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WHOLE-BODY COUNTER LABORATORY
MOBILE UNIT B
DESCRIPTION AND OPERATION

By

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INTRODUCTION

Research into the mechanisms of environmental exposure involves the study of the dispersion and transfer process in various pathways from plant effluents to man. One important part of the study is an investigation of the radionuclides present in individuals from the local population by means of a whole-body counter. Relationship of this body burden data to diet and radioactivity in local foodstuffs and the statistical distribution of these doses allows estimation of the average radiation dose received by large population groups, the dose to the "Maximum Individual" member of the population. In order to obtain whole-body radioactivity measurements from large and varied segments of the local population, a shadow-shield whole-body counter was constructed in a van that could be readily moved to various population centers for special research studies (Figure 1). The design emphasizes flexibility of application and self-containment so that the instrument can be used in a wide variety of situations. This particular whole-body counter is smaller and more maneuverable than most mobile whole-body counters now in existence. It's attractive interior, illustrated in Figures 2 and 3, aids in public acceptance of the program.

This manual describes the Whole-Body Counter Laboratory, Mobile Unit B, built and operated for the U.S. Atomic Energy Commission of the Pacific Northwest by Battelle-Northwest, Richland, Washington, and contains construction specifications, operating procedures, and routine maintenance data for the information of operating personnel.

SECTION II

GENERAL DESCRIPTION OF LABORATORY

The Whole-Body Counter Laboratory contains a number of highly specialized mechanical and electronic instruments designed to measure and record the radionuclide body burden of humans. The system is composed of a five-ton lead shadow-shield counting chamber with pallet and pallet-drive assembly and a 11-1/2 inch diameter by 6 inch thick, sodium iodide crystal, equipped with seven photomultiplier tubes (Figure 4). It also includes a pulse height multichannel analyzer and data readout system; a paper tape punch unit; a paper tape reader; a high speed printer; a high voltage power supply; and a line voltage conditioner to regulate electrical power to the electronic equipment.

The Laboratory is built into an 8 by 18 foot, fiberglass insulated, van which is temperature controlled by a heat pump. The van is mounted onto a truck rated at 12-ton gross weight. Power requirements for the Laboratory are 20 A at 208/240 V ac. These requirements are easily met through direct connection by the local electrical power company to a conventional industrial or domestic power source.

SECTION III

COMPONENTS

A. Shadow-Shield Counting Chamber

The shadow-shield counting chamber, constructed of lead brick, sheet lead and steel, is designed to shield the detector in all directions from gamma rays emitted from sources other than the subject being counted. The structure, illustrated in Figure 5, includes a rigid support for the detector crystal.

The exterior of the shadow-shield is 14 feet long, a maximum of 36 inches wide, and 20 inches high to the top of the crystal support plate. The crystal castle, located on top of the support plate, is an additional 20 inches high and is 25 inches in diameter. The inside physical measurements are 14 feet long and 24 inches wide, with a vertical space of 13-1/4 inches under the crystal support plate. The top and sides are open for access, a distance of 68 inches from each end of the structure.

The crystal castle is constructed of 15 lead rings, 1 inch thick, 4 inches wide, and 21-1/2 inches outside diameter, stacked one upon the other and capped with five solid lead discs 3/4 inch thick and 21-1/2 inches in diameter. A 3/8 inch thick, 25 inch steel top disc, and six steel rods tie the castle to the support plate.

The entire shadow-shield structure was covered with 16 gauge black sheet iron to secure the lead brick side walls. The sheet metal was then secured in place with counter-sunk flat-heat screws and painted. The entire shadow-shield structure was designed and assembled at the Pacific Northwest Laboratories.

B. Sodium Iodide Crystal

The gamma ray detector used in this Whole-Body Counter is an 11-1/2-inch diameter by 6-inch thick, thalium activated, sodium iodide crystal. The crystal is sealed into a thin stainless steel container which is equipped with seven quartz windows, each 3 inches in diameter.

The crystal container consists of a thin stainless steel covering for the crystal face and sides, a heavy mounting and support flange, and a heavy top containing the quartz windows for mounting the photomultiplier tubes. A heavy stainless steel support frame was locally fabricated and installed between the detector and the support plate of the shadow shield. This support frame is shock mounted from the crystal by a semi-firm synthetic rubber gasket and is tightly mounted to the support plate of the shadow-shield.

C. Photomultiplier Tubes

Seven RCA, type C70145, Lucolux, Aluminum Oxide Window, Photomultiplier tubes were used with the detector crystal to achieve a low ^{40}K background counting rate. The combination of the 11-1/2-inch diameter by 6-inch thick sodium iodide crystal and the seven Lucolux photomultiplier tubes was purchased as an assembly from the Harshaw Company. After phototube balancing, tests on the assembly revealed a resolution of approximately 8 percent.

D. Multi-Channel Analyzer

The analyzer used in this system is a 1024-channel, pulse height multi-channel analyzer (Northern Scientific, Model NS 610). This analyzer is of solid state construction and consequently is quite temperature insensitive. The 1024-channel capacity provides a sufficient number of channels for the resolution capabilities of the detector. The memory of the analyzer can be divided into four quarters so that background counts can be stored in one quarter, data accumulation in another and reference or special counts in the remaining quarters. Also, data can be transferred between quarters for faster and more versatile counting and analysis. The analyzer is designed to handle several different forms of data input and readout devices, such as visual readout by oscilloscope, high speed printout on paper tape, punched-paper tape readout, and punched-paper tape readin to the analyzer memory for data reusage.

E. Diet and Serial Number Coding Device

A locally designed and constructed Serial Number Device (SND) is included in the whole-body counter instrumentation. The function of the SND is to pulse a numerical code of 99 consecutive digits through the readout section of the multi-channel analyzer to a paper-tape punch machine. With the aid of this device, each whole-body radioactivity measurement can be prefixed with a serial number and pertinent information, such as dietary data, punched in code on the paper tape.

At the time this instrument was constructed, a special timer unit was incorporated to allow setting the multi-channel analyzer to count for a present time in either of two modes - live time (correcting automatically for dead time), or clock time. This feature increases the flexibility of the system.

F. Paper Tape Punch and Reader

A paper tape punch unit (Tally, Model 420 PR) is integrated with the SND and the memory readout section of the multi-channel analyzer. This unit punches a series of holes, representing a binary code, into a paper tape. This perforated tape can then be set to a computer for electronic analysis, computation, and permanent, magnetic tape, record storage of the whole-body count and diet information. A paper-tape reader (Tally, Model 424 PK) is coupled to the multi-channel analyzer so that the coded data on the punched paper tape can be read back into the analyzer memory for reuse or error checking of the tally punch unit.

G. High Speed Printer

A high speed printer (Monroe Data Logger, Model MC 1380) is used as an alternate form of readout for the multi-channel analyzer. This solid state printer is capable of electromechanically printing out digital analyzer data at a rate of 1380 lines of eight columns each per minute. The printer is used as a backup for the tally punch unit and for printing gain check and control count data.

H. Line Voltage Conditioner

An ac line voltage conditioner (Elgar, Model 6006) was added to the system to insure linearity, consistency, and accuracy of the counting equipment. The conditioner reconstructs the incoming line voltage and supplies the electrical power for the analyzer and the high voltage power supply of the photomultiplier tubes. The output of the conditioner is an 115 V ac sine wave free of all switching and power line transients. This instrument also serves as an isolation transformer, cutting harmonic distortion to less than 0.25 percent. Because of the extreme sensitivity of the analyzer and photomultiplier tubes, fluctuating line voltage could cause gain shifts resulting in a broadening of the photo-peaks of the radioisotopes being measured.

I. High Voltage Power Supply

A solid state high voltage power supply (John Fluke, Model 412-B) is used to raise the 115 V ac input to a regulated 1000 V as required by the photomultiplier tubes. The output voltage of the power supply is an extremely stable, undistorted power source, and a minimum of manual gain correction is required at the analyzer after the mobile unit has been moved to a new location.

J. Pallet and Drive Assembly

The Pallet and Drive Assembly consists of a sled, 75 inches long by 23-1/2 inches wide covered by a 2-inch thick plastic foam pad for the comfort of the subject being counted. The pallet bed is sloped towards the center so that the person being counted tends to lie on the center line of the bed and detector. The sled has eight small metal wheels which travel in two metal channels along the floor the full length of the shadow-shield.

The pallet drive unit consists of a 1/6 hp direct current, electric motor; a 100 to 1 gear reduction assembly; a variac "Ratiotrol" motor, speed control assembly; a pallet drive and speed control assembly. The pallet speed control mechanism permits the sled to be moved a precise distance in a set period of time. The distance of sled travel is manually set on the pallet drive speed control for each person being counted. Thus, subjects of different heights spend the same amount of time under the detector crystal.

K. Heating and Cooling System

For stable operation of the electronic instruments and of the sodium iodide crystal detector, a relatively constant temperature must be maintained in the Laboratory. To control the temperature in the van, a 230/208 V electric heat pump (General Electric Company, Model RCF-68D-D1) rated at 13,000 BTU/hr for cooling and 3650/3020 W for heating was mounted into the front of the truck body. Two 240 V, 500 W auxiliary electric heaters (General Electrical Company, Model 7205-2) were installed at the rear of the truck body as back-up heaters in the event additional heat were required. A year-around temperature of 75 F (± 2 F) is easily maintained to meet the requirements of the electronic equipment. As additional protection, a truck-type hot water heater (Hupp Corp., Model 901) was installed inside of the van. This heater operates from the truck's hot water system and battery. It can be used to prevent freezing of the sodium iodide crystal in the event of complete failure of the electrical power supply.

L. Radio

Background music is provided by an AM-FM radio (Raymer Music System, Model 394A) to relax the subjects while they are waiting for their turn to be measured and passing under the detector.

SECTION IV

TRUCK AND TRUCK BODY

A. Truck

The vehicle used to carry the Whole-Body Counter Laboratory is a 1966 International Loadstar CO-1700 Truck, of a gross weight capacity of 24,000 pounds. The truck has a 196 hp gasoline powered motor, power steering, and air brakes. The truck is equipped with a 17,000 pound rated rear axle, equipped with dual 12-ply tires, size 1000 x 20. The truck is of the cab-over type, and the frame is designed for an 18-foot van mounted above the wheels without wheel wells. Because of the off-center load of the shadow-shield, additional leaves were added to the front and rear springs on the left side only. The truck is easy to drive and handle in traffic because of its short wheel base, short turning radius, power steering, and air brakes.

B. Truck Body

The Whole-Body Counter Laboratory has been built into an 18-foot long, 8-foot by 8-foot FRUEHAUF truck body, Model RA, insulated with 3 inches of fiber glass.

The interior of this van is paneled with Masonite hardboard with a plastic finish, chosen for ease of cleaning and attractiveness. The ceiling is covered with a noncombustible acoustical tile. Mahogany trim board was installed in all corners and at the junction of the wall and ceiling. The rear wall is fitted with two doors. The main entry door is a hollow-core, mahogany, exterior type with a plastic thermopane window. A special bolt-closed panel door is adjacent to the entry for use when large equipment must be moved in or out.

The floor of the Laboratory is covered with green industrial grade nylon carpet and hair pad. This carpeting improves the appearance of the Laboratory, quiets instrument noises, and provides added insulation for the floor.

The layout of the equipment and furniture is shown in Figures 2 and 3. The seats are made of plywood padded with 2-inch plastic foam. The space under the seats is used for storage of miscellaneous supplies. The writing and work table was covered with a mar and stain resistant material (Formica). The table can be folded down when the truck is moved or when greater access to the instruments is needed.

The electronic equipment is mounted in a single instrument rack in the front corner of the Laboratory, out of the walk area but open for easy access by the operating technician. The instrument rack is specially shock mounted to the floor and to the side and front walls of the van to minimize vibration damage during transportation.

For entry to the Laboratory, a rear platform with two sets of steps, one for each side, are provided (Figures 1 and 3). The rear platform is the full width of the van and is 42 inches deep, including handrails. The platform was fabricated so that the handrails fold under, and the platform can be folded up and bolted to the rear of the van during transportation. When down, the platform is supported by only two removable legs and the hinges. The steps are made of light-weight aluminum with removable handrails. One man can easily carry and attach the steps to the platform.

A retractable awning is installed over the rear platform. The awning covers the width of the platform and when fully extended, overhangs the back by 6 inches. The awning is made of heavy nylon tarp and has extending semi-ridged arms. It is designed to roll and fold up against the rear of the van when not in use.

SECTION V

SET-UP AND SHUT-DOWN PROCEDURES

A. Set-Up Procedures

The truck should be parked on nearly level ground in a location where sufficient electrical power is available. If a level area cannot be found, the leveling blocks (carried in the truck) should be placed on the ground and the truck driven onto them for level parking. Electric power requirements are 208/230 V ac single phase, with a minimum of 30 A and preferably 50 A. This power can be furnished from a regular electric power line, or, if necessary, a portable generator.

After the truck has been parked, the rear platform is lowered and the support legs are set to level the platform. The steps are taken from their carrying compartments and attached. The hand and safety rails are now bolted in place. The four leveling and steadying screw jacks are placed at each of the four corners of the van and tightened. Some leveling can be done this way, but the main purpose of the jacks is to steady the Laboratory.

The electric power can now be connected to the unit through the receptacle located under the left rear corner of the van. Power can be brought to the unit in either of two ways -- a mast and meter base can be mounted on the side of the van for power company connection, or a 50-foot cable with necessary fittings can be used for a direct wire-in to a proper receptacle or generator. At the time of the initial electrical connection, a thorough check should be made to verify that the voltage is correct and properly wired. A great deal of damage can be done if the system is improperly wired.

At this point, the main power circuit breaker switches, at the breaker panel inside the van, can be turned "ON." The heat pump should be started. Make sure that the heat pump is set to the proper operating voltage (208 or 230 V) - the switch is located inside the recirculating air intake.

After these steps have been taken, check the voltage at one of the wall receptacles with a volt meter. Remove the wood side panel from the instrument rack. Set the INPUT VOLTAGE RANGE switch on the rear of the line voltage conditioner to the proper setting as indicated by the volt meter. Turn the power switch on the line voltage conditioner to "ON." After the green light has come on, depress the INPUT VOLTS button and read the meter. This reading should be the same as the volt meter reading taken at the wall receptacle. Release the button and read the regulated voltage. If the reading is 115-116 V ac, the unit is operating properly.

The next step is to check the signal input cable to the Northern Scientific 610 Analyzer. Connect this cable to the grounded connector on the top right corner of the analyzer. Turn on the power to the analyzer and place the unit in STOP mode for warm up by pushing the STOP button.

Now check all of the settings on the high voltage power supply. OUTPUT VOLTAGE should be set for 1000 V and POLARITY must be set to (+). Negative polarity could seriously damage the photomultiplier tubes of the detector. Now turn on the power switch and wait for the white standy-by light to come on. Recheck the high voltage settings; if they are correct, set the high voltage switch to "ON." The phototubes at the detector crystal are now activated. The meter should read 1000 V positive. If not, immediately shut off the supply and adjust to correct reading. At this time, the power switch on the Serial Number Device (SND) can be turned on. The SND will step through one cycle and come to rest in stand-by and warm-up mode.

If time is available, the system should be left standing for several hours, preferably overnight, to attain normal operating temperature and for all the electronic voltages to stabilize, before making radiation measurements. Once the system is set up and turned on, it should be left in "stand-by" condition when not being used for counting (See Section VI, Item I, below).

After the system has stabilized, sources should be counted and any necessary gain corrections made. Background and control counts are made periodically to verify the correct operation of the equipment. These operations are covered in Section VI below.

B. Shut-Down Procedures

When securing the unit for a move to a new location, be sure the signal input cable from the detector crystal to the analyzer is placed on the grounded terminal of the analyzer. This ground prevents positive pulses from reaching the analyzer. Such pulses could damage the amplifier and Analog to Digital Converter (ADC) of the analyzer. Now turn off high voltage supply, the SND, the analyzer, and finally the line voltage conditioner in that order. Then proceed as per the reverse of the set-up procedures to disconnect the electric power, dismantle the steps, and fold up the platform.

SECTION VI

DETAILED COUNTING PROCEDURES

A. Gain Check

1. Check high voltage power supply for a reading of 1000 V, positive polarity.
2. Remove signal cable from grounded connector and attach to AMP IN connector.
3. Place amplifier switch (above AMP IN connector) to "ON."
4. Check and set CONVERSION GAIN control to "1."
5. Place ^{137}CS and ^{40}K sources in shadow-shield under center of crystal.
6. Set READ MODE switch on analyzer to "CRTx4."
7. Press START READOUT button; turn CRT "INTENSITY" control (under scope), until spectrum can be seen.
8. Push ERASE button to clear memory.
9. Push STOP button.
10. Push timer RESET button on Serial Number Device (SND) - set timer to 10.0 minutes if not already set. (NOTE: There is no decimel point on timer dial. Right hand digit is tenths of minute.)
11. Push green START button on right center face of SND. Analyzer will go to STOP at end of gain count.
12. Set DISPLAY SCALE control on face of analyzer to "5 x 10^4." (Less if the count is to be less than 10 minutes.)
13. Push START READOUT button on lower center face of analyzer. Count should display on CRT.
14. The peak counts of ^{137}Cs should be in channel 33.1, and those for ^{40}K should be in channel 73.0, respectively. If gain is not correct, proceed to step 15.

15. If both ^{137}Cs and ^{40}K are too high, slightly increase setting of ADC zero level control.

16. Recount sources, starting at step 7.

17. If ^{137}Cs is approximately 33 but ^{40}K is several channels high or low, readjust amplifier gain control for gain correction.

18. Clear analyzer memory and recount sources starting at step 7 each time, until proper gain settings, as defined in step 14, are obtained.

B. <u>Background Count</u>

After the gain has been checked and necessary corrections made, proceed as follows:

1. Place READ MODE switch in "CRTx4" position.
2. Push START READOUT button.
3. Clear analyzer memory by pushing ERASE button. (Only baseline should be seen on the CRT at this point.)
4. Push STOP button.
5. Turn pallet-drive switch on lower left face of RATIOTROL control panel to "ON."
6. Set pallet gauge (ruled brass gauge above RATIOTROL panel) to approximate height of subject to be counted (if known) and tighten handle.
7. Turn switch on pallet timer motor "ON," using toggle switch "A" on pallet control panel located under analyzer.
8. Push timer RESET button on SND panel, check and reset timer for 10.0 minutes.
9. Set MEMORY GROUP switch to "2/4" setting.
10. Set slide switch under ADC ZERO LEVEL control to "SUB" position. (Subtract mode, i.e., count will be stored as negative numbers.)

11. Set DISPLAY SCALE in "10^3" position.

12. Flip toggle switch "B" on pallet control panel. This starts bed in motion.

13. Push green START button on SND panel immediately. A 10.0 minute background count is now being taken.

14. At end of count, push START READOUT button. The background should be displayed.

To store background for reuse and transfer, follow steps 15 - 22.

15. Push STOP button.

16. Turn MEMORY GROUP switch to "1/2" (red letters).

17. Place READ MODE switch to "TRANSFER" (red letters).

18. Push START READOUT button. (Background has now been transferred from second quarter of memory to first quarter.)

19. Push STOP button.

20. Place READ MODE switch to "CRTx4."

21. Turn MEMORY GROUP switch to "1/4."

22. Push START READOUT button. Background is now displayed and ready to use. Each time the background is needed, it can be transferred from the second quarter of the memory to the first quarter by repeating steps 15 through 22.

C. Control Count

1. After the gain has been checked and the background count has been taken, transfer background from "2/4" memory group to "1/4" memory group by using steps 15 - 22, under VI.B. above.

2. Push STOP button analyzer.

3. Place DISPLAY SCALE switch in "5 x 10^4" position and MEMORY GROUP switch in "1/4" position.

4. Push START READOUT button and check background; if okay, proceed.

5. Place ^{137}Cs and ^{40}K sources inside shadow-shield under center of crystal.

6. Push RESET button on SND panel to set 10.0 minutes on timer.

7. Push STOP button on analyzer.

8. Push green START button on SND. At end of count, analyzer automatically goes to STOP.

9. Press START READOUT button.

10. Observe control counts on CRT - ^{137}Cs should be in channel 33.1 and ^{40}K in channel 73.0.

11. If gain has shifted more than 0.2 channels, readjust gain and repeat steps 1-10 to recount control count. If control count is okay, proceed with step 12.

12. Push STOP button.

13. Set READ MODE switch in "PEN" position.

14. Start Data/Log printer.

15. Push START READOUT button on analyzer to print out count.

16. Add up channels 30 through 36 for ^{137}Cs. A total of about 10^3 counts per 10 minute per nanocurie of ^{137}Cs should be obtained.

17. Add up channels 68 through 78 for ^{40}K. A total of about 40 counts per 10 minutes per gram of KCl should be obtained.

18. Record these counts in the daily log book. If gain, background, and control counts are okay, then proceed with the Whole-Body Count Procedure (D. below). If counts are outside of limits, rerun.

D. Whole-Body Count

If the control count is satisfactory and the gain and background have not changed, proceed with the Whole-Body Count.

1. Have the subject remove shoes, extra clothing (such as hat, coat, etc.) and his watch (whether or not it appears to have a fluorescent dial).
2. Weight the subject and measure his height.
3. Have the subject lie on the pallet bed with head towards the crystal and even with the inner edge of the bed.
4. Set pallet height gauge (ruled brass gauge above Ratiotrol panel) to the nearest 1/10 inch of subject's height.
5. Place READ MODE switch in "CRTx4."
6. Place MEMORY GROUP switch in "1/4" position.
7. Push START READOUT button.
8. Push ERASE button to clear first quarter of memory.
9. Push STOP button.
10. Set READ MODE switch in "TRANSFER."
11. Set MEMORY GROUP switch in "1/2" position.
12. Push START READOUT button to transfer background from memory group "2/4" to "1/4." Observe on CRT.
13. Push STOP button.
14. Reset READ MODE switch to "CRTx4" and MEMORY GROUP switch to "1/4" position.
15. Flip up toggle switch "A" of pallet drive to "ON."
16. Push timer RESET button. It will automatically set the timer for 10.0 minutes.
17. Flip toggle switch "B" of pallet drive to start bed.

9. Push START READOUT button; observe count.

10. Push ERASE button. Analyzer memory is now cleared of count data only; SND data must be manually changed for next count readout.

H. Tally Paper Tape Readback

The need may arise for printing out count data stored on punch paper tape or for the re-use in the analyzer of count data. (NOTE: SND data can not be read into memory of analyzer.) Readback of count data may be accomplished by the following procedure:

1. Clear memory of analyzer.
2. Push STOP button on analyzer.
3. Lift handle at top center of Tally reader to open reader head.
4. Place paper tape in reader head so that sprocket holes match sprocket teeth of tape leader.
5. Close reader head.
6. Thread tape on reels if desired.
7. Set READ MODE switch to "READER."
8. Turn toggle switch on Tally reader to "ON."
9. Push START TAPE FEED button. Data from whole-body count will be read into memory of analyzer and reader will stop at end of tape.
10. Set READ MODE switch to "CRTx4."
11. Push start READOUT button. Observe data read from paper tape. It should be identical to original count.
12. If read-back is not correct, repeat procedure.
13. If data is correct, push "STOP" button.
14. Switch reader to "OFF."
15. Set up analyzer and readout data as desired. Print or repunch.

16. Clear memory of analyzer by pushing "ERASE" button.

17. Restart with step 3 if additional count data records are to be read back into analyzer.

I. Standby

During periods when no counts are being made, principally overnight and over week-ends, the following procedures should be following to place the equipment in standby status:

1. Shut off DATA/LOG printer by pushing large, white "POWER" button.
2. Turn punch switch to "OFF."
3. Turn reader switch to "OFF."
4. Set white SND switch (under SODECO Timer) to "OFF." Leave power on to SND.
5. Place READ MODE switch on analyzer to "CRTx4."
6. Push STOP button on analyzer.
7. Turn CRT "Intensity" knob counter clockwise until green dot disappears.
8. Remove signal input cable from "AMP IN" connector and place on grounded connector.
9. Shut off power to shadow-shield pallet drive unit by turning toggle switch at Ratiotrol control box to "OFF."
10. Make no changes in settings of high voltage power supply. Power should be left on the photomultiplier tubes except during complete power disconnect of Laboratory.

SECTION VII

ROUTINE MAINTENANCE

A. Photomultiplier Tube Balancing

Periodically, and especially after the unit has been moved a significant distance, a ^{137}Cs count should be made and the resolution of the detector crystal checked. The resolution of this detector for ^{137}Cs should be $\sim$ 8 percent (FWHM) and not greater than 9 percent. If the resolution is found to be greater than 9 percent, the following procedure should be used to reduce it:

1. Remove signal input cable from "AMP IN" connector and place on grounded connector on analyzer.
2. Switch high voltage power supply to "Stand-by:" after 2-3 seconds, the meter should drop to "0" voltage.
3. Disconnect signal and high voltage power cables at side of detector crystal housing.
4. Lift off metal cover from crystal castle.
5. Unbolt and remove steel tie-down plate.
6. Carefully lift off the 5 top lead discs, using special lifting clamps. Be careful not to damage the crystal, phototubes or cables. Caution: this is a two-man job.
7. Note position of all components and physical condition of each.
8. Reconnect high voltage and signal cables.
9. Switch high voltage power supply from "Stand-by" to "On" position.
10. Disconnect signal cable from each phototube, except #1, High Voltage should remain connected to all seven tubes.

11. On analyzer, set CONVERSION GAIN to "2," set FINE GAIN to "10.0" (Maximum).

12. Set ZERO LEVEL to "0.0" (Minimum).

13. Remove signal cable from grounded connector and connect to AMP IN connector.

14. Place ^{137}Cs source on floor of shadow-shield directly under center of crystal.

15. Set READ MODE switch at "CRTx4" and MEMORY GROUP switch at "1/4" setting.

16. Push READ OUT button, push ERASE button to clear MEMORY.

17. Push STOP button, then push START-MEASURE button. Observe scope for count in display, the ^{137}Cs peak should center on about Channel 40.

18. Adjust FINE GAIN <u>or</u> ZERO LEVEL control on analyzer to <u>Center</u> the ^{137}Cs to photopeak on either Channel 39.0 or Channel 40.0.

19. Several 2 to 5 minute counts may be necessary to attain a correct adjustment; work towards the best possible accuracy.

20. Disconnect signal cable from phototubes #1, reconnect phototube #2 (only one phototube is balanced at a time).

21. Again, take a 2 to 5 minute count. Note what channel the ^{137}Cs peak falls in. If different from that for phototubes #1 (i.e., 39.0 or 40.0), adjust the gain control (screw marked "G") on the phototube to place the peak in the proper channel. Several counts and adjustments may be necessary to attain a precise adjustment. Caution: only very small adjustments are normally required to achieve the required gain shift. Also, <u>DO NOT</u> make any change of <u>Focus</u> adjustment on photomultiplier tubes. This could affect count rate and calibrations.

22. Continue checking and balancing each tube separately so that the ^{137}Cs photopeak from each phototube will be recorded at the same energy (precisely the same channel).

23. After all seven phototubes have been balanced to match #1 phototube, recheck each tube separately again. All tubes should then center the ^{137}Cs photopeak in the same channel.

24. Reconnect the signal cables to all seven phototubes. Make sure all connections are tight.

25. Reset CONVERSION GAIN to "1."

26. Reset GAIN and ZERO LEVEL to normal operating settings, i.e., so that the photopeak for the ^{137}Cs is in Channel 33.1 and that for ^{40}K is in Channel 73.0

27. Count the ^{137}Cs source for ∿ 10 minutes, recheck resolution.

28. If counting rate and resolution are satisfactory, place signal cable on grounded connector on analyzer, place high voltage in stand-by. Check all connections and components on phototubes and put lead crystal castle back together by following steps #1 through #6 in reverse. Caution: the lead discs are heavy and hard to handle. This is a two-man job. Use the special lifting clamps to avoid injury. Be careful not to damage the detector or the cables.

29. Wait about one hour after reassembling the detector and then recount the ^{137}Cs source and recalculate the resolution.

30. Balancing the phototubes should not change the calibration of the detector unless the Focus adjustment on the phototubes has been changes.

31. Compare the daily control count before and after the phototubes have been rebalanced to confirm that the calibration has not changed.

B. Multi-Channel Analyzer

A routine maintenance program is necessary to assure accuracy and dependability of the multi-channel analyzer. Failures which have occurred to date in this complex instrument were caused by either a failed component or the fouling of a switch contact. Based upon this experience, a program was initiated for cleaning of all manual switches and for making operational checks of each mode of operation every three months. Yearly, the entire instrument is opened and all circuit boards, connectors and wiring cleaned and inspected.

An updated instrument manual with schematic drawings must be maintained with this equipment and at the service shop for ready accessibility.

C. Diet and Serial Number Coding Device (SND)

A routine maintenance program is also necessary for the SND, to assure that the correct pulse coding signals are sent to the multi-channel analyzer for data readout on the paper-tape punch unit.

Routine maintenance of this unit includes cleaning the contacts of the two 50-position stepping switches at least every three months. A thorough inspection and cleaning of all components, including the circuit boards, should be done at least once yearly to assure accuracy of output pulses.

D. Paper-Tape Punch Assembly

Operation of the paper-tape punch unit must be checked periodically throughout each day of operation, to assure correct hole punching and spacing. A hole spacing gauge should be kept available with the unit for this purpose. If hole spacing changes by more than 1/2 hole plus or minus, adjustment must be made to the punch head assembly. If erroneous data or characters are punched, the failure is probably originating in the serial number and diet coding device or the data readout portion of the multichannel analyzer. An instrument technician should be called upon for necessary repairs as special equipment and techniques are required to make repairs and precise adjustments.

E. Punch Paper-Tape Reader

Maintenance to the punch paper tape reader involves a periodic cleaning and adjusting of the star wheels, contacts and escapement assembly in the reader head. These adjustments must be made by an instrument technician as special tools and cleaners must be used. Serious damage or misalignment could occur if adjustments are made improperly.

F. High Speed Printer

Maintenance to the high speed printer involves a periodic checking of the ribbon for wear and the cleaning of paper lint from the exposed mechanical parts, using a clean soft brush. Any other adjustments must be made by an instrument technician and with the use of special tools constructed for this piece of equipment. Frequency of maintenance to this piece of equipment is determined by the amount of use that it receives.

G. Line Voltage Conditioner

Periodic maintenance to the A.C. line voltage conditioner is necessary after each six months of usage. Force air cooling of the unit necessitates the opening of the instrument case and removing the lint and dirt accumulations from the cooling fan, power transistors and transistor head sinks. If not periodically cleaned, overheating of the power transistors could cause erratic operation or component failure. This procedure should be undertaken by an instrument technician, because the conditioner must be pulled from the rack and disassembled.

H. Pallet and Bed Drive Assembly

Routine maintenance to the pallet assembly can be done primarily by the operating technician as required. Normal servicing consists of cleaning the screw shafts and riders with a good grade of solvent, such as "spray-clean" or an equivalent. Relubrication of moving parts is best accomplished with the use of a silicone lubricant or a molybdenum di-sulfide compound, such as Dry Lube, Lube-Glide, or Moly-Coat. The afore mentioned products are best suited as they do not leave a grease residue to collect dust, dirt, etc.

Maintenance to the bed drive mechanism consists of checking the grease in the motor gear box annually, adding 600 W cylinder oil as required. Check shadow-shield bed drive chain for slackness; remove excess slack as required by adjusting idler sprocket or if necessary, removing one chain link.

Electrical failures are best serviced by a competent electrician because of the complexity of the system.

I. Vehicle Servicing

Routine servicing and maintenance of the truck and associated mechanics is normally prescribed by the bus-automotive maintenance shops and their scheduling must be followed.

SECTION VIII

CONSTRUCTION DRAWING

Some of the major components of the Mobile Whole-Body Counter have been detailed in Scope and Construction Drawings. Other details are available in undocumented sketches.* The van truck body is similar to the ones illustrated in pamphlets "Order No. 5052 AP10M 365" and "Order No. 3436 RHG 5963" of the Fruehauf Trailer Division, Fruehauf Corporation. The following drawings are in the USAEC-BNW blueprint file at Richland, Washington:

H-3-27629 - Pallet Drive Motor Unit Assembly and Details, 1-31-67.

H-3-5658 - Sheets 1 & 2, Pallet Drive Details, 7-26-66.

H-4-39301 - Electrical Whole-Body Counter Truck Plan and Details, SCOPE, 2-25-66.

*Copies on file by R.T. Coffman, Facilities Engineering, and J.K. Soldat, Radiological Physics, BNW.

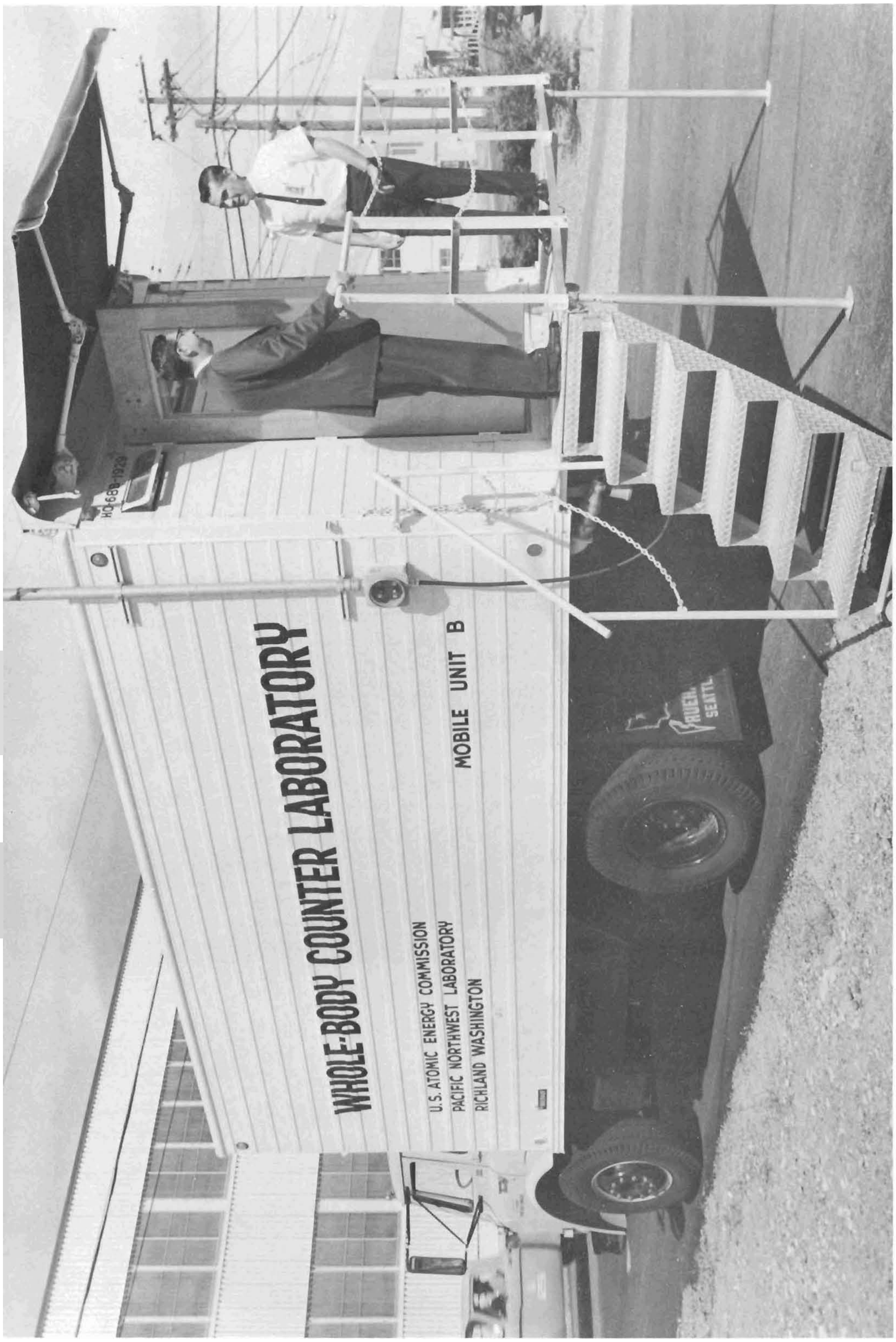

FIGURE 1
Whole-Body Counter Laboratory with Folding Platform in Place

FIGURE 2
Interior of Whole-Body Counter Laboratory, Mobile Unit B

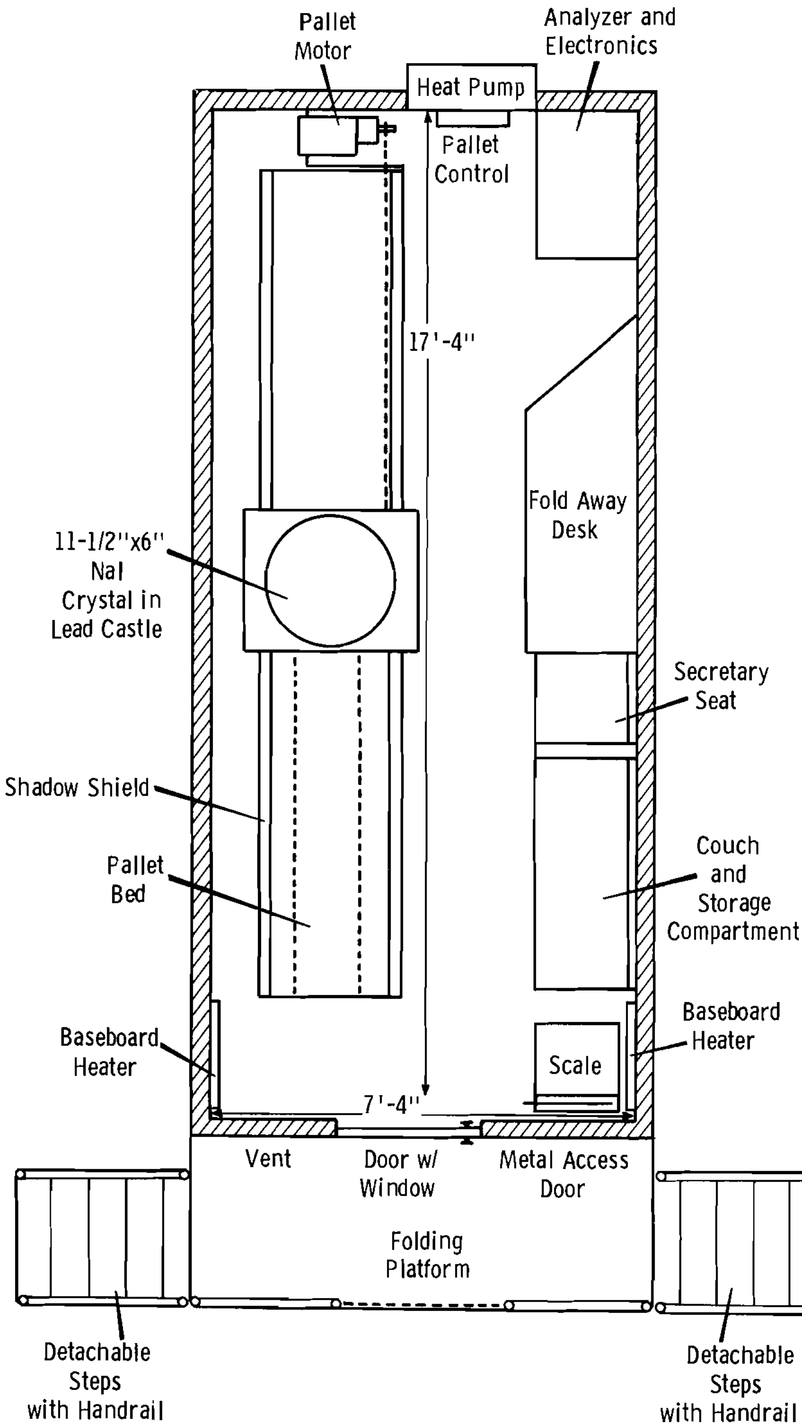

FIGURE 3
Schematic of Equipment and Furniture Arrangement in Whole-Body Counter Van, Mobile Unit B

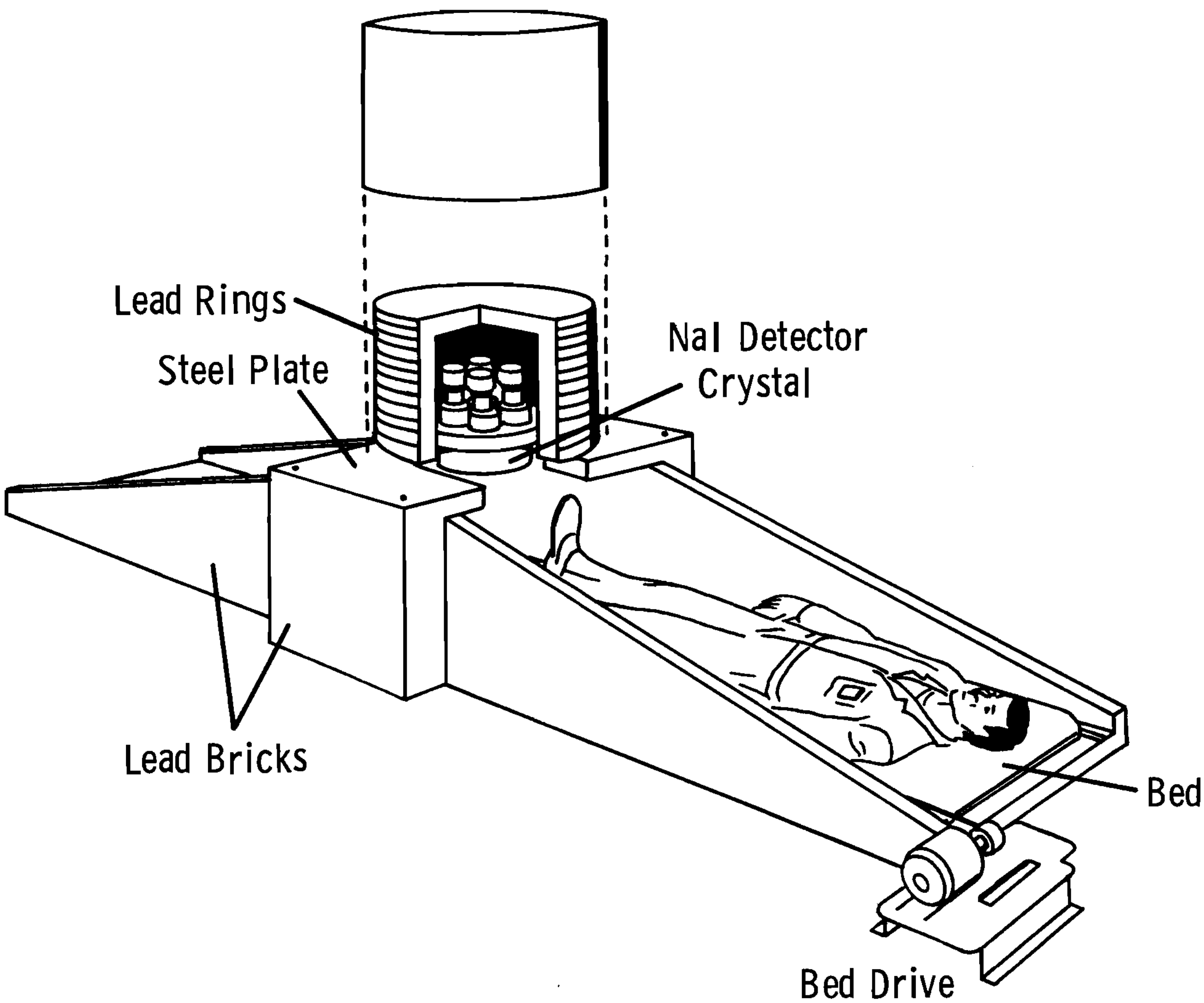

FIGURE 4
Schematic of Typical Shadow Shield Counter

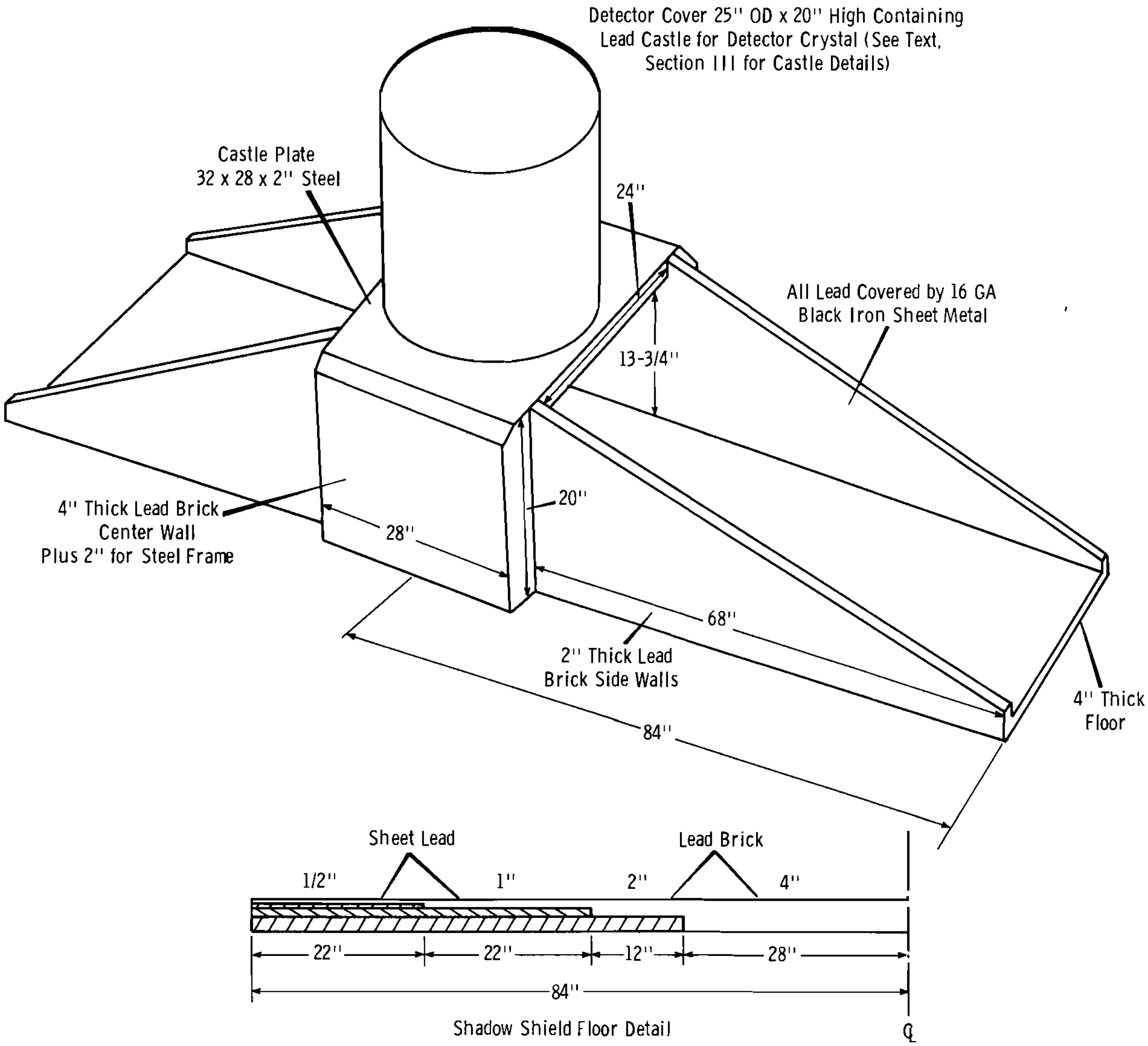

FIGURE 5
Schematic of Lead Shielding Installed in Whole-Body Counter, Mobile Unit B

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