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Design and assembly of a portable helium detector for evaluation as a uranium exploration instrument

By

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This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards and nomenclature.

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for evaluation as a uranium exploration instrument

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Abstract

Details are presented on the assembly of the helium detection instrument assembled and being tested by the U.S. Geological Survey for uranium exploration. This instrument is designed to evaluate the supposition that helium, a by-product of the radioactive decay of uranium can be used as an exploration guide for uranium.

Introduction

The project objective was to develop an instrument that could rigorously evaluate the use of helium-4 as a uranium exploration tool. Major considerations in the development of the instrument were equipment simplicity and economy; the equipment should have adequate sensitivity, a high degree of portability, and permit flexibility in sampling methods. All major components were to be commercially available, off-the-shelf equipment. A brief description of the resulting operational unit follows.

A mass spectrometer tuned for helium-4 is mounted in a 4-wheel drive, 4-door pickup truck. This arrangement serves as a portable laboratory that can be driven to the vicinity of the sampling site. The spectrometer and truck are self-contained, and can operate for about 50 continuous hours before replacement of consumables is required. The bed of the truck contains an electric generator, propane fuel, standard reference gases, and liquid nitrogen for the cold trap on the spectrometer. A constant pressure inlet system is used to introduce samples into the spectrometer. A plastic syringe injects the sample into a gas reservoir through a rubber septum. The injected gas causes the plunger of a glass syringe, vertically mounted on the reservoir, to rise. As the plunger of the glass syringe falls by gravity, a constant and reproducible pressure is maintained in the reservoir. The spectrometer responses to helium and pressure are monitored by a strip chart recorder. A generalized flow diagram of the system is shown in figure 1. The recorder, stabilized power supply and a generator voltage monitor are located in a radio chassis adjacent to the spectrometer (fig. 2). The particular components used for this assembly were those that were on-hand or priced competitively at the time of procurement. The specifications are not rigid requirements for the system concept. Design and construction of specific modifications to the instrument and vehicle were done by E. H. Denton, I. Friedman, W. D. Long, A. A. Roberts, R. A. Zimmermann, and G. M. Reimer. Previous descriptions of the instrument adaptation, but with different emphasis on detail, can be found in reports by Friedman and Denton (1975), Roberts and others (1975), and Reimer (1976).

Assembly details

Vehicle

A 4-wheel drive, 4-door crew-cab pickup truck was modified to accommodate the helium detection equipment. A six and one-half foot (198.12 cm) utility bed was installed to provide easy access to tools and equipment stored in the side compartments. A hard-top canopy was placed over the utility bed to provide protection to the equipment located in the bed (fig. 3). Swivel bucket seats were installed in place of the front bench seat (fig. 4). This permits an operator sitting in front to face the spectrometer installed in the rear section of the cab. The swivel seat mounting brackets, originally intended for use in a van-type vehicle were shortened for installation in the truck. Dealer installed air conditioning helps to maintain a stable temperature and helps to keep dust out of the spectrometer within the truck. The cab roof was painted white and insulation was placed in the cab ceiling. The heat from the spectrometer diffusion pump is vented to the outside through a flexible dryer-vent hose. Reflective coatings on the windows of the rear doors help to reduce heat buildup in the cab.

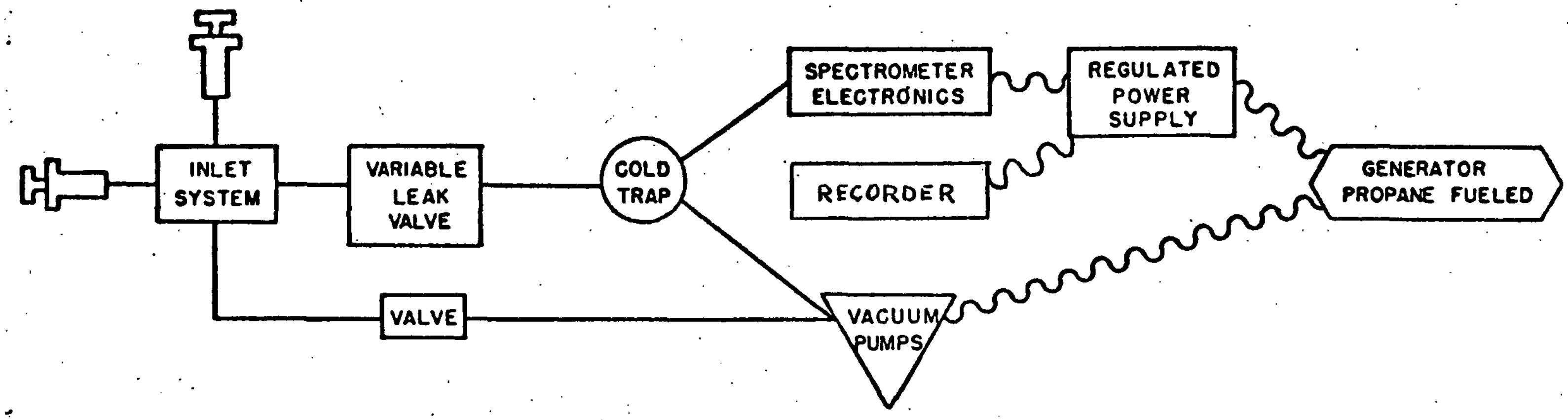

Figure 1.--Generalized flow diagram of helium detection equipment.

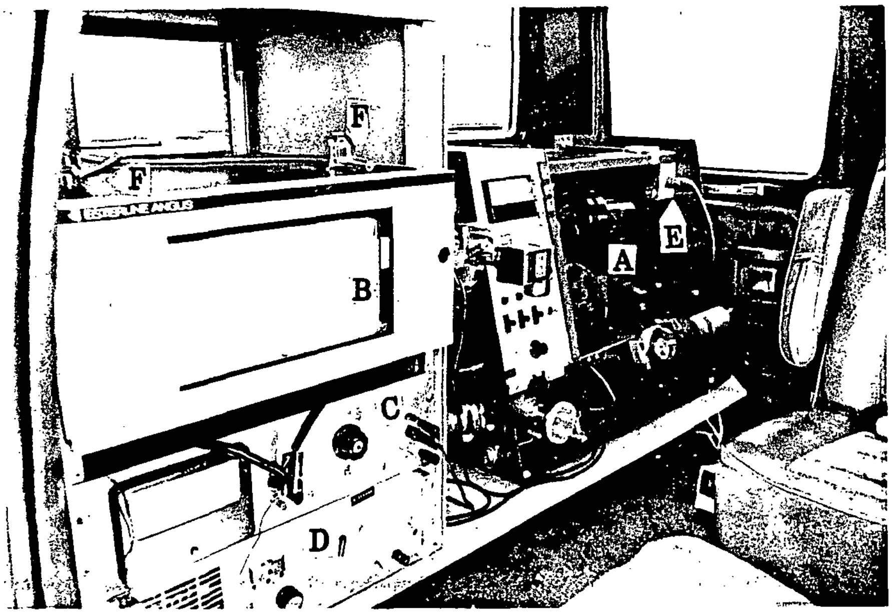

Figure 2.--Instruments mounted in rear of truck cab. A) spectrometer, B) recorder, C) generator voltage monitor, D) power stabilizer, E) patch plug, and F) reference gas.

Figure 3.--Style of vehicle used to accommodate helium detection equipment.

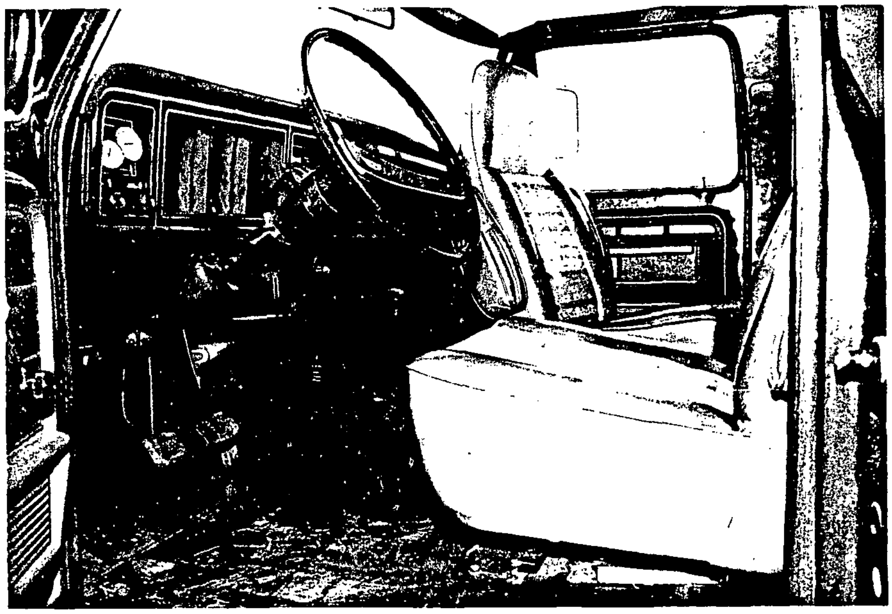

Figure 4.--Swivel seats in front of truck cab.

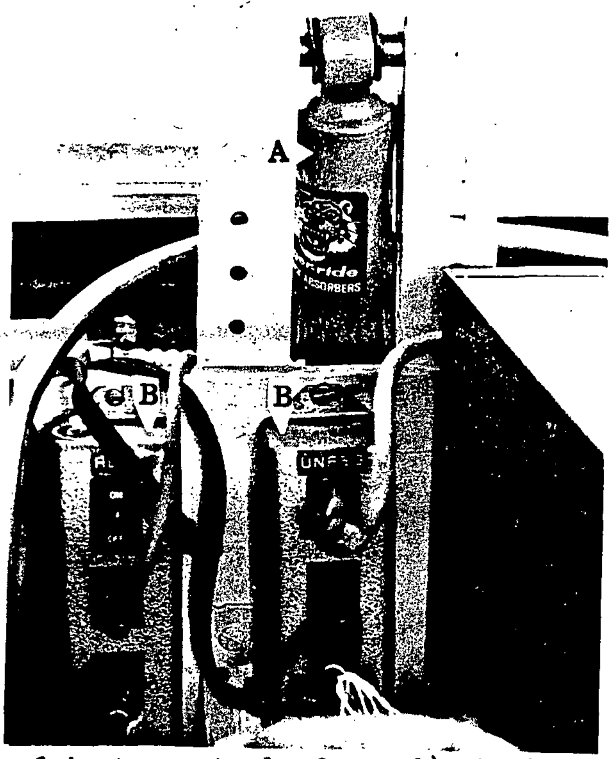

Figure 5.--Back of instrument platform. A) shock absorber mounted on instrument frame, and B) regulated and unregulated power outlet boxes.

A shock-absorbing platform, based on a design by W. D. Long, was mounted in the rear of the cab. A rectangular iron frame was bolted to the floor of the cab and 16 coil springs were bolted between the frame and a plywood instrument mounting platform. High density polyurethane foam sheeting was placed on the bottom of the floor to act as a cushion preventing a severe shock should the instrument bottom out (fig. 6). Automobile shock absorbers were attached to the back sides of the plywood platform to dampen rebound (figs. 5,6).

Probes for collecting soil gas samples are carried in a 4-inch (10.16 cm) polyvinyl-chloride drain pipe tube inserted from the rear into the side of the truck. A screwcap end provides easy access. A liquid nitrogen dewar, generator, reference gases, and tools are accommodated in the bed of the truck (fig. 7).

Generator

The generator and propane fuel supply are mounted in the bed of the truck. Propane was chosen in place of gasoline because it results in more stable speed control of the generator when driving over rough terrain. Two forty-pound (18.16 kg) tanks hold propane and two pressure regulators connected in series reduce pressure for the generator. The primary regulator switches automatically to the full tank when the other is empty. The secondary regulator, provided with the generator, supplies low pressure to the carburetor of the generator. Holes cut in the floor of the truck bed provide cool-air ventilation to the generator and allow the exhaust to be vented outside. Electrical outlet boxes are installed in the bed and the cab of the truck; all are protected by fuses or circuit breakers. Generator power can be by-passed if external power is available. Connection to external power by a patch cord activates a relay that disconnects the generator and supplies external power to the outlet boxes. Thus, the spectrometer can be operated independently of the generator. The same polarity is maintained whether using external or generator power. A voltmeter in the cab of the truck monitors generator output. An elapsed time indicator has been connected to the generator to record operating time.

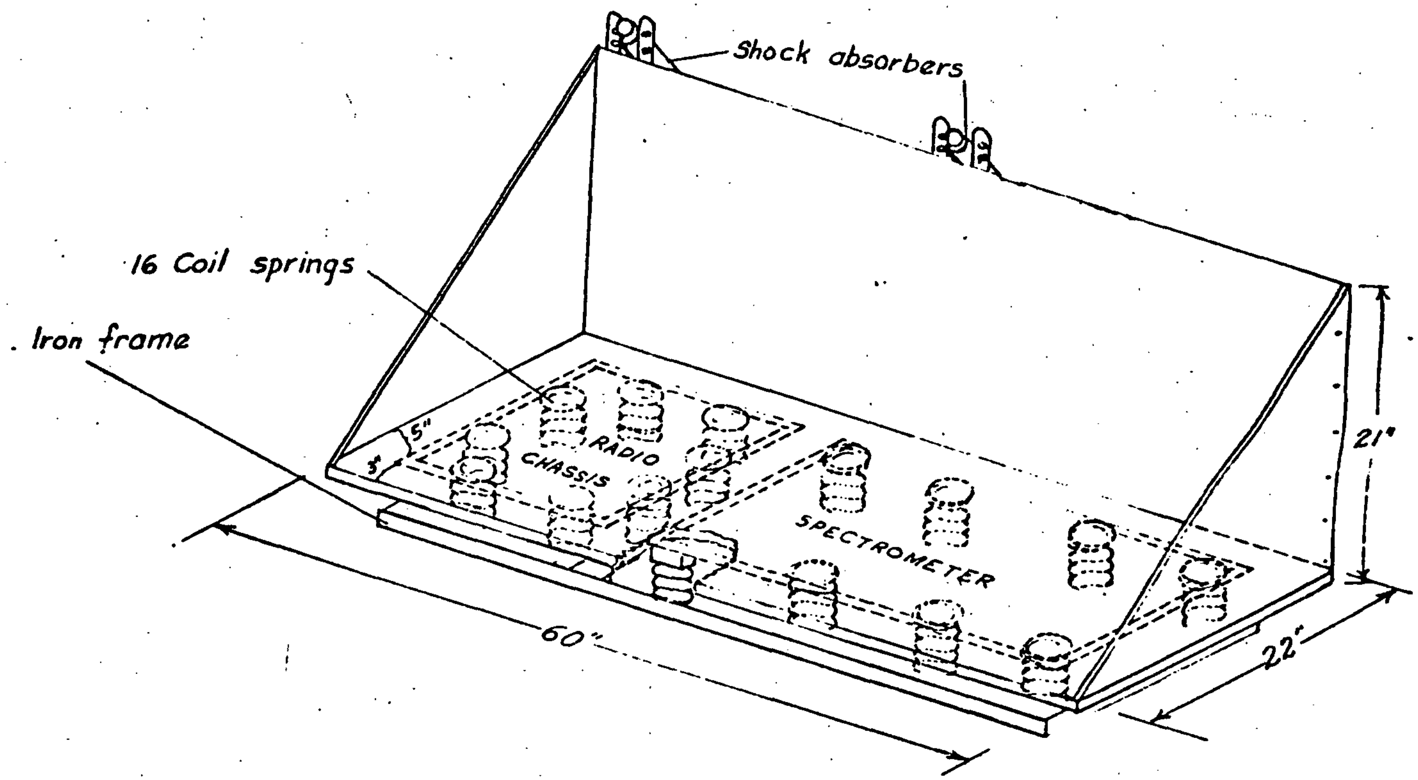

Figure 6.--Configuration of instrument mounting platform.

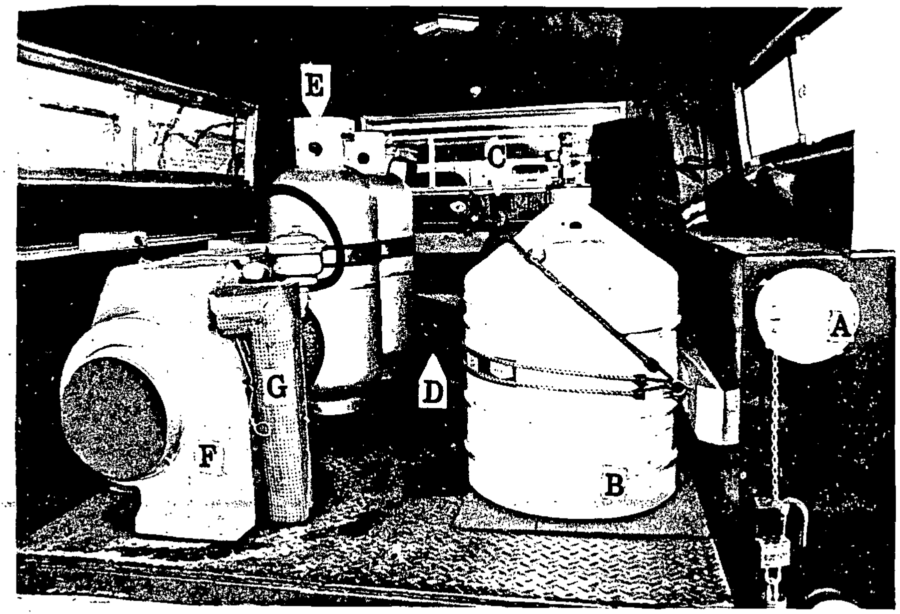

Figure 7.--Equipment in bed of truck. A) storage tube for probes, B) liquid nitrogen dewar, C) reference gases, D) auxillary vacuum pump, E) propane fuel tanks, F) generator, and G) generator exhaust pipe.

Power stabilizer

Unregulated generator power is satisfactory for vacuum pump operation but the spectrometer electronics require regulated power which includes voltage, frequency, and waveform. The power stabilizer converts the generator power to regulated power and a separate outlet box is provided (fig. 5). The stabilizer is not required for spectrometer operation if regular public-utility external power is used.

Spectrometer

The roughing pump and diffusion pump of the spectrometer are operated by unregulated power but the remainder of the electronics are operated by regulated power. This is accomplished by isolating the roughing the diffusion pump electrical circuitry from the remainder of the electronics. A patch plug is available to reinstate the original circuitry to permit operation of the pumps and electronics from a single electrical source, such as external power (fig. 2). The throttle protection valve housing supplied with the spectrometer, which isolates the inlet from the spectrometer, was originally made of plastic. This has been replaced with a brass unit (fig. 8) which is more rugged for field use. The force generated by turning the valve handle had extracted the face plate screws from the plastic housing of this particular unit. The spectrometer can be operated without this valve by using a face plate over the opening of the valve housing.

Ionizing current and accelerating voltage adjustment controls (fig. 8) have been relocated from the side to the front of the spectrometer for convenience.

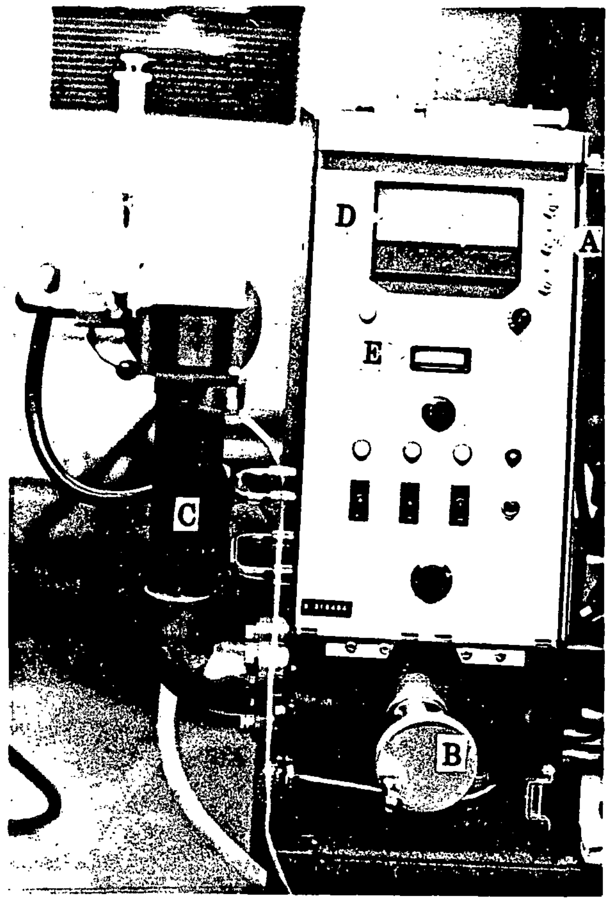

Figure 8.--Front control panel of spectrometer. A) relocated spectrometer adjustment controls, B) throttle protection valve, C) inlet extension elbow, D) output meter, and E) multimeter.

The inlet system was modified by E. H. Denton to accommodate various sampling schemes. Samples of soil gas, air, and water are of interest and have to be collected in areas not always accessible by the truck. A sampling method, using syringes allows the samples to be transported to the spectrometer. Any technique can be used that allows gas to be extracted and collected in a syringe, such as a direct probe in soil, or a gaseous reflux system that purges gas from water. The syringes have a side-hole needle which prolongs the useful life of the septa they penetrate. A ten-inch (25.4 cm) long and two-inch (5.08 cm) diameter copper tube with elbow fittings connects the inlet system to the spectrometer (fig. 9). This elevates the inlet for operator convenience and is sufficiently rigid to support the inlet without the need for additional bracing. The inlet system consists of a variable leak valve, the outlet of which leads into the two-inch (5.08 cm) copper pipe and the inlet of which goes to a swing arm valve that acts as the gas receiving reservoir and isolates the variable leak valve from a roughing pump. Either the spectrometer roughing pump or an auxillary roughing pump is connected to the swing arm valve to evacuate it after the sample has been analyzed. The auxillary pump can be located in the bed of the truck.

Two septum holders (fig. 10) are mounted on a limb of the swing arm valve, on the variable leak valve side. One holder is in a vertical position for the glass constant pressure syringe and the other holder is at an angle to accommodate the plastic sampling syringe (fig. 11). A detailed view of the septa holders is shown in figure 12. The valve system has a dead-volume of about 2.0 cc. Only 2.5 cc of sample is needed to fill the valve dead volume and cause the glass syringe plunger to rise with sufficient gas for one sample analysis; therefore, an original sample of 10 cc would be enough for four replicate analyses.

Recorder

A two-channel recorder with a thermal writing system is used to monitor spectrometer output and pressure. For controlled comparison of samples, the pressure should be maintained. The glass plunger of the vertical syringe can get stuck and monitoring the pressure indicates this condition immediately. The recorder inputs are from leads connected to the two output meters on the front of the spectrometer, one to the output, the other to the multimeter (pressure, current, and voltage). The selector switch on the spectrometer will allow any one of those functions to be monitored by the recorder. The recorder operates from regulated power.

Reference gases

Two cylinders ($\sim$16,000 cc capacity) of helium-in-air are contained in the bed of the truck. Lines from the cylinders lead into the cab of the vehicle and a sample of the gas can be extracted by a sampling syringe (fig. 2). The concentration of helium in the cylinders is about 5 and 10 parts of helium per 10^6 parts of air (5 and 10 ppm). The use of these reference gases allows the instrument to be calibrated for that concentration range.

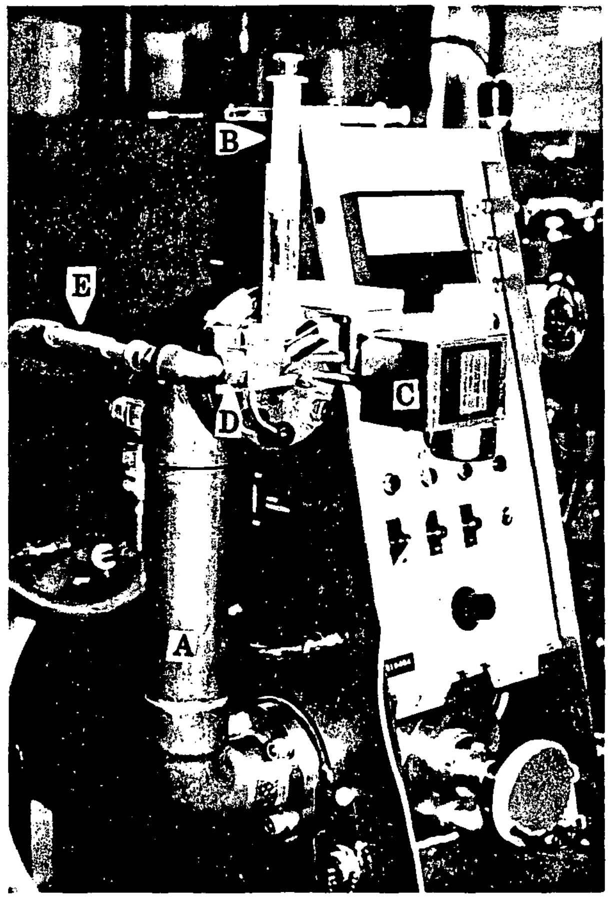

Figure 9.--Inlet system attached to spectrometer. A) extension elbow, B) glass syringe in vertical position, C) variable leak valve, D) swing arm valve, and E) auxillary pump outlet.

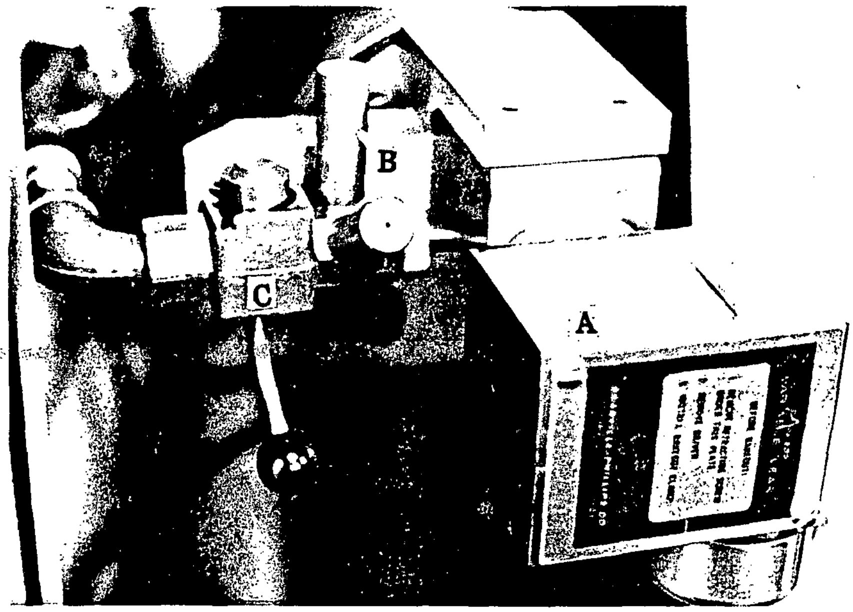

Figure 10.--Variable leak valve connected to swing arm valve with septa holders mounted on limb. A) variable leak valve, B) septa holders, and C) swing arm valve.

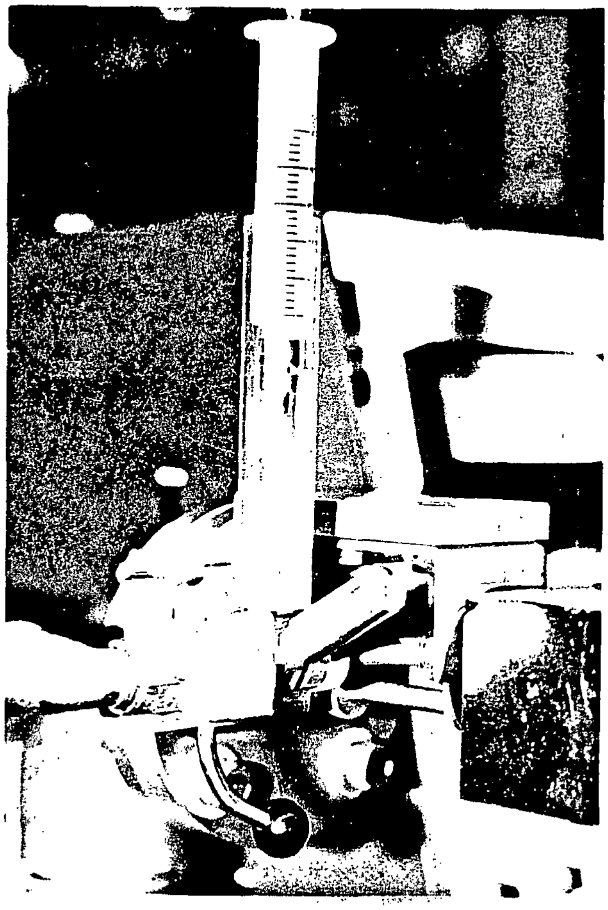

Figure 11.--Close-up view of inlet showing glass syringe in position with support tube.

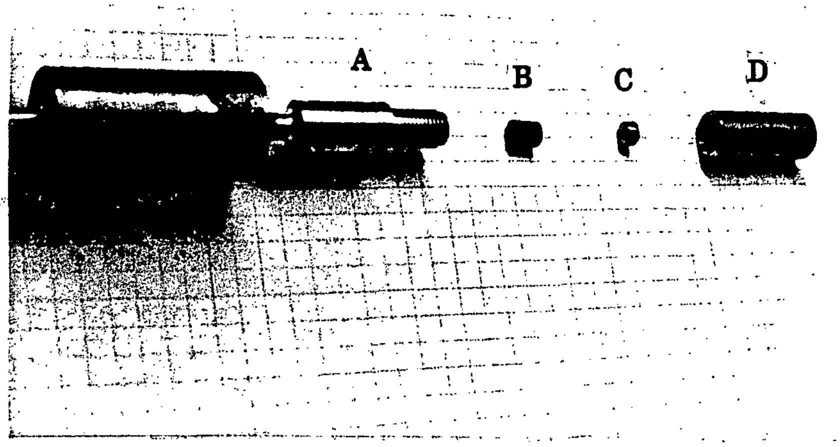

Figure 12.--Exploded view of a septum holder. A) base, B) rubber septum, C) compression ring, and D) cap. This view is the top of a sample probe but the configuration of the septa holders on the swing arm valve is the same. The grid spacing is 1/4 inch (6.35 mm).

Major equipment and fabrication list[1]

Equipment listing--The following is the manufacturers or suppliers of the major components used in the assembly.

Spectrometer - E. I. Dupont, Model 24-120B, Helium Leak Detector

Power Stabilizer - Elgar, Model 251, A.C. Power Source with Model 461-.01 oscillator

Recorder - Esterline Angus, Model L1112S-MV4-MV4-M1060075-E1-Q2-C4

Generator - Onan, Model 2.5LK-3R, 2.5kW, 60 cycle, 120 v., A.C. Generator

Variable Leak Valve - Granville Phillips, Model 203019, style 05 with stainless steel tube

Swing Arm Valve - Circle Seal, 9200 series, 90° swing

Septa - Searle Analytical, Number 570-599266, 1/2 hole

Mounting springs - Barry Controls, Type SB1-0.6-AA

Auxillary Roughing Pump - Sargent Welch, Model 1400-B, Two stage vacuum pump

The following list is the major shop fabricated equipment.

Angle iron frame base and plywood instrument support platform

Inlet system valve with septa holders, brackets, and copper extension tube

Syringe needles

Brass front housing of throttle protection valve

[1]Disclaimer

Use of a specific brand name does not constitute endorsement of the product by the U.S. Geological Survey. Substitutions of similar type equipment could be made for all the components listed.

References

Friedman, Irving, and Denton, E. H., 1975, A portable helium sniffer: U.S. Geol. Survey Open-File Rept. 75-532, 6 p.

Reimer, G. M., 1976, Helium detection as a guide for uranium exploration U.S. Geol. Survey Open-File Rept. 76-240, 14 p.

Roberts, A. A., Friedman, I., Donovan, T. J., and Denton, E. H., 1975, Helium survey, a possible technique for locating geothermal reservoirs: Geophys. Research Letters, v. 2, p. 209-210.