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METHOD OF AND APPARATUS FOR IRRADIATING FLUID AND SOLID MATERIALS WITH EMANATIONS FROM A RADIOACTIVE SOURCE

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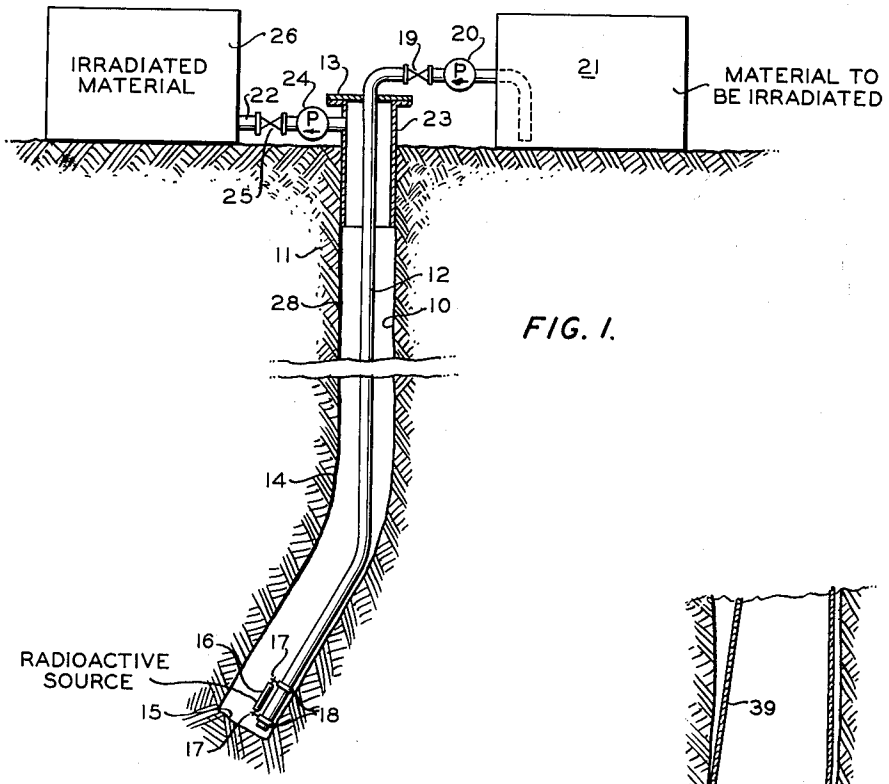


FIG. 1.

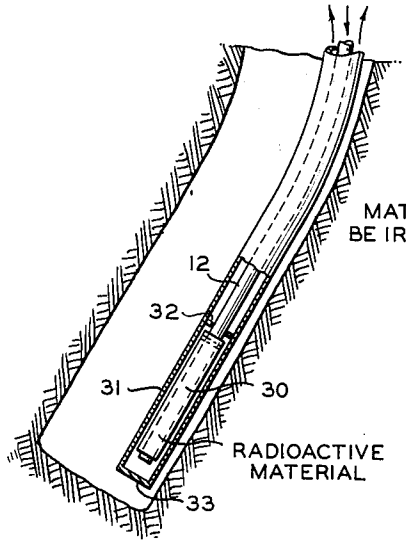


FIG. 2.

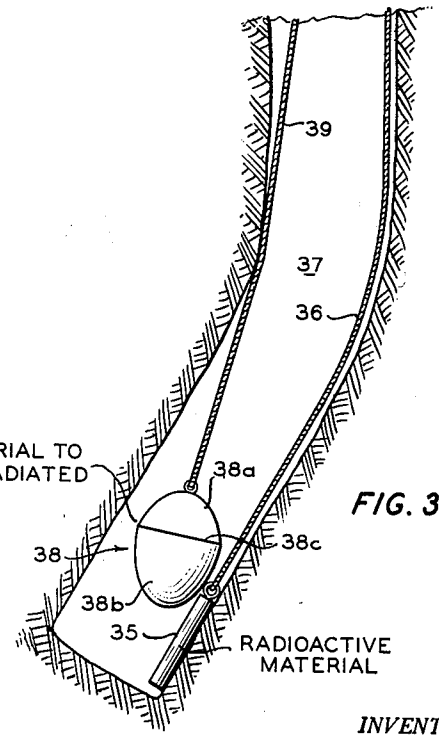


FIG. 3.

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METHOD OF AND APPARATUS FOR IRRADIATING FLUID AND SOLID MATERIALS WITH EMANATIONS FROM A RADIOACTIVE SOURCE

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This invention relates to a method of and apparatus for irradiating fluid and solid materials with emanations from a radioactive source. Heretofore, when material has been irradiated by emanations from a radioactive source, either for experimental or for commercial purposes, elaborate shielding systems have been necessary to protect the operator from receiving dangerous doses of radiation. In particular, massive concrete shielding structures have been utilized in the construction of hot caves and for surrounding treating vessels where radioactive materials are subjected to chemical transformations.

It is a major object of this invention to provide a simple and inexpensive method and apparatus for subjecting fluids or solids to radioactive radiation, even where the radioactive source produces very intense or energetic radiation or particles.

It is a further object to provide a method and apparatus for utilizing high intensity radiation without danger to the operating personnel handling it.

Various other objects, advantages and features of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a vertical sectional view, partially in elevation, of an irradiation system constructed in accordance with the invention;

FIGURE 2 is a detail view of a modified feature of the of the invention; and

FIGURE 3 is a vertical sectional view of a modification of the invention.

The invention resides in the provision of a well drilled into the earth to a depth such that the intervening earth provides adequate shielding for a radioactive source lowered into the well. Advantageously, the hole is whipstocked or otherwise departs from the vertical to a sufficient extent that there is no direct path for the radiation to the surface through the open hole.

Referring now to the drawings in detail, and particularly to FIGURE 1, I have shown a hole 10 drilled or otherwise formed in the earth, the hole being of sufficient depth that the layer of earth 11 between the bottom of the hole and the surface of the earth is sufficient for adequate shielding, with any desired safety factor.

A metal pipe or elastic hose 12 extends downwardly through a well head 13 to the bottom of the hole and, in drilling the hole, a bend 14 is formed, as by whipstocking, so that the lower end 15 of the hole is not in vertical alignment with, i.e, laterally spaced from, the top portion thereof.

A radioactive source 16 is secured to the lower end of the pipe or hose 12, as by supports 17 suitably secured to straps 18 which, in turn, are fixed to the lower end of pipe or hose 12.

At the surface, the pipe or hose 12 is connected by a valve 19 and a pump 20 to a storage vessel 21 containing the material to be irradiated. A conduit 22 extends into a section of casing which supports a well head 23, and this conduit is connected through a pump 24 and a valve 25 to a storage vessel 26 for receiving the irradiated material.

In operation, the material to be irradiated, which can be a liquid or a gaseous material, is pumped down into

the hole through hose or pipe 12, the material being irradiated with emanations from the source 16 as it passes through the lower end of the hose or pipe 12. Thereupon, the material issues from the lower end of hose or pipe 12 and returns to the surface through the well, wherefrom it is removed through conduit 22 and passed to storage vessel 26. The inner wall of the drilled hole can be lined with a sealing material, such as drilling mud, plastic material, and the like, to prevent escape of the irradiated material into the adjacent formations or, in some instances, the hole can be cased.

Due to the bend 14 in the well, it will be noted that the entire body of the radioactive source 16 is laterally spaced from the vertical edge 28 of the well adjacent the top thereof. Consequently, no radiation from source 16 can pass directly to the surface and endanger personnel working at the surface. Furthermore, the layer 11 of earth provides satisfactory shielding with wells of practical depth for even the most intensely radioactive material.

Any suitable radioactive isotope or naturally radioactive material can be used as the source 16. The source may be a beta particle emitter, a gamma particle emitter, or even a neutron source. Cobalt 60 is a suitable combination beta and gamma emitter, chlorine 36 is a suitable beta emitter as is sulfur 35, and suitable neutron sources are well known to those skilled in the art. The radioactive isotopes can be used as such, or in the form of their salts and compounds. For example, the isotopes iron 55 and iron 59 are available as various salts and compounds such as the chloride, oxalate, oxide, phosphate, sulfate, sulfide, acetate, and in the form of potassium thiocyanate. Other suitable radioactive isotopes available as source material are antimony 125, arsenic 77, barium 140, bismuth 210, cadmium 150, calcium 45, cerium 141, cesium 134, chromium 51, germanium 71, iodine 131, mercury 203, nickel 63, phosphorus 32, selenium 75, silver 110, sulfur 35, strontium 90, tin 113, tungsten 185, and zinc 65. There is no limitation as to the strength of the radioactive source which can be used for irradiation, as wells drilled to a depth of two or three hundred feet furnish sufficient shielding for the most energetic radioactive isotopes known. The term "radioactive source" is to be understood as comprehending a reactor of small size located at the bottom of the well.

The material to be irradiated can be any material upon which it is desired to perform experiments, or which is to be irradiated for commercial purposes. For example, gases such as methane, vaporized hydrocarbon fractions, and the like can be sent into the well for irradiation by the source 16, or the effect of irradiation of various liquids, such as alcohols, gasoline, hydrocarbon fractions and the like can be investigated.

In the system of FIGURE 1, it will be noted that the material, after irradiation, rises to the surface through the body of the well. Thus, a considerable volume is occupied by the treated liquid which must either be pumped out of the well to be recovered, or be permitted to remain in the well between periods of operation. In FIGURE 2, I have shown a modification of the invention where the material, instead of returning to the surface through the well, passes through the interspace between two concentric pipes or tubes. In this modification, the material, as before, is introduced to the bottom of the well through a pipe or hose 12. This pipe or hose is surrounded, at its lower end, by a sleeve or cylinder 30 of the desired radioactive material. The material being irradiated, instead of passing from the lower end of pipe 12 to the interior of the well, is received within the lower end of pipe 31 which is held in concentric relation with the pipe 12, as by a spider 32. The pipe 31 has a closed lower end 33 so that the irradiated material reverses its direction and passes upwardly through the an-

nular space between the pipes **12** and **31**. In addition to reducing the holdup of material to be irradiated in the system, the effectiveness of the treatment with radioactive material is increased due to the fact that the material to be irradiated passes in close proximity to the source both as it leaves the pipe **12**, and as it begins its return passage to the surface through the annulus between the pipes **12** and **31**. Like the system of FIGURE 1, the modification of FIGURE 2 is suitable both for the irradiation of liquid and gaseous materials.

In FIGURE 3, I have illustrated a system which is particularly adaptable to the irradiation of solid material. In this system, a radioactive source **35** is lowered to the bottom of the well by a cable **36**. Due to a bend **37** in the well, no irradiation from the source **35** reaches the surface. The solid material to be irradiated is placed in a vessel **38** which can conveniently be formed of two metal hemispheres **38***a* and **38***b* secured together by threads **38***c* and constructed of material which is pervious to the radiation emitted by the source. The container **38** and its included material to be irradiated is lowered into the well by a cable **39** into close proximity with the radioactive source **35**. Various structural materials can be tested in this manner to determine the effects of radiation thereon.

From the foregoing discussion, it will be evident that I have achieved the objects of my invention in providing a safe economical system for the irradiation of materials whether solid, liquid, or gaseous, with sources of the high intensity, without danger resulting from the irradiation to any of the operating personnel.

While the invention has been described in connection with a present, preferred embodiment thereof, it is to be understood that this description is illustrative only and is not intended to limit the invention.

I claim:

1. The method of irradiating material which comprises lowering a radioactive source into a curved bore hole in the earth so that the strata between the surface of the earth and the region to which the source is lowered and the curvature of the bore hole prevent dangerous radiation from reaching the surface of the earth, positioning material to be irradiated in a hollow container, lowering the container into the bore hole to the region of the source, and thereafter raising the container to the surface of the earth, the source remaining in the bore hole at the time the container is raised.

2. The method of irradiating material which comprises attaching a radioactive source to the end of a first cable, lowering the source by means of the first cable into a curved bore hole in the earth so that the strata between the surface of the earth and the region to which the source is lowered and the curvature of the bore hole prevent dangerous radiation from reaching the surface of the earth, positioning material to be irradiated in a hollow container, attaching the container to the end of a second cable, lowering the container by means of the second cable to the region of the source, and thereafter raising the container to the surface of the earth, the source remaining in the bore hole at the time the container is raised.

3. Apparatus for use in irradiating material comprising a curved first pipe positioned in a curved bore hole, the lower end of said curved first pipe extending to a depth such that there is no direct line through the bore hole from said lower end to the surface of the earth, a hollow radioactive source secured to the lower end of said first pipe to form an extension thereof, and a curved pipe enclosing said first pipe and said source, said second pipe being spaced from said first pipe and said source so that fluid material to be irradiated can be lowered through one of said pipes to the region of said source and returned to the surface of the earth through the other of said pipes.

4. The apparatus of claim 3, further comprising pumping means communicating with said one pipe to force fluid into said bore hole through said one pipe.

5. Apparatus for use in irradiating material comprising an elastic hose positioned in a curved bore hole, the lower end of said hose extending to a depth such that there is no direct line through the bore hole from said lower end to the surface of the earth, a radioactive source secured to the lower end of said hose, and means to pump a fluid to be irradiated downwardly into the bore hole through said hose so that the fluid passes adjacent said source and returns to the surface of the earth through said bore hole outside said hose.

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