A PORTABLE PROFILING SNOW GAGE 1/

By

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Introduction

Measurements of snow packs using radioisotopes have a history (1) of more than 25 years. Most of these systems measure only the total water content of the snow, most are fixed location systems and nearly all utilize the attenuation of gamma rays by snow between an isotopic source and a radiation detector. These systems have produced excellent results, accuracies from 1 to 5 percent of actual water present for snow depths up to 10 or 15 feet and snow packs up to 52 inches water equivalent. However, the limitations of these systems have prevented a wide application.

These limitations are:

1. Each fixed location system measures only one site.
2. Deep snow may exceed the capabilities of the system.
3. Relatively large sources are required.
4. The sensitive detectors used (usually sodium iodide scintillation) are prone to temperature instability.

A profiling isotopic snow gage developed by Smith (1,2) which uses a Cs-137 source and a scintillation detector lowered simultaneously down two parallel pipes, avoids the last three of these limitations. A portable version of this system avoids all four, but it is relatively large and cumbersome. Smith's gage is capable of resolving the density profile within ½ inch to $\pm 1\%$ accuracy. To accomplish this, it requires a pulse height analyzer, to calibrate the scintillation detector, and data reduction by computer.

The system described in this report, a Portable Profiling Snow Gage called the DIGIRAY PSG-1, is quite similar to Smith's gage. The PSG-1 measures the density profile of the snow by lowering a probe down a tube in the snow. However, it uses only a single tube, because it operates by backscatter instead of transmission. It uses a Geiger Mueller (G.M.) tube instead of a scintillation detector and a Kr-85 gaseous source. Because backscatter is proportional to snow density and because G.M. tubes are stable with temperature, the electronics are much simpler in the PSG-1. The savings in power, weight and complexity result in a lower cost and a more portable system. Some performance characteristics are sacrificed; the PSG-1 has about half the accuracy, $\pm 2\%$ instead of $\pm 1\%$ and one fourth the resolution, 2 inches rather than ½ inch, compared to the Smith gage.

Description of the PSG-1

The PSG-1 consists of three basic pieces of equipment which can be seen in Figure 1. The Drive Assembly in the center of the slide contains a motor and reel in the box at its top. The reel holds 33 feet (10 meters) of nylon coated wire for lowering and raising the probe through the Mt. Rose snow tube. The probe can be raised or lowered by motor at either 1 foot/min (slow) or 2 feet/min (fast) or can be hand cranked up or down the snow tube. A depth indicator in the measurement head shows the distance the probe has traveled in inches or in centimeters in the metric model.

The electronic housing shown just to the left of the measurement head in the figure contains the electronics for the gage, the displays for percent moisture and total water index and the controls for the system. The third component is the battery box shown to the right of the measurement head in the figure. The battery box holds four 22½ volt

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cells connected in parallel (the PSG-1 operates from 16 to 28 volts) which will furnish operation time of approximately 30 hours. A Simpson portable recorder is also shown in this photograph. The PSG-1 recorder output is compatible with most strip chart recorders including the battery operated Simpson unit.

Figure 2 shows the PSG-1 probe extended out of the Measurement Head tube. The detector power and signal are carried to the probe through the coiled cable above the probe. The container to the left of the probe is the calibration can. When the PSG-1 probe is lowered into this can, the backscatter is equivalent to a certain snow density, in this case 54% water, which is marked on the can. The gage is calibrated by adjusting two potentiometers in the electronics: the "high" pot to the density marked on the calibration can when the probe is in the can, and the "low" pot adjusted so that the gage reads zero when the probe is in a Mt. Rose snow tube surrounded by air.

Figure 3 shows the internal arrangement of the probe: The source, detector and collimators. The lead collimators are shaped so that the X-ray beam from the source and the "look angle" of the G.M. tube intersect in a do-nut shaped volume around the Mt. Rose snow tube. This scattering area is approximately 2 inches thick and extends from just outside the snow tube out to a diameter of nearly 24 inches. The PSG-1 source contains Krypton-85 gas in a sealed capsule. Kr-85 emitts both gamma and beta particles. However, the gammas are emitted in only 0.4% of the disintegrations so the 150 millicurie source is equivalent to about 0.6 millicuries of Cs-137. The operation of this gage depends not on the gamma, but on X-rays generated when the Kr-85 betas are stopped in a heavy metal liner inside the source. These X-rays have about the same energy as a dental X-ray machine, 60 to 100 Kev, but the average dental X-ray machine produces a million or more times as much radiation. Because Kr-85 is an inert gas and will dissipate into the air if a source should be broken open, it is considered one of the safest radioisotopes. The State of California, along with the AEC, has issued a General License for this gage, which means that users do not need to obtain a license.

A "blind end" tube is also part of the PSG-1. This tube replaces the cutter section on the Mt. Rose snow tube (after the core is removed) when the profile is taken down the Mt. Rose tube.

Data From Snow Pack Measurements

The first PSG-1 was put in use at the Central Sierra Snow Laboratory (CSSL) in November 1972. The gage was set up near the CSSL (Smith's) gage to provide comparison of accuracy and resolution. Figure 4 shows snow density profile for the CSSL gage and the PSG-1 in the different operational modes. The CSSL gage shows its ability to respond faster to sharp density changes in the snow than does the PSG-1; this is a result of the finer resolution (½ inch compared to 2 inches) of the CSSL gage and also of higher counting rates. The total water equivalent, from the CSSL gage measurement, was 11.09 inches; thus the average density for the 42 inch snow pack was 26.41%. The three measurements with the PSG-1 gage averaged 3% higher than the CSSL gage. Since the two gages were not measuring exactly the same snow, the 3% correlation was considered quite good.

Figure 5 compares the results from the PSG-1 in four different operational modes. The PSG-1 can be operated at two speeds; 12 inches per minute (slow) or 24 inches per minute (fast), and at either a fast time constant (3 seconds) or a slow time constant (6 seconds).

Figure 6 shows the results of two different operational modes, each run twice to test repeatability. Runs 1 and 2 are both at slow time constant, slow speed. The total water (and the average density) from these two runs differ by about 1%. Runs 3 and 4 are both at fast time constant, slow speed. These two runs also agree within less than 1%. The two modes of operations gave 5% different average densities however.

The PSG-1 was used throughout the 1972-73 season at six snow stations established on the CSSL snow course. A fixed aluminum tube had been installed at each of these six locations and additional lengths were added as the snow pack increased. The snow pack profile was measured at each of these six stations with the PSG-1 at approximately one week intervals throughout the winter. The system accuracy for both snow density and total water

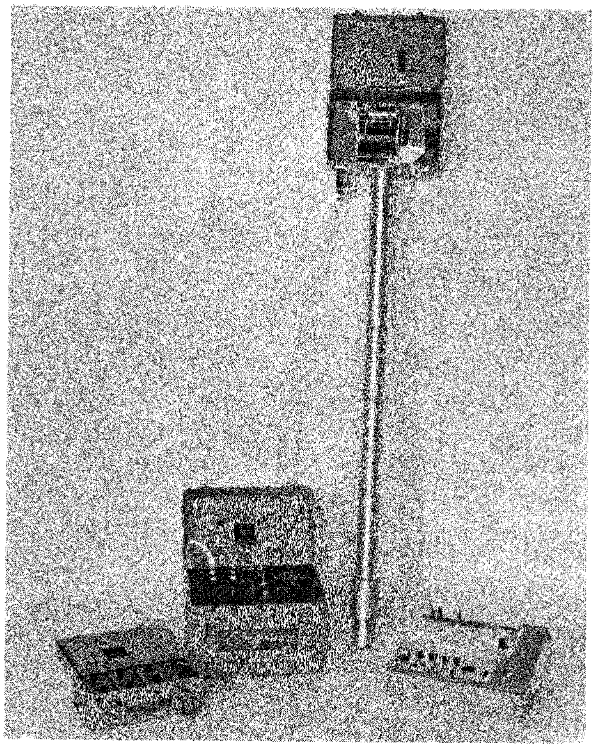


FIGURE 1
DIGIRAY PSG-1 SYSTEM

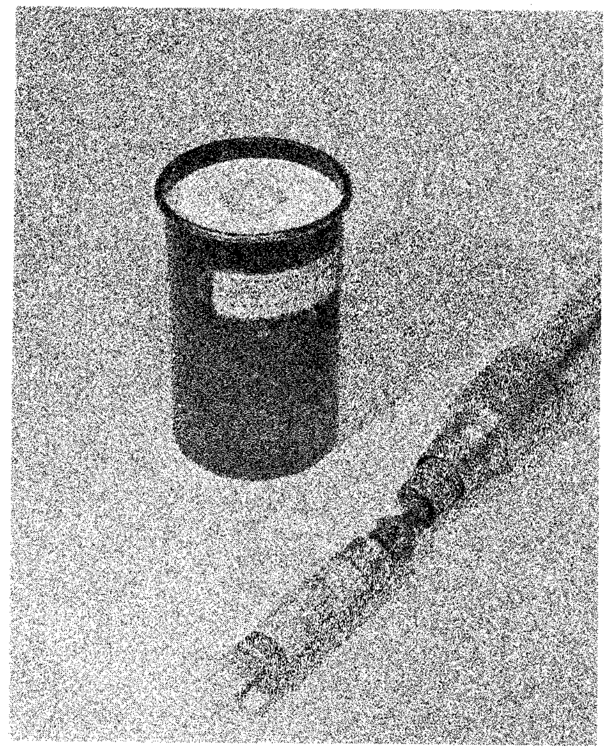
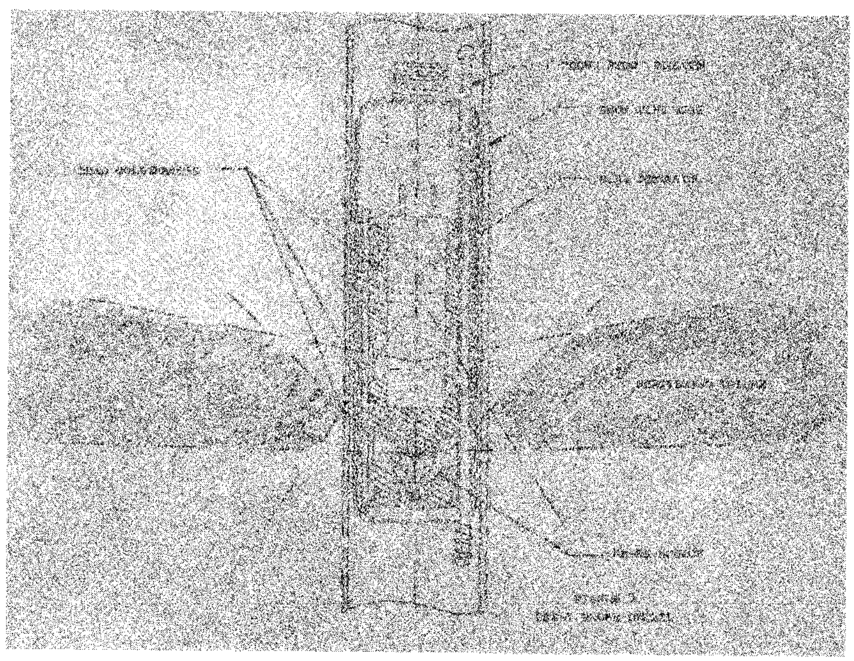


FIGURE 2
PSG-1 PROBE AND CALIBRATION CAN



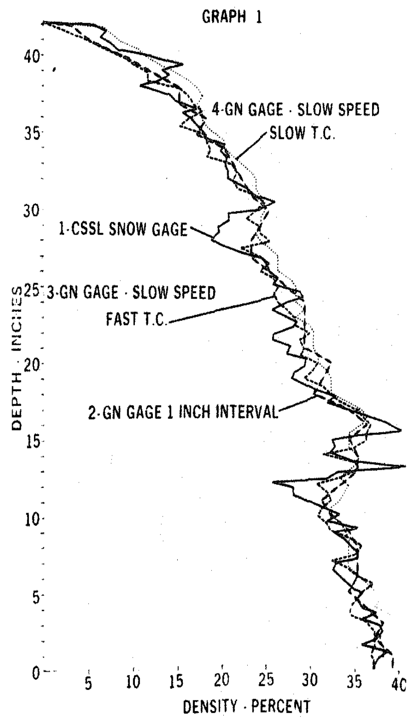


FIGURE 4

DENSITY PROFILES FROM CSSL & PSG-1 GAGES

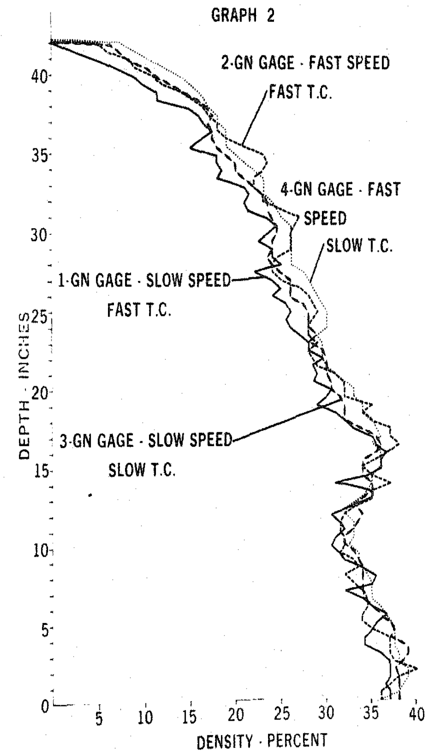


FIGURE 5

DENSITY PROFILES FROM PSG-1 IN DIFFERENT MODES

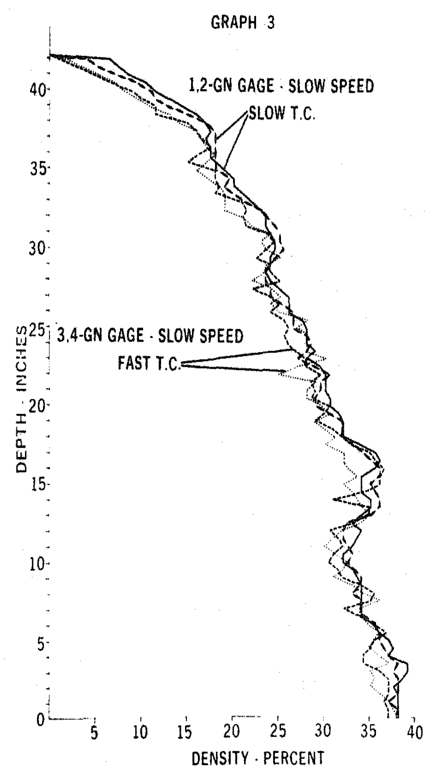


FIGURE 6

REPRODUCIBILITY RUNS WITH PSG-1 GAGE

content has proved to be comparable to the CSSL double tube gage. This gage was subsequently used on the South Cascade Glacier with a Mt. Rose snow tube with good results. Units are in use this season in Canada and in the Cascades where the users anticipate they will need the full 10 meter (33 ft.) range of the gage.

REFERENCES

1. J. L. Smith, D. W. Willen and M. S. Owens, "Portable Radioactive Isotopic Snow Gages for Profiling Snowpacks", Isotopes - Industrial Technology; TID-23368, February 10, 1966

2. J. L. Smith, H. G. Halverson and R. A. Jones, "The Profiling Radioactive Snow Gage", Transactions of the Isotopic Snow Gage Information Meeting; Idaho Nuclear Energy Commission and Soil Conservation Service, USDA, October 28, 1970