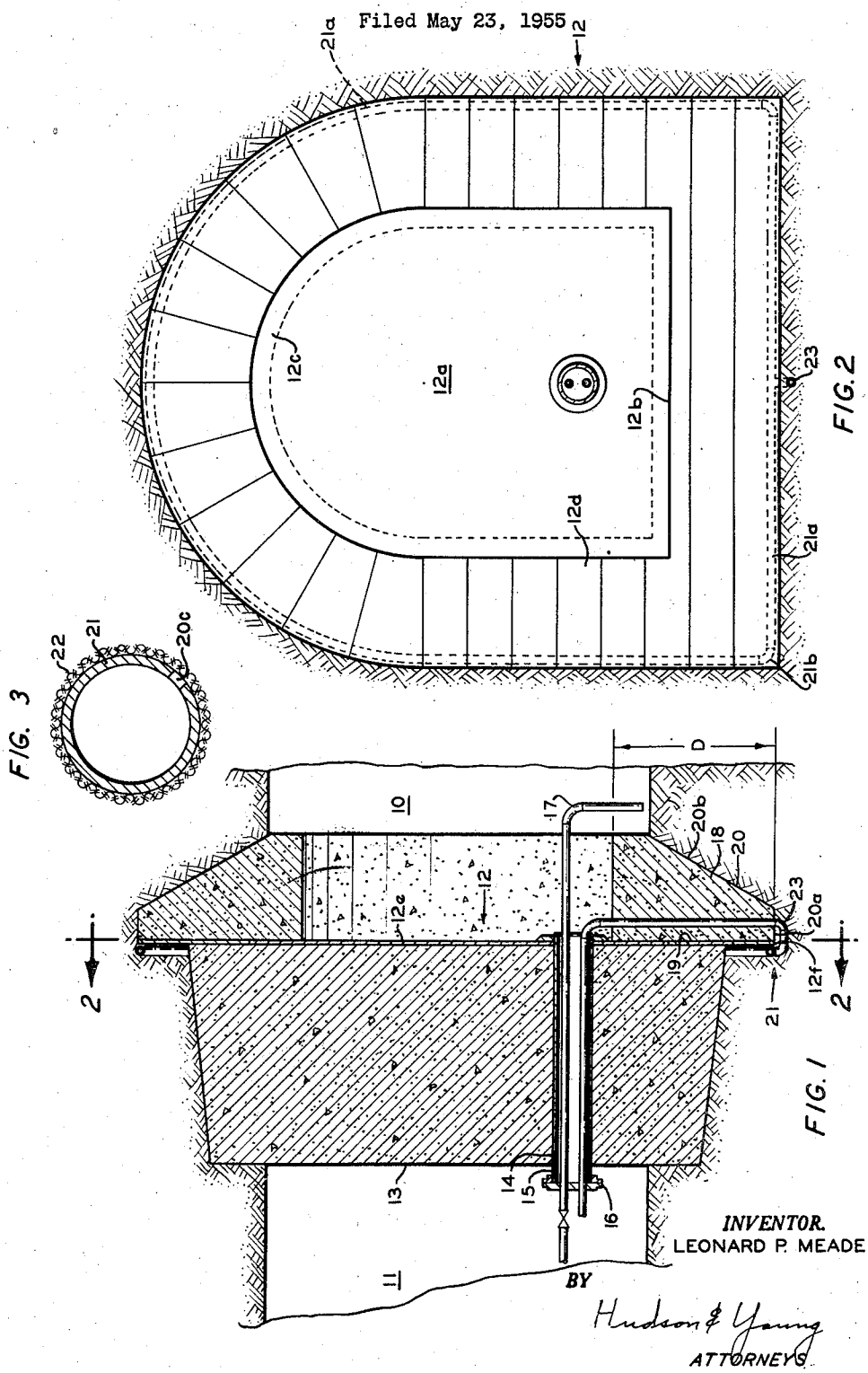
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SEAL FOR UNDERGROUND PASSAGE, AND STORAGE SYSTEM EMBODYING SAME

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SEAL FOR UNDERGROUND PASSAGE, AND STORAGE SYSTEM EMBODYING SAME

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This invention relates to a system for sealing a subterranean passage against uncontrolled vapor leakage. In another aspect, it relates to an underground storage system embodying such sealing system.

Underground storage, particularly of high vapor pressure materials such as propane, ammonia and the like, is now widely practiced in the petroleum and other industries. Oftentimes, such systems utilize either natural or excavated caverns for storage purposes. These can include, for example, excavated subterranean caverns, abandoned oil or gas wells, and abandoned railway tunnels. In both types of storage, it is necessary to seal an opening, usually an access opening, to the storage facility.

Previously, it has been proposed that such sealing be effected by concrete bulkheads. However, concrete is not sufficiently impervious to prevent leakage of the stored material, particularly where the stored material has a high vapor pressure. Various types of sealing compounds have been proposed both for application to concrete bulkheads, and for application to the rock walls of the cavern to effect sealing thereof. However, insofar as I am aware, none of the coating materials thus far developed provides a coating which will prevent leakage over the extended period of time required for successful commercial operation. Moreover, leakage through the zone of contact between the bulkhead and the rock is also a serious problem in installations of this type.

In accordance with this invention, a subterranean passage, for example, part of an underground storage system such as an abandoned tunnel, is sealed by a transverse plate of metal which is impervious to the stored material. Where high pressure materials are stored, this plate is backed on one side, as by a concrete bulkhead, to prevent pressure of the stored material from dislodging it. The plate is impervious and all leakage of stored material must occur around the edges of the plate. This leakage is collected at a multiplicity of openings spaced around the edge of the plate and either vented or returned to the storage facility.

Specifically, this vapor collection system can be a pipe extending substantially the entire distance around the edge of the plate and having a plurality of orifices or openings formed therein for vapor collection purposes. Advantageously, the pipe can be wrapped with a permeable fibrous material, such as burlap, to prevent clogging of the openings by the surrounding rock.

In one important aspect of the invention, the aforementioned sealing means consists of a mass of concrete poured behind the plate on the cavern side of the bulkhead. This mass of concrete engages the plate at a zone bounded by the outer edge thereof and extending inwardly toward the center a sufficient distance as to substantially seal that zone of contact. Moreover, the concrete member substantially seals the zone of contact of the concrete with the rock. Any vapors leaking through both zones of contact are collected by a single pipe or other collector assembly as already described.

In this manner, an efficient seal is provided, and any vapors which may escape are caused to flow in guided paths to a single leakage collection system from which they are either vented harmlessly to the atmosphere or returned to the storage cavern.

Accordingly, it is an object of the invention to provide an improved sealing system for a subterranean passage which substantially prevents leakage, and permits any leakage which may occur to be readily collected for disposal, thus preventing leaking into the region of the passage in front of the sealing structure.

It is a further object to provide an improved underground storage system embodying such sealing means.

It is a still further object to provide such a system at a low cost, and with increased simplicity of construction and operation.

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 of a sealing system constructed in accordance with the invention;

Figure 2 is an end view of the sealing structure of Figure 1; and

Figure 3 is a detail view of a portion of the collector system.

Referring now to the drawings in detail, the storage system, as described, includes a storage region **10** which, in the example shown, is an abandoned railway tunnel. Alternatively, the passage **10** can be a horizontal tunnel leading from a vertical shaft to an excavated underground storage facility, or it can be a portion of a vertical hole, such as an abandoned well, or a shaft extending downwardly to an excavated cavern. In a still broader aspect, the sealing system can be applied to any underground passage where sealing is required.

Ordinarily, according to present economic conditions, the stored material is a high vapor pressure material such as propane, ethane or ammonia. However, the particular material stored is not of the essence of the invention, and can be varied as desired. Generally, the pressure in the storage area **10** is substantially greater than that existing in the connecting or access portion **11** of the underground passage which, in most instances, communicates with the atmosphere.

A plate **12** extends transversely of the passage and, in one specific application, includes a central member **12*a*** conforming in shape with the abandoned railway tunnel to be used for storage and of somewhat larger dimensions than the tunnel. Thus, the plate includes a lower section **12*b*** of generally rectangular cross section and an upper arched section **12*c***. Extending outwardly from the edges of the central portion **12*a*** are a series of plates **12*d*** which are welded together to form a unitary impervious plate assembly. It will be noted that the plate **12**, therefore, is of considerably larger cross section than the tunnel so that the edges of the plate protrude into the rock beyond the tunnel walls.

Where the material in the storage portion **10** is of high vapor pressure, a backing means is required to hold the plate in position. Such backing means can take the form of a concrete bulkhead **13** abutting the plate **12** and engaging the central portion thereof. Preferably, the bulkhead is of larger cross section than the tunnel but somewhat smaller in cross-sectional area than the plate **12** so that it is securely imbedded in the rock defining the tunnel walls. The bulkhead and plate can conveniently be provided with a manway **14** traversed by a casing **15** provided with a sealing cap **16**, and a valved conduit **17**

can extend through this manway or through the bulkhead for introduction and withdrawal of the stored material. This is an optional feature, however, and any suitable means can be used for providing access to the storage cavern and for introduction or withdrawal of the stored material.

At the side 12*e* of the plate opposite the bulkhead 13, there is provided a sealing facility 18. In the example shown, this facility is formed from a mass of concrete anchored in the rock defining the walls of the passage and engaging the entire outer edge 12*f* of the plate. The zone of contact 19 between the concrete and the plate extends inwardly from the edge of the plate a distance D sufficient to substantially seal this zone. Moreover, the concrete mass 18 intersects the ground along a second zone 20 which extends a predetermined distance substantially parallel to the walls of the passage, as indicated by reference numeral 20*a*, and thence diagonally inward to the walls of the passage, as indicated by reference numeral 20*b*. It will be noted that any vapors leaking through either or both zones 19, 20 are thus directed to a localized region around the edge 12*f* of the plate 12.

In accordance with the invention, these vapors are collected at a multiplicity of passages spaced around the edge of the plate, each passage terminating closely adjacent said edge of the plate. To this end, I provide a pipe assembly 21, formed from suitable pipe sections 21*a* and elbows or other fittings 21*b*, this assembly extending substantially or, in the example shown, completely around the edge of the plate 12 and closely adjacent thereto. This pipe is provided with a multiplicity of openings or passages, one of which is shown at 20*c* which are spaced around the edge 12*f*. Accordingly, the vapors leaking around the edge 12*f* from either of the zones 19 or 20, pass through the openings 20*c* into the pipe 21.

Preferably and advantageously, the pipe 21 is wrapped with a layer 22 of coarse pervious fibrous material, such as burlap. This prevents clogging any of the openings provided in the pipe and provides a pathway for the escaping vapors to the nearest opening 20*c*.

The vapors collecting in the pipe 21 are withdrawn by a conduit 23 which extends through the concrete 18 into the passage 10 and, thence, through the manway 14 in bulkhead 13 and the cap 16 to the outer portion 11 of the passage. The vapors thus collected can be vented harmlessly to the atmosphere or compressed and returned to the storage unit, as those skilled in the art will readily understand. The conduit 23 can, alternatively, extend to the outer portion of the passage in any other suitable manner.

It will be evident that I have provided an improved sealing system for an underground passage which substantially prevents leakage of stored material therethrough, even where the stored material is maintained at high pressure. Moreover, any leakage which does occur passes through control leakage paths to a single leakage collection system from which it can be vented harmlessly or returned to storage, thus eliminating loss of the material and obvious hazards which would result from leakage of the stored material into the outer portion 11 of the passage.

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. In an underground storage system, a subterranean passage forming a part of an underground storage system, an impervious metal plate extending transversely of said passage and forming a vapor seal in said passage, said plate being of substantially greater cross-sectional area than said passage so that the edges of the plate extend into the rock beyond the walls of the passage, a mass of concrete anchored in the rock and engaging one side of said plate at a zone bounded by the entire outer edge of said plate and extending inwardly toward the center of the plate a sufficient distance as to substantially seal a first zone of contact between the concrete and plate against the passage of vapors, said mass of concrete having a second zone of contact between it and the rock which extends, from the edge of the plate, a predetermined distance substantially parallel to the walls of said passage, and thence diagonally inward to the walls of the passage, a concrete bulkhead anchored in the rock and engaging the other side of said plate throughout a central area larger than the cross section of said passage, a pipe positioned in the ground adjacent said other side of said plate, said pipe extending substantially the entire distance around the edge of said plate, and said pipe having a multiplicity of openings spaced around said edge, each such opening terminating closely adjacent said edge, whereby fluids leaking through both zones of contact enter said pipe, and a fluid withdrawal conduit connected to said pipe, said conduit extending from the edge of the plate through said mass of concrete to the interior of said subterranean passage and thence through said bulkhead.

2. In an underground storage system, a subterranean passage forming a part of an underground storage system, an impervious metal plate extending transversely of said passage and forming a vapor seal in said passage, said plate being of substantially greater cross-sectional area than said passage so that the edges of the plate extend into the rock beyond the walls of the passage, a mass of concrete anchored in the rock and engaging one side of said plate at a zone bounded by the entire outer edge of said plate and extending inwardly toward the center of the plate a sufficient distance as to substantially seal a first zone of contact between the concrete and plate against the passage of vapors, said mass of concrete having a second zone of contact between it and the rock which extends, from the edge of the plate, a predetermined distance substantially parallel to the walls of said passage, and thence diagonally inward to the walls of the passage, a concrete bulkhead anchored in the rock and engaging the other side of said plate throughout a central area larger than the cross section of said passage, a pipe positioned in the ground adjacent said other side of said plate, said pipe extending substantially the entire distance around the edge of said plate, and said pipe having a multiplicity of openings spaced around said edge, each such opening terminating closely adjacent said edge, whereby fluids leaking through both zones of contact enter said pipe, and means to withdraw fluids from said pipe.

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