# United States Patent [19]

**Martin**

[11] **3,774,034**

[45] **Nov. 20, 1973**


[54] **PORTABLE NUCLEAR DENSITY-MOISTURE INSTRUMENT**


[75] Inventor: **John R. Martin,** Glendale, Wis.

[73] Assignee: **Soiltest, Inc.,** Evanston, Ill.



[22] Filed: **May 12, 1971**

[21] Appl. No.: **142,450**

[52] **U.S. Cl.** ..... **250/388**

[51] **Int. Cl.** ..... **G 21h 1/00**

[58] **Field of Search** ..... 250/83.6 S, 106 S



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,998,527 | 8/1961 | Shevick et al. | 250/106 X |
| 3,393,317 | 7/1968 | Spencer | 250/106 S |



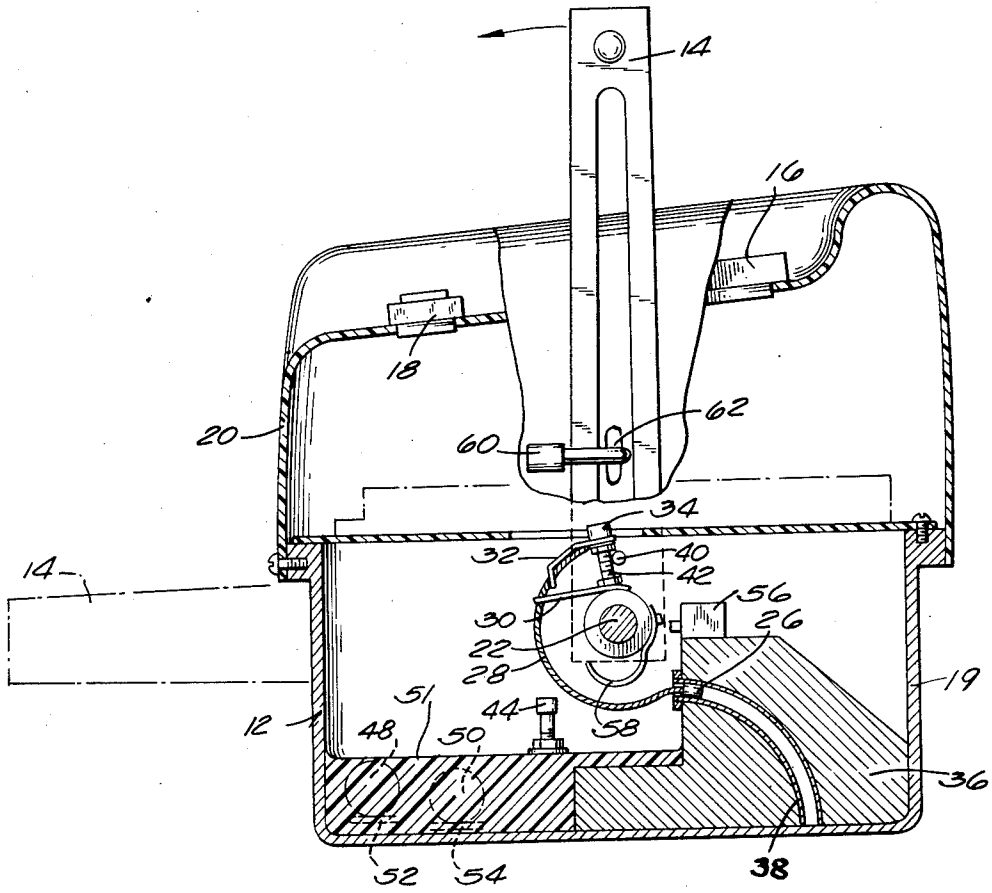
*Primary Examiner*—Archie R. Borchelt
*Attorney*—Robert E. Wagner and Robert E. Browne



[57] **ABSTRACT**

The instrument has a two-piece housing and a radiation shield mounted to the flat-bottomed base of the housing. A capsule carrying a radioactive source is connected to a rotatable shaft by a flexible push-pull cable. The capsule is moved back and forth in an arcuate passage in the shield by the rotation of the shaft between a "safe" position (where there is no direct, unshielded line of sight from the outside of the housing to the source) and an "operate" position (where the source is located in an unshielded position adjacent the bottom of the housing). An actuator mounted on the shaft actuates an on-off switch so that the electrical system detecting the radiation back-scatter from the material being measured is energized only when the source is in the "operate" position. The shaft is rotated by a handle, which is also used to carry the instrument, and the source is in the "safe" position when the handle is in the carrying position.


**7 Claims, 4 Drawing Figures**



PATENTED NOV 20 1973

3,774,034

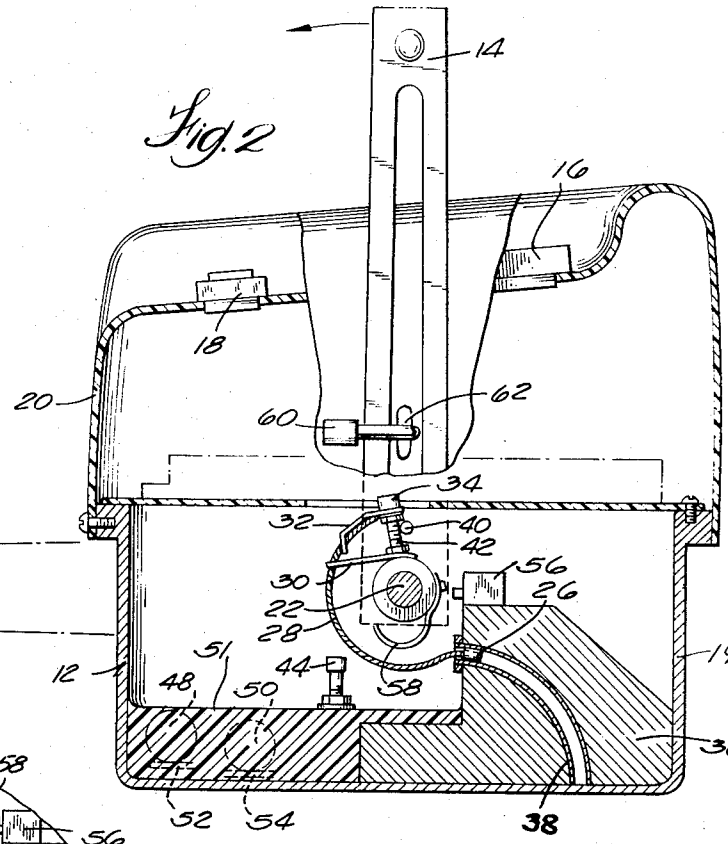



Fig. 2

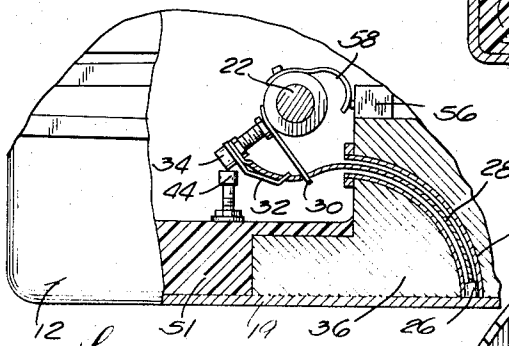



Fig. 4

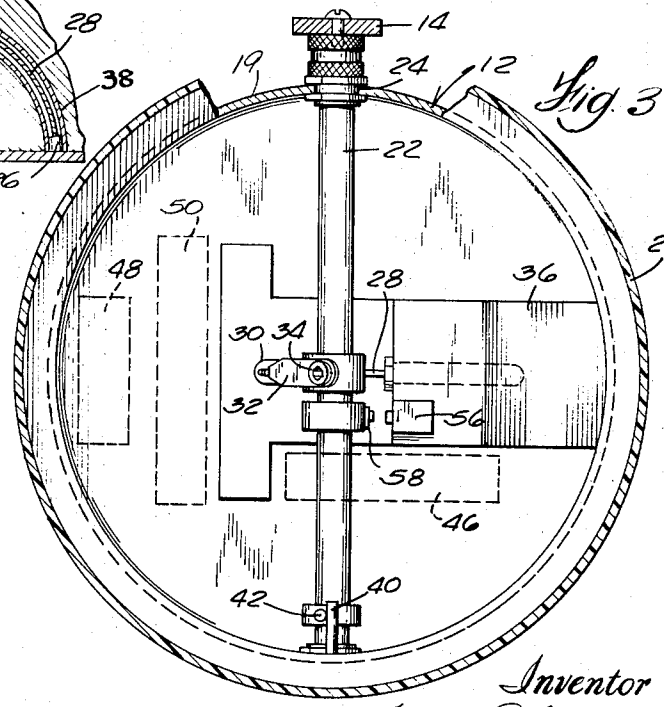



Fig. 3

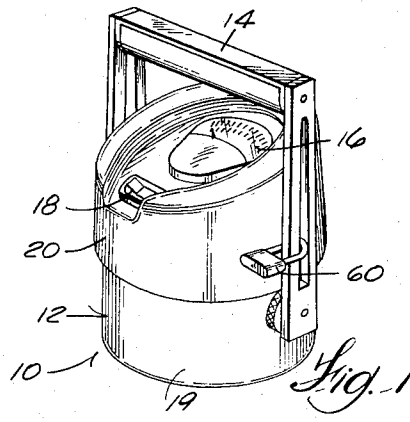



Fig. 1

Inventor
John R. Martin
By Glenn A. Busé
Attorney

# PORTABLE NUCLEAR DENSITY-MOISTURE INSTRUMENT

## CROSS REFERENCE TO RELATED APPLICATIONS

This application is related to application Ser. No. 142,458 filed by the applicant on May 12, 1971 which discloses and claims an arrangement of the radiation detection system for obtaining an accurate density measurement with a single contact reading.

## BACKGROUND OF THE INVENTION

This invention relates to portable nuclear density-moisture instruments for taking in situ measurements of the density and moisture content of soils, aggregate material, concrete or asphalt and the like.

Recently, portable nuclear instruments have been developed which are capable of rapidly measuring both the density and moisture content of the surface layer of materials. These instruments include a radioactive source which emits gamma rays and fast neutrons into the material being measured and electrical systems which detect the back-scatter radiation of gamma rays and slow neutrons from the material and provide a readout of the moisture and density content. In the operating mode, the radioactive material must be positioned as close as possible to the surface of the material in order to obtain adequate penetration of the radiation into the material for meaningful results. This is usually accomplished by lowering the source to a position adjacent to the bottom of the instrument housing. When in the non-operating mode, the radioactive source must be shieled to prevent harmful radiation to operating personnel. Adequate shielding is particularly important for portable devices which might be carelessly handled by relatively unskilled operators. Therefore, the device must be designed to insure proper positioning of the radioactive source for operation but yet shield the source in a manner so that personnel handling the device is not exposed to injurious radiation.

In one approach, such as disclosed by U.S. Pat. No. 3,353,023, the radioactive source is mounted on the control rod. The control rod is moved up and down to position the source in the operating and non-operating positions and a movable shield covers the bottom of the source when it is retracted to the non-operating position. This approach requires several parts, indexing and keying arrangements and therefore is quite expensive. Also, the additional parts and additional lead shielding substantially increases the overall weight of the instrument.

In another approach, such as shown by U.S. Pat. No. 3,511,997, the source control rod has a handle which must be rotated to a non-operating position before it can be lowered to enable closing of the cover on the case enclosing the instrument. This approach does not insure proper shielding of the source for devices which do not employ a closable cover. A careless operator can move such an instrument with the control rod handle in the raised position. Also, the additional parts and additional lead shielding substantially increases the overall weight of the instrument.

Portable nuclear instruments typically have self-contained electrical systems, i.e., rechargeable batteries as a power source and electrical radiation detector systems. After the instrument is positioned on the surface of the material for measurements and the source has been lowered to the operating position, an on-off switch is actuated to the on position to energize the electrical systems. If this switch is inadvertently left on or accidentally moved to the on position, the batteries can become discharged thereby making the instrument inoperable without replacement or recharging the batteries. Also, the detection systems can be unnecessarily energized for extended periods of time.



## SUMMARY OF THE INVENTION

Because of its simple arrangement, the instrument described in the Abstract is extremely lightweight, relatively inexpensive to fabricate and is substantially fool proof from radiation hazard and premature discharge of the battery power supply standpoints. The novel arrangement of the shielding with an arcuate passage in which the radioactive source is moved back and forth between the non-operating and the operating positions permits a more efficient utilization of the lead shielding thereby reducing overall cost and weight. In addition to serving as the means for carrying the instrument, the handle is used as the actuation means for controlling the positioning of the source and the energization of the electrical systems. The reduction in the number of components results in reduced overall weight and costs and improved reliability. Any time the instrument is lifted by the handle, the source is automatically retracted to a "safe" position within the shield and protection against harmful radiation during handling is insured. The electrical systems are energized only when the radioactive source is in the operating position and unnecessary drains on the power supply and energization of the detector systems are eliminated.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the portable density-moisture instrument of this invention.

FIG. 2 is a side elevation view, partially sectioned of the density-moisture instrument.

FIG. 3 is a plan, sectional view taken along the plane designated 3—3 in FIG. 2.

FIG. 4 is a fragmentary view showing the radioactive source in the operating position.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Density-moisture instrument **10** includes a housing **12**, a carrying handle **14**, a meter **16** which indicates density and moisture content in pounds per cubic foot, and a density/moisture control switch **18**.

Housing **12** includes a flat-bottomed base **19**, constructed from a lightweight material (e.g., aluminum) and a one-piece top portion **20** constructed from a sturdy lightweight material (e.g., fiberglass). Although the housing can have any cross section configuration, the bottom of the base is preferably circular to facilitate seating of the instrument on the surface of the material to be measured. Handle **14** is rigidly attached to the opposite ends of control shaft **22**, which extends through and is rotatably attached to base **19** via bearings **24**. A small, stainless steel capsule **26** carrying a radioactive source is connected to control shaft **22** by a flexible push-pull cable **28**. Cable **28** is guided by guide plate **30** and held by retainer **32** to lever **34** which is attached to control shaft **22**. The radioactive source can be any suitable source which emits gamma rays. If the instrument is used solely to measure density,

sources such as radium 226, cesium 137 and cobalt 60 can be used. Preferably, the instrument is used to measure both density and moisture, in which case the radioactive source must be capable of emitting fast neutrons as well as gamma rays. For example, a suitable amount (e.g., 4.5 millicuries) of a mixture of radium and beryllium can be used as the source for both measurements.

Lead shield 36 is cemented to bottom of base 19 and includes an arcuate passageway, such as a molded-in copper tube 38. Capsule 26 is moved back and forth inside tube 38 between a "safe" position and an "operate" position. When in the "safe" position shown in FIG. 2, capsule 26 is remotely positioned in the upper portion of tube 38 so that radiation emitted from the radioactive source is shielded by shield 34. The curvature in tube 38, preferably about 90°, insures there is not a direct, unshielded line of sight between the housing and the source. Thus, the instrument can be safely handled by personnel without the danger of radiation. When handle 14 is moved approximately 90° in the direction of the arrow shown in FIG. 2, capsule 26 is moved down inside tube 38 to the "operate" position adjacent to the base 18 as shown in FIG. 4. When in this position, the bottom of the radioactive source is unshielded and radiation is emitted therefrom through the bottom of the aluminum base. Stop pin 40 mounted to the side wall of base 18 engages detent lever 42 mounted on control shaft 22, when handle 14 is in a vertical position, and insures that capsule 26 is positioned in the "safe" position within tube 38. As shown in FIG. 4 proper positioning of capsule 26 with respect to the bottom of base 18, when handle 14 is lowered to the "operate" position, is controlled by lever 34 engaging stop pin 44. If the device is inadvertently picked up by handle 14 (which is the only suitable grip) before the handle has been raised to the vertical position, it rotates about bearings 24 until stop pin 40 engages detent lever 42. Thus, any time the device is lifted by the handle, the radioactive source is automatically retracted to the "safe" position. In the event the capsule becomes jammed within the tube in the "operate" position, the handle cannot be raised and the operator is made aware of the malfunction. If the capsule becomes jammed in the upper or "safe" position, cable 28 will collapse when the handle is lowered and radiation protection is still provided to the operator. The shield is arranged so that, in event the capsule becomes jammed in the tube at any position between the "safe" and "operate" positions, shielding is provided to personnel in all directions except through the bottom of the base.

Moisture detector 46 and gamma ray density detectors 48, 50 are mounted in the lower portion of base 18 and positioned with respect to shield 36 so they are shielded against direct radiation from the radioactive source when capsule 26 is in the "operate" position. A layer of silicone rubber 51 or similar material, poured over the detectors and the lower portion of the shield, permanently sets the detectors in place and further seals the shield in place.

Moisture detector 46 can be of any conventional type capable of detecting slow neutrons, such as a thin-wall Geiger-Mueller counter tube surrounded by a silver foil or other materials which convert slow neutrons into beta rays, a scintillation counter, a boron filled Geiger-Mueller tube and the like. Gamma ray density detectors 48,50 can be of any conventional type capable of detecting gamma rays, such as Geiger-Mueller counter tubes, scintillation crystals, photomultipliers and the like. Although a single density detector can be used, separate density detectors having different spectral response characteristics are preferred. As disclosed in co-pending application Ser. No. 142,458, filed on May 12, 1971 by the present applicant and assigned to the present assignee, the provision of separate density detectors having different spectral response characteristics permits the accurate measurement of the material density with a single contact reading. The necessity of taking separate contact and air gap reading to determine an air gap ratio is eliminated. For the sake of completeness of disclosure, the disclosure of that application is incorporated herein.

The difference in spectral response characteristics of the density detectors can be accomplished by providing detectors of different sizes, positioning them in the base so that one is further removed from the radiation received from the material being measured and/or providing different shielding therefor. As shown in FIGS. 2 and 3, detector 48 is smaller than detetor 50 and is positioned above detector 50 with respect to the bottom of the base. Also, a thin lead shielding plate 52 is positioned beneath detector 48 whereas a thin stainless steel shielding plate 54 is positioned beneath detector 50.

Moisture detector 46 is connected in a conventional frequency counting electrical system, including rechargeable batteries (not shown) as a power supply, mounted inside housing 12. The electrical system shapes, smooths and scales the pulses from the moisture detector and transmits an electrical signal, proportional to the frequency of the pulses, to meter 16. Meter 16 is a dual-scale gauge and is calibrated to indicate the moisture content of the material in pounds per cubic foot on one of the scales. As disclosed in the above-identified co-pending application, density detectors 48,50 are connected to separate conventional frequency counting electrical circuits, each of which includes a conventional pulse shaping circuit and a conventional smoothing and shaping circuit. The outputs from the respective smoothing and scaling circuits of the detectors are fed to a conventional comparator circuit and electrical signal representative of this difference is transmitted to meter 16, which is calibrated to indicate density in pounds per cubic foot on one of the scales. Various electrical components and associated circuitry for performing the pulse shaping, scaling, smoothing and comparing (all of which are mounted inside housing 12) are well known to those skilled in the art and do not constitute part of this invention. Therefore, details of same have been omitted for the sake of brevity.

On-off switch 56 mounted atop shield 36 controls the energization of the electrical detector systems by the power supply. When handle 14 is moved to the "operate" position, switch 56 is actuated to the on position by actuator 58 mounted on control shaft 22 (as shown in FIG. 4) and the instrument is ready for taking a measurement. The type of measurement being taken is controlled by density-moisture control switch 18 which selectively connects meter 16 to either the moisture detector system or the density detector systems

To operate the instrument, it is first placed on a flat area on the surface of the material to be measured so that the complete bottom of the base is in intimate contact therewith. Density/moisture switch is moved to the

appropriate setting to obtain the desired measurement. Handle **14** is then moved down to the horizontal or "operate" position and capsule **26** carrying radioactive source is moved down tube **38** to the operating position. Switch **56** is simultaneously actuated to the on position and the electrical system is energized. Depending on the setting of the density/moisture control switch, the density or moisture content is indicated on meter **14** in pounds per cubic foot. After the desired measurements have been made, handle **14** is returned to the vertical or "safe" position and capsule **26** is retracted inside tube **38** to the "safe" position. Switch **56** is simultaneously deactuated to the off position and the electrical system is de-energized. With the handle in this position, the instrument can be safely handled without the danger of harmful radiation. Lock **60** extending through an eyelet **62** mounted to top **20** locks the handle in the "safe" position so it cannot be inadvertently moved to the "operate" position during handling.

From the above detailed description, it can be seen that the novel arrangement of the shielding, means for controlling the positioning of the source, and means for controlling the energization of the electrical systems, permits the construction of a compact, lightweight and inexpensive nuclear density-moisture instrument capable of taking readings immediately upon seating and lowering the handle to the "operate" position. The light weight of the instrument reduces operator fatigue when multiple readings are being taken. In addition to increasing the portability, the compactness of the instrument facilitates its seating because of a smaller, smooth seating surface is required. The simplicity of the means for placing it in the operating mode reduces the degree of skill required to operate the instrument. The two piece housing can be easily weatherproofed by sealing the top to the base and constructed from rugged materials so that the instrument can be operated during inclement weather conditions

I claim:

**1.** A unitary portable instrument for measuring characteristics of a material comprising

a housing having a flat bottom wall which is positioned on the surface of the material to be measured;

the radiation shielding block disposed inside said housing and secured to said bottom wall, said block having an arcuate passage extending upwardly from said bottom wall;

a radioactive source slidably disposed in said passage and movable therein between an operating position adjacent said bottom wall and a safe position in the upper portion of said passage where radiation from said source through said housing is shielded by said block;

a control shaft positioned inside and pivotally mounted on said housing;

means for rotating said control shaft between first and second positions corresponding to the safe and operating positions of said source, respectfully; and

means connecting said source to said control shaft so that said source is moved from the safe position to the operating position when said shaft is rotated by said rotating means from first position to the second position.

**2.** The instrument according to claim **1** wherein said rotating means comprises a carrying handle positioned outside said housing and connected to said control shaft, said handle being rotatable with said control shaft from a carrying position corresponding to the safe position of said source to the second position corresponding to the operating position of said source.

**3.** The instrument according to claim **2** wherein said passage approximates a 90° circular arc.

**4.** The instrument according to claim **2** wherein said connecting means is a flexible cable.

**5.** The instrument according to claim **2** including a stop positioned inside said housing; and

a detent mounted on said control shaft which engages said stop when said carrying handle is in the carrying position, said carrying handle being arranged so that, if said said instrument is lifted by said carrying handle when in a position other than in the carrying position, said carrying handle rotates with respect to said housing until said stopping engages said detent.

**6.** The instrument according to claim **1** including

a power supply disposed inside said housing;

a detecting means disposed in said housing for detecting radiation from the material being measured;

an electrical switch disposed in said housing for selectively controlling the energization of said detecting means by said power supply, said switch being in a non-energizing position when said control shaft is in the first position; and

actuating means operatively connected to said control shaft so that said switch is actuated to energize said detecting means when said control shaft is rotated to the second position.

**7.** The instrument according to claim **6** wherein said rotating means comprises a carrying handle positioned outside said housing and connected to said control shaft, said handle being rotatable with said control shaft from a carrying position corresponding to the safe position of said source to the second position corresponding to the operating position of said source.

* * * * *