Oct. 3, 1967 P. R. McEACHRAN 3,344,608

METHOD OF LINING DITCHES

Filed Jan. 7, 1965

FIG. 1.

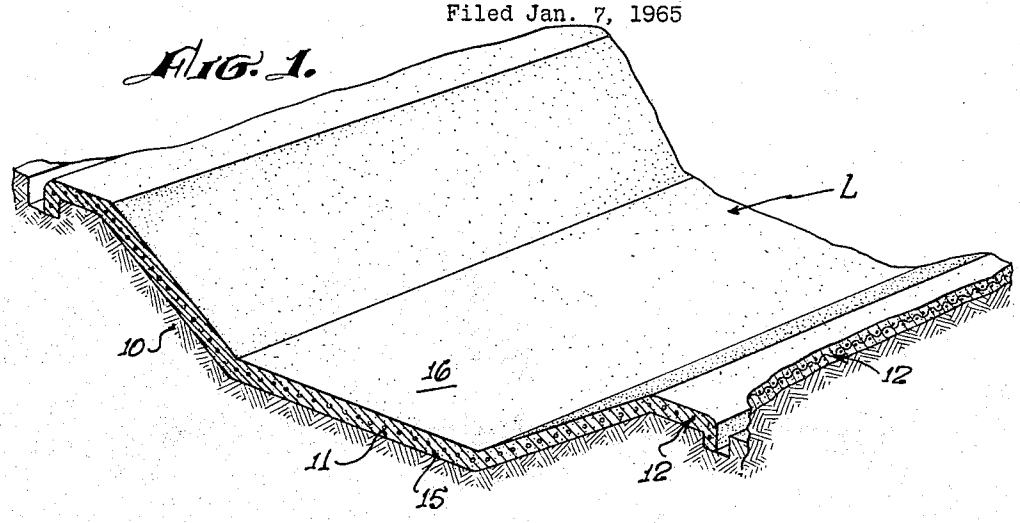


FIG. 2.

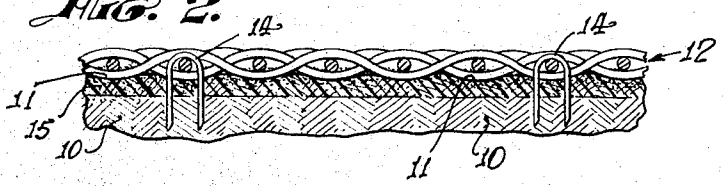


FIG. 3.

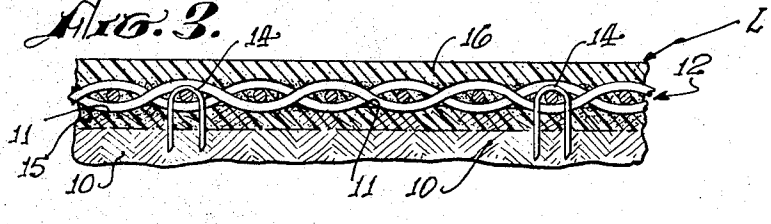


FIG. 4.

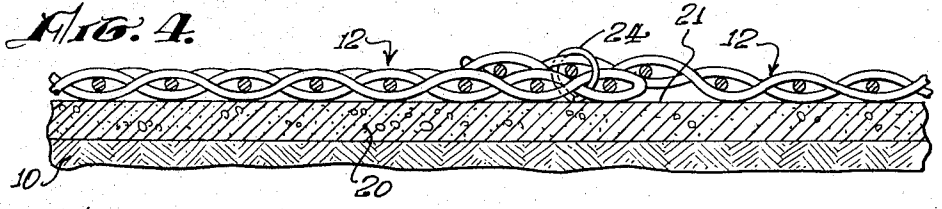
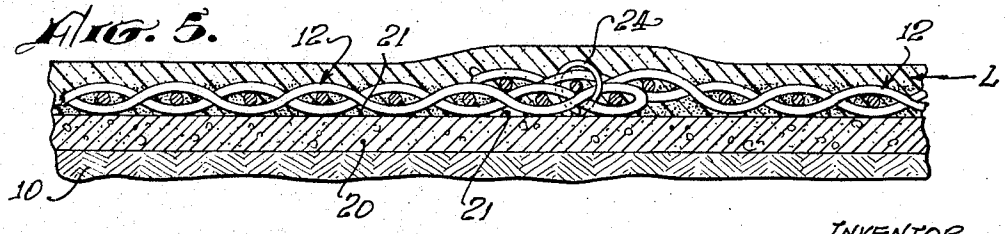


FIG. 5.



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METHOD OF LINING DITCHES

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9 Claims. (Cl. 61—7)

This application is a continuation-in-part of my copending parent application, Ser. No. 288,313, filed June 17, 1963, now abandoned for the same subject.

The present invention relates to an improved method of forming a waterproof lining for canals, ditches, reservoirs and the like formed typically by excavating the ground and then placing a waterproof lining over the ground surface to retain water within the structure; and it also relates to the lining produced by my improved method.

It has been a general practice for many years to line reservoirs, canals, and the more important ditches or open conduits for conveying water in order to conserve the water and prevent it from being wasted by seepage into the earth below. A material widely used for this has been concrete. In an attempt to find a less expensive lining, varying types of macadamized lining materials utilizing an asphalt base have also been developed. Both of these types of lining structures have been unsatisfactory in many cases, because of cracks which may develop after relatively short periods of use, such cracks usually resulting from a shift or settlement of the earth beneath. As in the case with roadways, it is possible to fill these cracks with an asphalt or a mastic composition in order to close them and thereby avoiding the loss of liquids; but the obvious problem that arises with treatment of this character is removal of the water normally covering the lining in order to gain access for such repair work.

An ideal lining for structures of this character, formed by excavation of the ground, should have many different characteristics in order to meet all of the conditions imposed upon it. Obviously, such linings must be waterproof and resistant to any action by the water that would cause deterioration in the quality and character in the lining, either by chemical action or by erosion. Otherwise the lining fails in its purpose of retaining water within the structure and preventing loss of water by seepage into the underlying soil.

From a practical standpoint, a lining is preferably a continuous, monolithic sheet in order to eliminate joints that are hard to seal satisfactorily against leakage and are a frequent source of trouble because of leakage. In other words, a satisfactory lining should be formed as a unitary, monolithic structure over the surface to which it is applied, whether that surface be the underlying soil itself or a foundation such as concrete. This is to be preferred over a lining composed of sheets which are laid on or over the surface and then joined together by cement or mastic at the joints.

An ideal lining material also has a desired degree of flexibility. That is, the lining is preferably sufficiently plastic that it flows slowly and not only conforms initially to the original configuration of the supporting surface but is able to conform continuously to a changing configuration of the underlying ground. In this manner, the lining maintains its continuity and freedom from cracks which cause leakage that oftentimes results in deterioration of the lining structure itself because of penetration of water into the supporting structure.

It is also an advantage of any lining if it can be formed in place, since it then conforms exactly to the supporting surface. The ability to form the lining in place also is economically desirable since it generally means a reduction in the cost of transportation of materials to the job site and a lining which, because it is in continuous contact with a supporting structure, such as the underlying soil, is less subject to cracking.

A desirable lining for ditches, canals, reservoirs, and the like is also tough, strong, and weather resistant. There may often be times when it is submerged and maintained completely wet; but again in some types of installations, the lining is exposed to the sun and the action of the elements, often over substantial periods of time when no water is contained within the structure. Likewise, the lining should have sufficient inherent strength to resist cracking or breaking when walked on by persons, or even by horses or cattle since in many cases, as in rural areas and on ranches, it is impractical to protect ditches or reservoirs and the like from traffic of this kind.

From a practical standpoint, a low cost inexpensive lining is highly desirable because it makes possible a much more extensive use of such a lining. When the lining is relatively expensive, an unfortunate characteristic of many known types, its use can be justified only in the case of major structures, whereas it is obviously highly desirable that an impervious lining be placed in all water supply structures of this kind in order to effect maximum conservation of water. Low cost of the finished lining involves not only use of materials that have a relatively low initial cost, but also the means required for and the method of application of the lining. A lining that can be applied easily and economically is economically desirable.

Another characteristic of a lining which makes it highly desirable is that it be versatile in its manner of use. For example, a lining may be advantageously applied to a relatively rigid structure, such as a conduit or a reservoir formed of concrete, as a means of providing an impervious covering which protects the underlying rigid structure. The same type of lining may also be advantageously applied to a prepared ground surface directly in many instances, thus making it suitable for lining minor canals and ditches.

These advantages are achieved according to the present invention by forming a water impervious lining for water holding structures that comprises chiefly a monolithic body of asphalt formed from a plurality of layers of asphalt-water emulsion and an internal reinforcement consisting of a plurality of cords of a loosely twisted fiber, such as fibers of hemp, jute and the like. This waterproof lining is formed in place over the supporting surface by laying over the surface a heavy netting having a plain, open mesh of substantial size and made from natural or synthetic fibers that has previously been impregnated with asphalt or the like. The netting is preferably laid over a dry surface. After the netting is in place, it is sprayed with one or more coats of the asphalt-water emulsion in order to bond the fibers to the asphalt membrane, formed when the emulsion has dried, and to allow the asphalt to penetrate into the supporting ground surface, when the netting is laid directly over the ground. This penetration has the effect of bonding the liner to the substrate. After at least one spray coat has thus been

applied, the meshes of the netting are filled with a small sized aggregate, such as sand, small gravel, or other rocky material, and then finally the netting and aggregate are sprayed with one or more coats of asphalt-water emulsion that penetrate through the aggregate to bond the aggregate to the netting and to coalesce with the asphalt membrane below from the previous coat. The resulting structure forms a monolithic sheet of water impervious lining over the supporting structure.

The supporting structure or surface over which this lining is applied is typically and most often a prepared ground surface, but it may be in some cases a smooth, rigid surface such as a concrete lining, especially when repair or rehabilitation of the concrete is desired. In order to prepare a ground surface properly, it is preferable to smooth the ground to some extent over the area to be covered in order to obtain a relatively smooth, regular surface by filling in cracks and depressions in eroded areas and then lightly compacting any filled areas in order to obtain a suitable surface. Next the ground surface is moistened. It is now ready for application of the asphalt emulsion, either before or after the netting is laid down.

It will be realized that in order to obtain a heavier or thicker lining, additional thickness of the lining can be obtained by repeating the above operations to build up the lining in successive layers to gain greater strength as in traffic areas, on a dam facing, or for any other reason. Also a similar effect can be achieved with but a single layer of the mesh but by applying a plurality of spray coats of the emulsion. In the event thta more than one layer of netting is used, each layer of netting is preferably substantially filled by the application of a layer of a finely divided rocky material, such as sand and the like in order to fill meshes in the opening of the netting before applying a coat of asphalt emulsion.

How the present invention achieves the above objects and advantages, as well as others not specifically mentioned, will be understood by reference to the following description and to the annexed drawing, in which:

FIG. 1 shows in perspective a portion of a ditch lined with a lining constructed according to the method of the present invention.

FIG. 2 is a fragmentary vertical section through a liner on the ground, showing one stage in the construction.

FIG. 3 is similar to FIG. 2, showing the liner completed.

FIG. 4 is a fragmentary vertical section through the liner showing one stage in the application of it to a hard, impervious surface such as a concrete foundation.

FIG. 5 is a view similar to FIG. 4 showing the liner completed.

Referring now to the drawing, and more particularly to FIG. 1, numeral **10** indicates the earth in which a ditch has been dug to the desired depth. The ditch, typical of any water channel or water holding structure of this character, is provided with a liner L which is waterproof and guards against erosion of the soil. The ditch is provided with sloping sides, as is customary with ditches or channels of this type. While this configuration is typical, it will be realized that the present invention is not dependent on any particular configuration of the water holding structure.

Since it is one of the particular advantages of the present method of constructing the liner that it may be applied directly to the surface of the ground, it will be described in such application to illustrate a preferred embodiment of the method and the liner produced thereby. For various reasons, it is obviously advantageous to prepare the surface of the ground in a manner to make it relatively smooth. Minor depressions, such as cracks, eroded areas, and the like, should be filled in order to produce a comparatively smooth surface. Since the lining produced is fairly uniform in thickness, and it conforms closely to the surface of the ground, any substantial irregularities in the prepared ground surface show up to some extent in the surface of the finished lining. Obviously, water flows more smoothly with less friction loss when the irregularities in the surface of the lining are minimized; although the character of the surface is for this reason of less consequence in the case of a reservoir where there is no movement of the water. In the preparation of the surface, it is preferable to compact the loose soil at least lightly as the compaction offers a better support for the ditch lining and reduces the likelihood of settlement or shifting of the soil which will produce a crack, as well as shaping the final surface more closely to the desired configuration or grade.

An optional preparatory step is to apply sterilants or weed poisons to the ground in order to prevent germination of seeds beneath the applied lining. This reduces the likelihood of the lining being punctured by any plant.

As an initial step in the application of the lining to the prepared ground surface at the canal, it is advantageous that the soil be dampened with water. This moisture reduces the surface tension between the soil and the asphalt emulsion applied thereto and permits the emulsion to flow out over the soil in a more uniform film without breaks or interruptions in it. This moistening also facilitates penetration of the soil by the asphalt-water emulsion and thus secures a better bonding of the completed lining to the soil base. Moistening can be carried on simultaneously with the application of sterilants or weed poisons since they are normally applied in aqueous solutions. Water need be added only as required and will vary in amount as the soil may already contain some moisture.

When the soil base **10** is prepared as just described, there results an upper supporting surface **11** of the soil which serves as the supporting surface upon which the water impervious liner is formed.

Although the sequence of steps in preparing the base can be varied, as subsequently described, it is preferred that the first step is to lay upon surface **11** a layer of netting **12**, as shown in FIG. 2. Netting **12** is formed from a coarse yarn woven with an open weave. This netting is previously impregnated with asphalt or other bituminous composition and allowed to dry. As a consequence, the impregnated netting is waterproof and bonds well with the asphalt emulsion applied to it.

The yarn from which the netting is made is composed of fibers, either natural or synthetic, hemp or jute being excellent natural materials. The yarn is loosely twisted and preferably has a diameter in the neighborhood of ¼ inch, more or less, but it is prefered that the yarn differ not more than 50% from the nominal diameter. Thus if the yarn is specified to be ¼ inch in diameter, the range of the twisted strand should be between ⅛ inch and ⅜ inch. Strands of smaller diameter than ⅛ inch do not provide the desired strength, and strands of larger diameter than the maximum are larger than necessary and tend to be imperfectly covered by a single coating of the asphalt, applied as described. Of course, more than one coating may be applied. The yarn is woven into a netting having an open mesh in which the size of the openings is preferably approximately ½ inch square, a range of openings from ¼ inch to ¾ inch being entirely suitable for the purposes of this invention, but this range is not necessarily limitative on the invention.

Initially netting **12** is simply laid over surface **11**. Wherever it is necessary to form joints in the netting, successive pieces of netting are overlapped with the upstream piece uppermost, if water is flowing in the canal or ditch. The successive pieces of netting are overlapped preferably by two or three inches. In the areas of overlap, as well as on slopes which are sufficiently steep to require the netting to be anchored in place, U-shaped wire anchors **14** may be driven into the soil to anchor the netting in place.

It has previously been mentioned that preliminary wetting of the soil may be desirable. If this has not already

been done, it may be done after the layer of netting **12** is in place as shown in FIG. 2. With the netting in place, there is then applied the first layer of the asphalt-water emulsion. This is an emulsion composed of finely divided asphalt suspended in a continuous water phase and stabilized by adding any suitable emulsifying agent, which agent may be any one of several widely known and commonly used in the industry. It is preferable that the asphalt be ground to as fine a size as possible, preferably such that the average particle size is of the general order of one micron or so, since this results in an emulsion which can be applied more evenly, thus achieving a more uniform coating. The asphalt used is preferably and typically one which has a high melting point, preferably in the vicinity of 150° F., but a range of 140° F. to 160° F. is quite satisfactory. A melting point in this range insures a minimum of sag in the asphalt at elevated temperatures which may be reached when the asphalt is exposed directly to the sun for a continued period of time, while at the same time retaining in the asphalt a desired degree of flow or resilience at lower temperatures in order to resist cracking. This flow in the asphalt permits the material to follow slowly any settling or shifting in the conformation of the underlying surface of the soil.

The first application of the emulsion of asphalt and water to the netting and the surface of the ground beneath the netting is preferably by spraying the emulsion in a uniform layer at the rate of one-half gallon per square yard of surface covered. When the emulsion is dried, it will be found that the layer of netting **12** is thoroughly bonded to the asphalt membrane produced and that the asphalt has also penetrated into the ground or substrate for a short distance, which zone of penetration is indicated at **15** in the drawing. Impregnation of the netting prior to application of the asphalt emulsion, as previously mentioned, facilitates formation of a strong bond between the netting and the asphalt applied by the spray coating. It also renders the fibers waterproof and preserves the netting against attack by fungus or bacterial action. This is of consequence in the case of natural fibers, like jute, as it greatly prolongs the life of the netting.

Penetration of the asphalt emulsion into the ground forms a bond between the netting and the ground surface **11**. Application of the asphalt emulsion at the rate of one-half gallon per square yard results in a layer or membrane of asphalt, when dried, approximately ⅛ inch thick, which is less than the thickness of the layer of netting **12**. A thinner initial asphalt layer may require the application of a second spray coating in order to build up to the desired thickness. A thicker single layer has no disadvantage except that it requires longer to dry and produce a continuous, cohesive membrane of asphalt over the ground to be covered.

After the first layer of asphalt has been sprayed over the netting, a layer of aggregate, such as sand or other finely divided rocky material, is spread over the netting. The application of such aggregate is at a rate sufficient that the openings in the netting are filled substantially to the depth of the layer of netting **12**. In other words, it is desirable to fill the openings to a depth of approximately ¼ inch or more. Since the average thickness of the netting layer is probably somewhat in excess of the nominal diameter of the yarn of ¼ inch, it will be found that with a netting having the specifications mentioned above, approximately one pound of sand per square foot of netting is required.

Ordinary sand is preferred and is entirely suitable for this purpose, but it is preferably washed in order to eliminate an undesirable percentage of clay. The sand may be relatively coarse, or even be a fine gravel, such as pea gravel, or a mixture of the two; consequently it may be defined as a finely divided rocky material or aggregate. This fine aggregate settles chiefly into the openings or meshes of the netting and some of it may become

more or less embedded in the emulsion already sprayed over the netting and on the ground.

The first sprayed coating of the emulsion is preferably, but not necessarily, allowed to dry to the extent that the emulsion has broken and the asphalt particles coalesced, before the application of the sand over the asphalt. This condition of the spray coating may be determined visually by the change in color from brown to black, the latter typically being the color of the asphalt. The length of time required for drying to take place depends upon several factors, such as the thickness of the applied layer, weather conditions, the amount of moisture previously applied to the soil, if any, and so on. However, under average conditions, the applied emulsion will have dried sufficiently in about one hour to permit the application of the second spray coating.

It is desirable that the sand be moist when the next coating of emulsion is applied. The sand may be moist when spread over the netting; or dry sand may be spread and then water added. The quantity of water should be sufficient to moisten substantially all sand particles. The purpose is to insure that the next coat of emulsion penetrates the sand and coalesces with the subjacent asphalt membrane previously laid down, thereby producing a fully integrated, unitary product.

Now, a second coat of the asphalt-water emulsion, similar to the first coat, is sprayed over the netting and the moist sand layer that fills in the mesh openings. This ultimately builds up a smooth coating of asphalt over the netting, shown at **16** in FIG. 3. This second coating is similar to the first one, and is also preferably applied at the same rate of one-half gallon per square yard of surface covered. The second layer increases the total thickness of the lining by another ⅛ inch. Since the openings in the mesh and small irregularities in the netting have been generally filled and smoothed out by the body of sand, the asphalt at **16** is mostly above the reinforcing mesh; but it will be realized that the thickness of the ultimate asphalt coating varies at different points on the mesh. The last applied emulsion bonds to the upper fibers of the netting and also saturates the sand in the openings in the mesh, thus bonding together securely all the material already laid down.

After drying for approximately three days, the lining L may be considered as completed. It is then sufficiently hardened to be subjected to water and normal usage. When completed and viewed in cross-section, the liner L appears as in FIG. 3, although it will be realized that the drawing is somewhat idealized in showing different layers of the asphalt more or less sharply defined and separate from the mesh. Actually, the netting, the sand, and the asphalt are bonded all into a unitary, continuous liner resting upon surface **11**, and yet the liner is also bonded to the soil because of the penetration of the asphalt into the soil for a slight distance, as indicated at **15**.

The lining L produced by the method described above is a continuous, monolithic sheet of asphalt with a sand filler and a central reinforcing provided by the fiber netting. The final structure resulting from the method first described is normally in the range of ⅜ inch to ½ inch thick, depending upon the exact rate at which the emulsion is applied, how evenly it is applied, and various other factors. This is a satisfactory thickness to develop all of the advantages in the invention, including strength, flow to adapt itself to the underlying surface, and resistance to weathering and erosion. However, in any areas, either general or local, where additional strength or resistance to traffic wear or erosion are desired, additional thickness may be easily obtained by applying either more layers of asphalt or an additional layer of netting along with the third or more coating of the asphalt emulsion, as described.

When it is desired under some circumstances to build up a thicker and therefore heavier and stronger lining for large canals, reservoirs, dams, or areas where traffic

is heavy, this may be done by repeating the above described operations. Emulsion is sprayed over lining L, followed by a second layer of netting with mesh openings which are subsequently filled with moist sand as previously described. This netting and the sand are added after the last layer of asphalt emulsion has broken to form a membrane that bonds to the asphalt below. After the last spray coat is adequately dried, another spray coat of emulsion is sprayed over the second layer of netting and sand, forming a continuous coating over the entire structure, as already described.

The structure produced has sufficient elasticity to follow the contours of the ground after it hardens and thus avoids cracking or breaking as a result of any subsequent settling of the underlying soil. The fibers of the netting are located centrally in the liner where they are protected against deterioration from exposure to sun and air or by bacterial action and afford a flexible, pliable reinforcement which not only strengthens the asphalt lining in a manner to make it more resistant to cracking and breaking but should any such cracks occur, the reinforcing action of the netting prevents chunks or pieces of the asphalt from breaking down. Thus water flowing through the canal is not able to penetrate beneath the cracks and scour away the soil underneath. Obviously, such action would result in heavy damage to the canal in a short time and is to be avoided.

One of the advantages of the present invention is that the lining may be satisfactorily applied to a rigid surface, such as a concrete wall or lining for a reservoir or canal. The asphalt bonds adequately to the concrete and provides a water impervious coating or lining over the concrete structure which prevents loss of water by penetration through the concrete or at the joints which almost always are formed in the concrete structure itself.

When the asphalt layer is placed over a concrete base or foundation, the lining appears as in FIGS. 4 and 5. In this case the concrete base **20** affords a smooth, hard surface **21** over which netting **12** is laid. Ordinarily, anchor means, such as U-shaped pins **14**, are not applied, although any other suitable anchor means may be used in the event that surface **21** is sufficiently inclined to warrant such anchor means. However, in the area of overlap of successive pieces of netting **12**, it is usually desired to secure two pieces of netting together by the use of iron rings **24**, as shown in FIG. 4.

After the netting is in place, it is sprayed with the first coat of emulsion which is followed by the application of moist sand as previously described. Finally, the second coat of emulsion is applied, producing the upper layer of asphalt **26**, as shown in FIG. 5 which illustrates a section through a completed structure.

One of the advantages of the method described of laying down the netting prior to the application of any emulsion is that this eliminates the necessity for walking over the membrane formed by a first coat of emulsion. Walking on the weak membrane, especially before it is dry, is, of course, liable to interrupt its continuity because of the lack of strength; also the coating tends to stick to the workmen's shoes, pulling away from the ground. However, in my parent application referred to above, an alternative method of laying the lining is disclosed in which the first layer of emulsion is applied to the supporting surface **11** or **21**, as the case may be, and allowed to dry, after which the netting **12** is laid over the asphalt emulsion and subsequently filled with sand. From here on the method of forming the lining is the same as already described since it now may be completed by the addition of a second coating of emulsion.

From the foregoing description, it will be realized that various changes in the exact procedures and sequence of operations may occur to persons skilled in the art, without departing from the spirit and scope of my invention. Accordingly, it is to be understood that the foregoing description is considered as being illustrative of, rather than limiting upon, the invention as defined by the appended claims.

I claim:

1. The method of forming a waterproof liner over a surface, that includes the steps of:
- laying over the surface to be covered a netting of open mesh providing openings of widths substantially no smaller than one-fourth of an inch and being made from organic vegetable fibers;
- applying to the netting an emulsion of asphalt and water to bond the netting to said surface;
- spreading a layer of sand over the netting to a depth to substantially fill the openings in the netting;
- and finally applying to the netting and the layer of sand an emulsion of asphalt and water in sufficient quantity to form a non-porous asphalt liner in which the sand and netting are embedded.

2. The method according to claim **1** in which the openings in the mesh are substantially one-half inch in size.

3. The method according to claim **1** in which the sand is applied after the first coat of emulsion has broken and formed an asphalt membrane.

4. The method according to claim **1** in which the netting is woven from yarn having a nominal diameter of ¼ inch and the liner is built up by successive asphalt coatings to a thickness of at least approximately ⅜ inch.

5. The method according to claim **1** in which the waterproof liner is formed over a ground surface which is part of a canal, reservoir, dam or the like and the first emulsion coat is applied in quantity sufficient to penetrate into the ground beneath.

6. The method according to claim **5** in which the surface to be covered is first moistened.

7. The method of forming a waterproof liner over a surface, that includes the steps of:
- laying over the surface to be covered a netting of open mesh providing openings of widths substantially no smaller than one-fourth of an inch and being made from fibers impregnated with asphalt;
- applying to the netting an emulsion of asphalt;
- substantially filling the openings in the netting with moist sand;
- and finally applying to the netting and the sand an emulsion of asphalt and water in sufficient quantity to form a non-porous asphalt liner in which the sand and the netting are embedded.

8. The method of forming a waterproof liner over a surface, that includes the steps of:
- laying over the surface to be covered a netting of open mesh providing openings of widths substantially no smaller than one-fourth of an inch and being made from organic fibers;
- applying to the netting an emulsion of asphalt and water;
- spreading over the netting a layer of finely divided aggregate of sizes no larger than the openings of the netting to substantially fill the openings in the netting;
- moistening the aggregate;
- and finally applying to the netting and the layer of aggregate an emulsion of asphalt and water in quantity sufficient to form a non-porous unitary liner in which the aggregate and netting are embedded.

9. The method of forming a waterproof liner over a ground surface, that includes the steps of:
- laying a netting of open mesh providing openings of widths substantially no smaller than one-fourth of an inch directly on the ground surface to be covered;
- applying to the netting and the ground beneath a liquid at ambient temperature containing asphalt in a liquid carrier in a quantity to produce a continuous asphalt membrane of non-porous character about one-eighth inch thick;

spreading sand over the netting and asphalt membrane to a depth sufficient to fill the openings in the mesh; and finally applying over the sand a second coating of said liquid at ambient temperature, in quantity to embed the sand and netting and produce a unitary, continuous, non-porous liner over the ground surface when the second coat has dried.

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