Dec. 8, 1970 G. SEBOR ET AL 3,545,213

STRUCTURE FOR LINING UNDERGROUND SPACES

Filed April 10, 1968 2 Sheets-Sheet 1

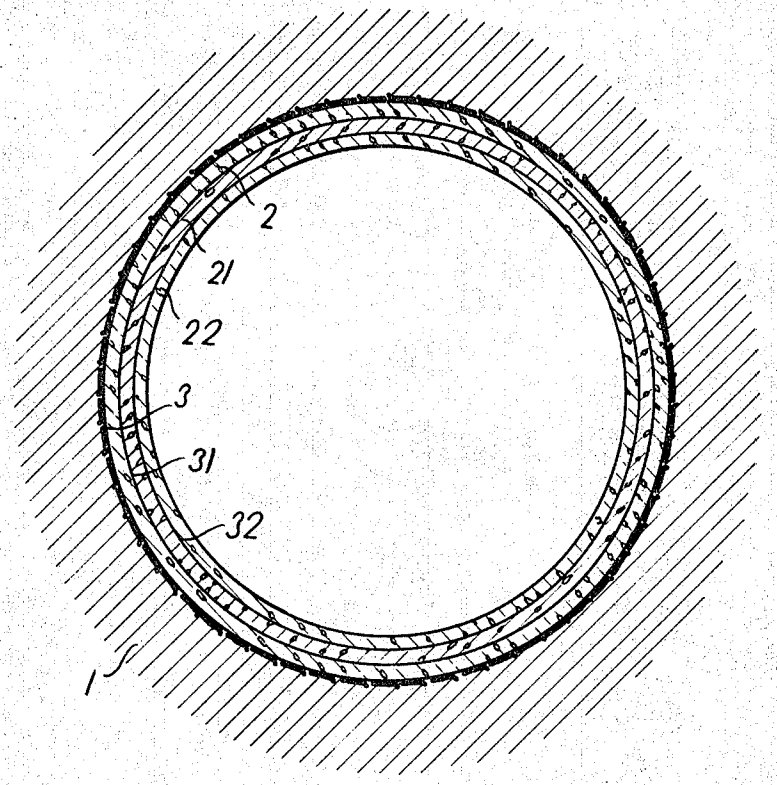

FIG. 1

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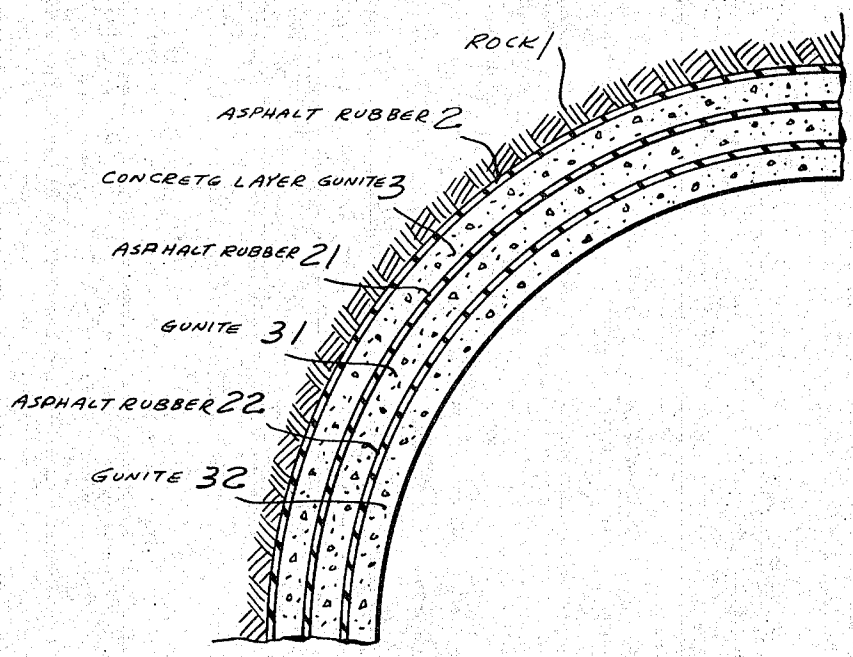

FIG. 2

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STRUCTURE FOR LINING UNDERGROUND SPACES

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ABSTRACT OF THE DISCLOSURE

A structure for lining underground spaces such as tunnels and the like. The structure engages the underground surface which defines the underground space and includes a number of layers made up of elastic and concrete layers which engage each other. The elastic layers are preferably asphalt rubber while the concrete layers are preferably Gunite, and they are alternately arranged in engagement with each other to form a strong elastic multilayer crust body.

BACKGROUND OF THE INVENTION

The present invention relates to structures for lining underground spaces.

In particular, the present invention relates to lining structures for reinforcing underground installations, particularly by providing a strong lining for an underground surface which defines an underground space.

Structures of this type have been used, for example in tunnels or mine galleries, and the lining structures can extend horizontally, or they may be inclined or even vertical. In general such structures are intended to distribute uniformly the pressure of the ground which surrounds the underground space.

It is possible to obtain a suitable distribution of pressure by utilizing a lining structure of suitable profile, and, for example, known lining structures of this type can be made of brick. Reinforcements of this latter type have proved to be particularly advantageous in vertically extending spaces where the stress is applied to the reinforcing structure primarily in a horizontal direction with the stress being located at an elevation lower than in the case of underground spaces which are inclined or horizontal. It is customary to build a panel of molded bricks to form the reinforcement in such a way that the rear surface of the panel contacting the surface of the excavation, particularly in the case of mining operations, so that it is possible to obtain in this way, within certain limits, a given degree of pressure distribution. However, reinforcements of this latter type are extremely expensive, and there are undesirable inconveniences and costs involved not only in the structure itself but also in the transportation of the panels and in the professional skills which are required to manufacture the reinforcing lining.

It has also become customary in recent times to use, for reinforcements of this general type, Gunite which forms a concrete which can be delivered in fluent form to the required location where it sets. Thus, this particular type of reinforcement enables an exceedingly good bond to be achieved with rock in the event that the excavation surface is formed of rock. The space of the excavation is used in this case to the maximum extent, the air resistance is reduced, and the possibility of settling of harmful dust is also reduced. In addition, a reinforcement of this type has refractory properties. Such Gunite reinforcing structures have also been used in combination with reinforcements for roof bolts.

However, linings made of Gunite, of panels of suitable profile, or of bricks all have the common drawback of being incapable of providing sufficient resistance to bending and tension stresses so that the result is that undesirable ruptures are frequently encountered, such ruptures leading to a lessening or even a complete loss of the load-carrying capacity of the lining structure.

SUMMARY OF THE INVENTION

It is accordingly a primary object of the present invention to provide for underground spaces a lining structure which will avoid all of the above drawbacks.

In particular, it is an object of the invention to provide a lining structure which not only will have a large load-carrying capacity but which in addition will have a relatively great degree of elasticity enabling forces to be reliably absorbed and uniformly distributed throughout the structure.

Also, it is an object of the invention to provide a lining structure of this type which will seal the interior space off from any fluids such as gases or liquids which might otherwise have access to the space.

Furthermore, it is an object of the invention to provide a lining structure which can be easily and inexpensively manufactured and which will conform without difficulty to the configuration of the underground space which is to be lined.

In accordance with the invention, the structure for lining the underground space includes a number of layers made of elastic and concrete layers engaging each other. These layers alternate with each other so that except for the innermost and outermost layers, each elastic layer is sandwiched between a pair of concrete layers and each concrete layer is sandwiched between a pair of elastic layers. The innermost layer can take the form of a concrete layer, while the outermost layer can be either elastic or concrete, the thickness of the several layers and the choice as to whether the outer layer is elastic or concrete depending upon the particular conditions which are encountered in the underground cavity.

BRIEF DESCRIPTION OF DRAWING

The invention is illustrated by way of example in the accompanying drawing wherein:

FIG. 1 is a schematic transverse section of a lining structure of the invention which in the illustrated example is composed of cylindrical layers; and

FIG. 2 is a partial section on an enlarged scale of the structure illustrated in FIG. 1.

The structure illustrated in the drawing forms a lining structure for an underground space which may be any tunnel, pit, well, mine gallery, etc., such excavations in general having either a circular or an elliptical cross section. In the illustrated example the outermost layer 2 is an elastic insulating layer applied directly against the surface of the excavation which is, in the illustrated example, formed in rock 1, and preferably the elastic layer 2 is made of asphalt rubber. The thickness of the layer 2 and of the subsequent layers described below will be determined by the geological structure of the rock where the excavation is situated. Thus, the outermost layer 2 will constitute an elastic base for the next layer, which is a layer of concrete, this latter layer preferably being a layer 3 of Gunite. It is to be noted that in addition to forming a base for the concrete layer 3, the outer elastic layer 2 also seals the concrete layer 3 so as to protect it against water or other fluids which might attack the concrete, and in addition the interior space is sealed so that gases will not escape therefrom into the ground. Thus, there is situated upon the inner exposed surface of the elastic insulating layer 2, which is preferably of asphalt rubber,

a first load-carrying layer 3 of concrete, the concrete also having therein a suitable plastic ingredient. In the case where the underground excavation is of a circular profile, as illustrated, the layer 3 has a uniform thickness along its entire circumferential profile, so that the entire wall which forms the layer 3 is of a uniform thickness. However, if the profile of the underground excavation is of a different shape, which is not circular as illustrated, then the thickness of the concrete can be varied so as to be adapted to the individual pressure conditions which may be encountered at different parts of the excavation.

After this first concrete layer 3 has set and hardened, there is applied to the exposed inner surface of this layer a second elastic insulating layer 21, which also is preferably of asphalt rubber and which serves to provide a uniform transmission of pressure, particularly in the case of irregular loads, over the maximum possible area of the next load-carrying layer 31, which is also of concrete. Thus, this next layer 31 will be placed against the exposed inner surface of the second elastic layer 21. In addition, this second elastic insulating layer 21 eliminates undesirable stresses derived from the first load-carrying layer 3 of concrete, particularly bending stresses, and at the same time tangential tensions are also eliminated. The second concrete layer 31 is made in the same manner as the first layer 3.

After this second layer 31 has set and hardened, there is applied to its exposed inner surface a third insulating layer 22 also preferably made of asphalt rubber. The purpose of this third elastic layer is to further transmit the pressure and to protect the reinforcing lining against undesirable effects of aggressive fluids. Finally, this third elastic insulating layer 22 has applied to its inner surface the innermost concrete layer 32 illustrated in the drawing, so that with the structure of the invention as illustrated in the drawing the outermost layer is elastic, the innermost layer is concrete, and except for these outermost and innermost layers, each elastic layer is sandwiched between a pair of concrete layers and each concrete layer is sandwiched between a pair of elastic layers.

Instead of using Gunite for the innermost layer it is also possible to use a layer of a different material to form the inner protective layer of the lining structure of the invention. The number and sequence of the elastic and concrete layers, with the latter being made of Gunite with a suitable plastic addition, can be modified in accordance with the pressure conditions of the rock. While the outermost layer is shown in the illustrated example as being elastic, in many cases it may be preferable to provide an outermost layer of concrete, particularly where it will form a good bond with rock so as to give in this way an outer equalizer layer for the lining structure of

Thus, by bonding together the several layers of the lin-

the invention.

ing structure of the invention, as described above, there is achieved a single strong unitary lining structure which, while having elastic properties, nevertheless is also in the nature of a strong monolithic shell providing an excellent lining for protecting against conditions which are encountered in practice. Resistance is achieved against irregular loads because any irregular load will have its forces evenly transmitted to a large surface so that any particular tension on a given surface area will be reduced by the reinforcing structure of the invention through the distribution of the forces. It is thus possible to use the lining structure of the invention even under conditions where the pressures are localized in a highly unfavorable

manner, because with the structure of the invention the pressure will be transmitted evenly to the entire reinforcement throughout the whole profile, and this is of particular importance in connection with mining operations. Thus, as compared to the conventional shell structures for lining underground excavations, where, for example, a simple application of concrete is used, the reinforcing structure of the invention has highly advantageous elastic properties, and particularly where the elastic layers are made of asphalt rubber the concrete is very reliably protected against liquids or other fluids which might otherwise attack the concrete, and in addition the lining structure of the invention is both gas-proof and water-proof.

It is to be particularly noted that the structure of the invention can be used in the building industry as inserts, particularly where the Gunite is combined with elastic insulating layers of asphalt rubber, this construction being especially suitable in those cases where there is a danger of movement of the foundation of a structure or where it is required to create an exceedingly heavy insulation and to provide protection against mechanical damage. The structure of the invention is particularly suitable in all cases where it is required to equalize irregular loads and to provide protection against fluids such as streaming liquids or gases which might otherwise attack the structure.

Although this invention has been illustrated and described with reference to one preferred embodiment thereof, it is understood that it is in no way limited to the details of such as embodiment but is capable of numerous modifications within the scope of the appended claims.

What is claimed is:

1. A structure for lining a surface which defines at least part of an underground space, comprising a plurality of layers of asphalt rubber and layers of concrete engaging each other including an outer ground-engaging layer directly engaging said surface which defines at least part of said underground space, and an inner layer of material different from said outer layer having an inner exposed surface directed toward the interior of said space, said layers including, except for said outer and inner layers, at least one layer of concrete sandwiched between a pair of layers of asphalt rubber, and at least one layer of asphalt rubber sandwiched between a pair of layers of concrete.

2. The combination of claim 1 and wherein said inner layer is a Gunite layer.

3. The combination of claim 2 and wherein said outer layer is an asphalt rubber layer.

4. The combination of claim 1 and wherein said layers are of a cylindrical configuration.

5. The combination of claim 1 and wherein said layers include three layers of asphalt rubber respectively alternating with and engaging three concrete layers.

6. The combination of claim 5 and wherein all of said layers are of cylindrical configuration.

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