device at this elevation, a source in the source positioning device will be ⅛" from the top of the tube, the closest it can be placed. A second mark, ⅞" farther along the rod, will be the 1" distance, and additional marks at inch intervals along the rod provide for reproducible positioning of the device and sources at reproducible known distances above the tube. Such positioning marks are visible in Figures A1 and A2.

Manufacturing a Source Positioning Device: This device is used to locate and fix a radioactive source at various vertical positions above the center of the Geiger tube. It is fashioned from a piece of 1" x 2" red oak lumber, cut to a length of 4½". (The true dimensions of the wood are ¾" x 1½"). At ¾" from one end of the device, and on the horizontal centerline of the piece, a 17/32"-diameter hole is drilled through the piece, which allows the device to slide easily up and down along the ½"-diameter source positioning rod. In order to fix the device in position at some vertical location, a 10-24 NC thumbscrew is mounted at the center of the device end, near the 17/32"-diameter hole, as illustrated in Figure A4. The thumbscrew threads into a metal "threaded insert" whose internal thread is 10-24, and the outside is threaded to fit a 9/32"-diameter hole drilled into the end of the device. Thus, the thumbscrew can be tightened and released many times without wearing out the threads.

At the other end of the device, the thickness of the piece is reduced to half the original in order to be able to conveniently get a source closer to the G-M tube. This reduction in thickness extends 2½" from the end of the device. At about the center of the thinned area of the device, at a distance of 3½" from the end containing the threaded insert, and at the device centerline, two holes are drilled. A 1⅛"-diameter hole is drilled to a depth of ¼" into the thinned area. Concentric with this hole, a second hole, ⅞" diameter, is drilled entirely through the remaining ⅛" thickness of the device, leaving no wood between a source and the G-M tube that will be located beneath it. All of this becomes much clearer on viewing Figure A4. (I used a band saw to shape the source positioning device).

With the holes properly drilled, the source positioning device, mounted on the source positioning rod, can be positioned and fixed at any distance above the G-M tube, and the hole in the device should be directly above the center of the tube. At its lowest

position, with the bottom of the source positioning device in contact with the tube, a source placed in the 1⅛″-diameter hole will be at a distance of about ⅛″ above the top of the G-M.

Adding Counting Capability: This module incorporates a digital event counter, an on-off switch and a connecting jack all mounted in an aluminum "project box." The box, 3″ x 5″ in area, 2″ deep, was purchased at RadioShack and has a removable bottom portion that allows one to make the necessary electrical connections between the various components. The arrangement of the components on the box is shown in Figure A5a, and the wiring diagram is shown alongside, as if looking at the bottom of the module, in Figure A5b. The connecting jack and on-off switch are mounted by drilling holes of ¼″ and ½″ diameter respectively into the top of the module, at positions indicated in Figure A5a. Similarly, the digital event counter is mounted into a hole in the box, but the process is a bit more complicated due to the counter's rectangular cross section. A saber saw was used to cut the requisite 22 mm x 45 mm hole, as located in Figure A5a. Two ½″-diameter holes drilled into the rectangular cut-out area provide a starting place for the saw cuts.

Wiring between the various components is straightforward. With the exception of the digital counter, all of the components have solder connections. Number 20 gauge hook-up wire is recommended for connections, as the holes in the various connectors are small. The digital counter has screw-tightening connections and comes with a detailed instruction sheet. To use the event counter in this device, the signal lead is attached to terminal 2, and the common lead to terminal 3. Experimentation has determined that the device works best with the 1 megohm resistor between the off side of the switch and the common connection, terminal 3. Placing the resistor directly between terminals 2 and 3 results in unnecessary battery drain. This hookup is illustrated in Figure A5b.

A convenient way of wiring the module is to mount the jack and switch in the box, unconnected. The event counter, with a 3″-long, red signal lead and a 4″-long, green common lead already mounted in the counter, is then put into position. One end of the 1-megohm resistor, wrapped around the green common lead, is also positioned into terminal 3 before the counter is placed in the box. These leads are held in place by tightening a screw onto them, and once the counter is in place in the box, it is difficult to tighten these screws. These leads, and the remaining red signal lead to the switch terminal, may then be soldered in place. One should strip both ends of the leads attached to the event counter before mounting.

The instruction sheet provided with the event counter gives detailed instructions on how to program the device to function as a counter. There is a reset button located

directly below the LED screen, on which event counts are recorded digitally. As arranged, the counter will register events occurring in the G-M survey meter only when the switch is in the "on" position. Radiation detection events, pulses, are fed to the input jack from the external amplifier output on the audio amplifier used with the survey meter (see Introduction above and Figure A5b).

Figure A6 is a bill of materials required for this transformation, giving the items required, where they may be found, and an approximate cost. The total, including the audio amplifier, is $75.00.

Figure A1. The survey meter stand, source positioning rod, and device

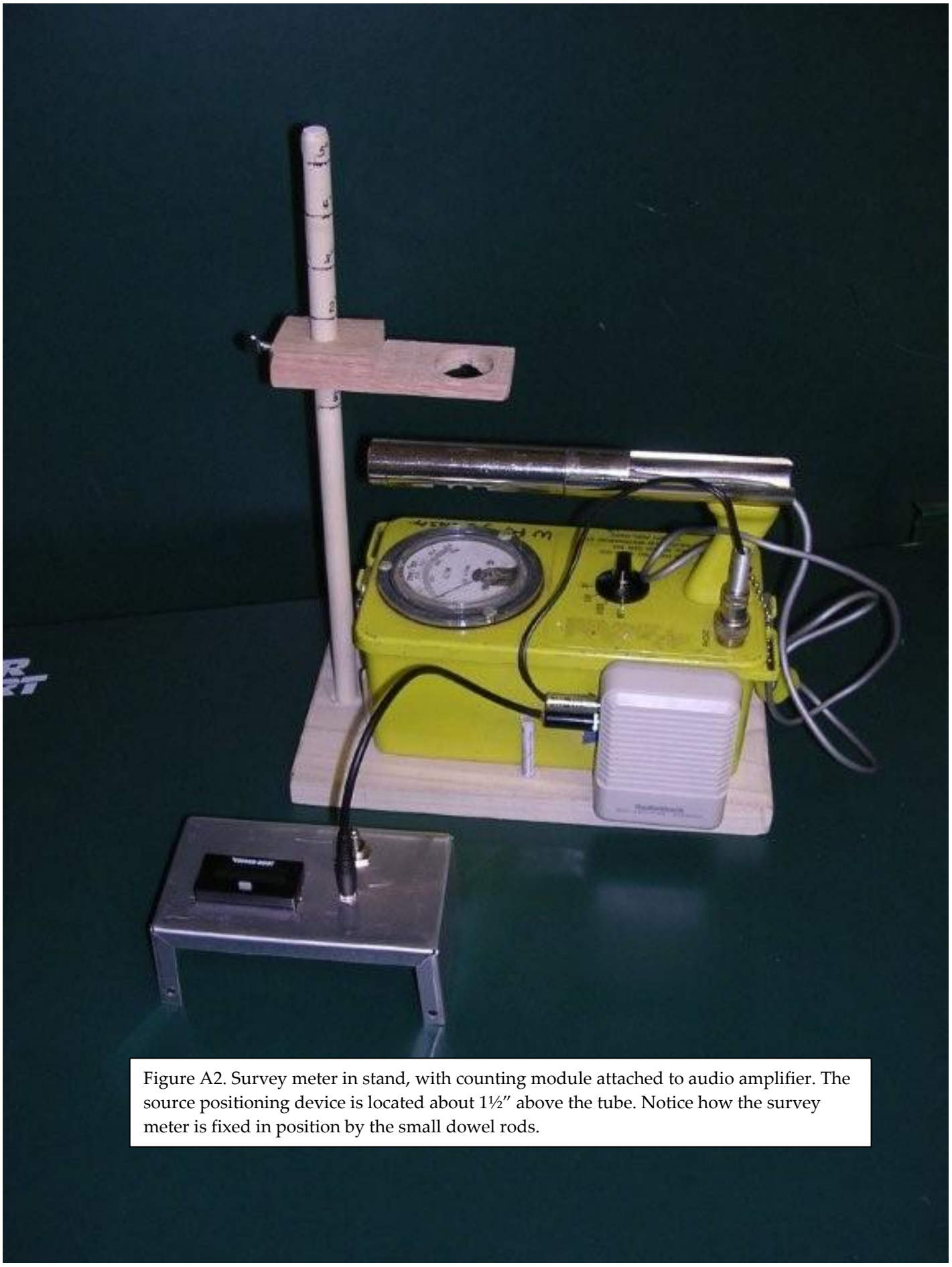


Figure A2. Survey meter in stand, with counting module attached to audio amplifier. The source positioning device is located about 1½" above the tube. Notice how the survey meter is fixed in position by the small dowel rods.

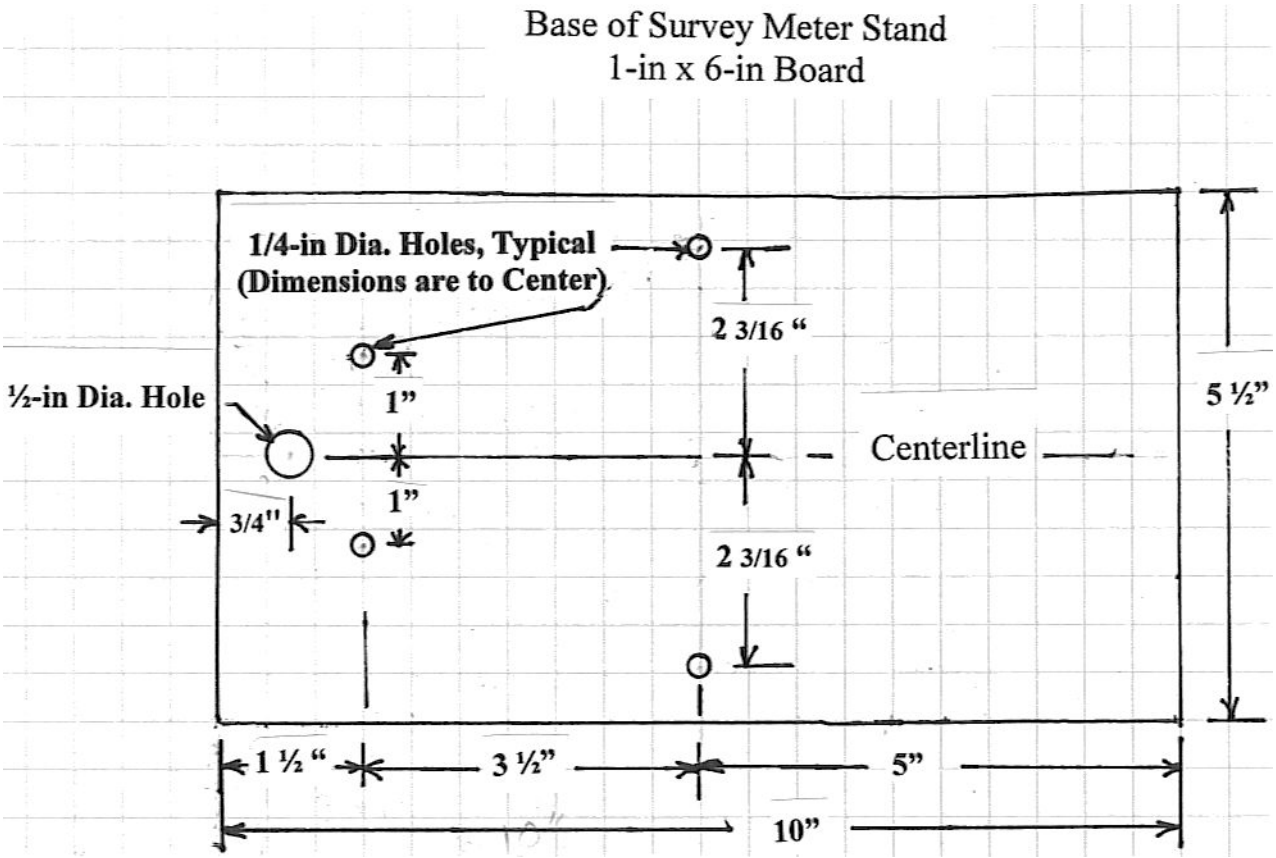
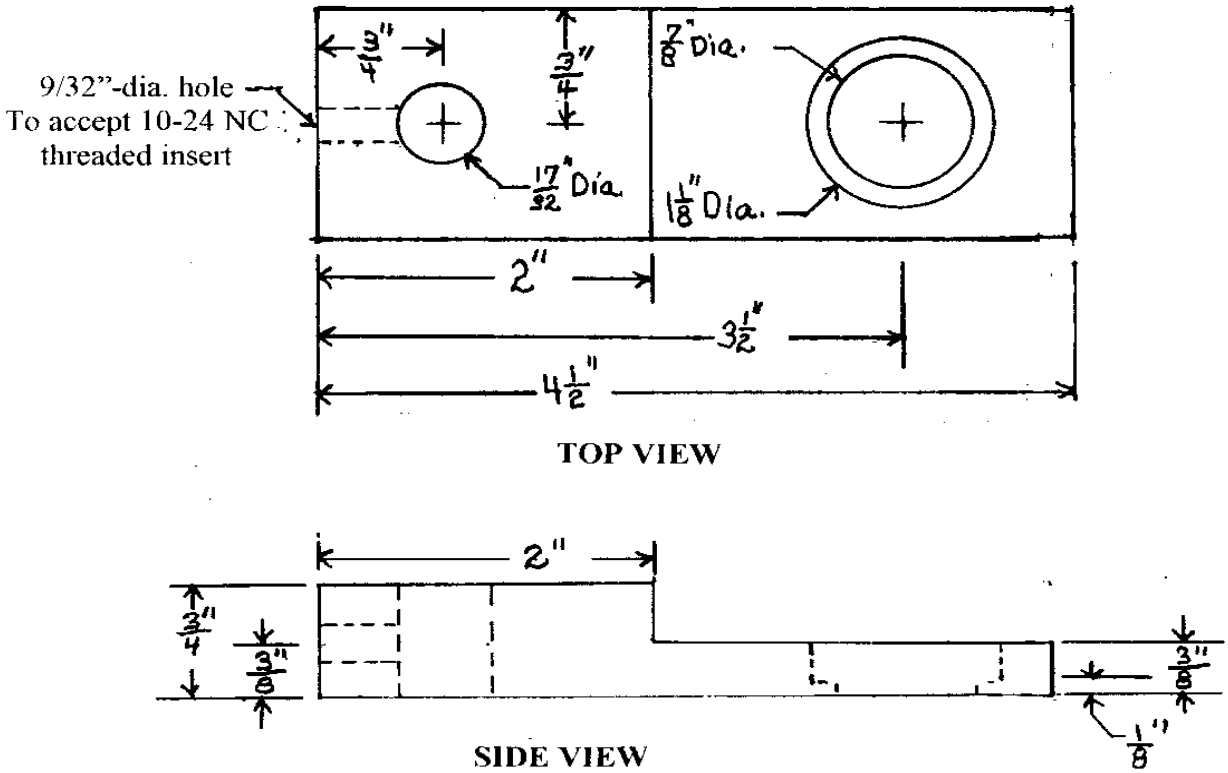


Figure A3. This drawing depicts, at about ½ scale, the base of the source positioning stand. A piece of 1″ x 6″ poplar board was used for the base material. Quarter-inch holes are drilled at symmetric locations to accommodate 2″ lengths of ¼″ dowel rod, which provide positioning stops for locating the survey meter with respect to the source positioning rod (Figs. A1 and A2). The rod itself, a ½″ dowel rod, 16″ long, fits into the ½″-diameter hole at the left. This arrangement positions a source in the source positioning device (Fig. A4) directly above the G-M tube, as shown in Figure A2.

SOURCE POSITIONING DEVICE

SCALE 1" = 1"



TOP VIEW

SIDE VIEW

Figure A4. This drawing, at about full scale, shows how to fashion a source positioning device, to be placed on the source support rod to locate a disc source above the G-M tube (Figs. A1 and A2). The base material is a red oak 1"x 2" board. The 9/32" hole at the left side is drilled to accept a metallic threaded insert, having 10-24 NC threads. This allows one to thread a 10-24 thumb screw into the positioning device to be used to fix the device at a selected position along the positioning rod. The thumb screw is visible in Figures A1 and A2.

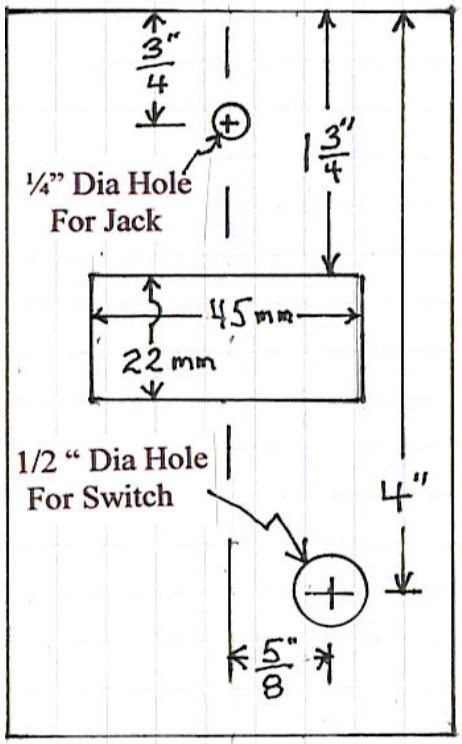


Figure A 5a
Counting Module
Top View, Scale ¾" = 1"

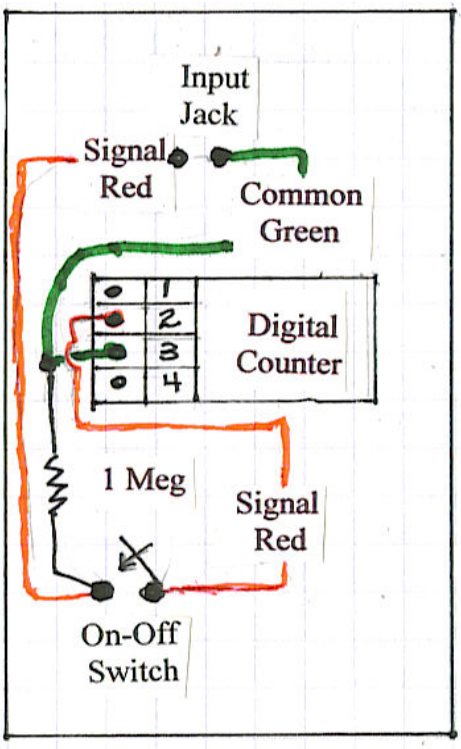


Figure A 5b
Counting Module
Bottom View, Inside
Wiring Schematic

Figure A6

BILL OF MATERIALS
Survey Meter-to-Laboratory Counting Instrument Transformation

Date:_____

UNIT	ITEM	WHERE FOUND	APPROXIMATE COST
STAND			
	1″ x 6″ poplar board, 10″ long	Any lumber or hardware store	$2.00
	¼″-diameter dowel rods, about 1 foot long	Any lumber or hardware store	$1.00
SOURCE POSITIONING ROD			
	½″-diameter dowel rod, 16″ long	Any lumber or hardware store	$2.00
SOURCE POSITIONING DEVICE			
	1″ x 2″ red oak board, 4½″ long	Any lumber or hardware store	$2.00
	10-24 internal, threaded insert	Any lumber or hardware store	$0.50
	10-24 thumbscrew, 1″ long	Any lumber or hardware store	$0.50
COUNTING MODULE			
	Digital Event Counter Veeder-Root # C342-0464	Thal-Mor Associates, Inc. Dayton, Ohio Phone: 937 298-9939	$45.00
	Project box, RadioShack #270-0238	Any RadioShack store	$3.00
	Toggle switch, RadioShack #275-0602	Any RadioShack store	$3.00
	Input jack, RadioShack #274-0251	Any RadioShack store	$2.00
	Connecting cable, RadioShack #420-2420	Any RadioShack store	$4.00
	1-megohm resistor, RadioShack #271-1356	Any RadioShack store	$1.00 (5 pack)
AUDIO AMPLIFIER			
	Mini amplifier, RadioShack #277-1008C	Any RadioShack store	10.00
TOTAL, with Amplifier			**$76.00**