Feb. 9, 1943. A. E. BROOKS ET AL 2,310,391

ABSORPTIVE MOLD LINING

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Fig. 1

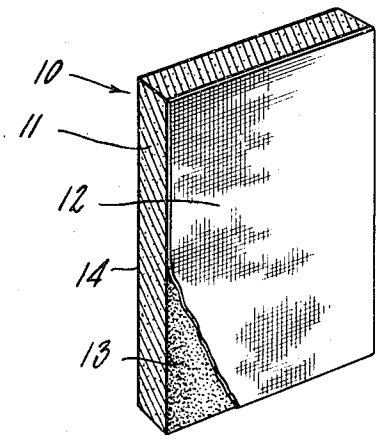


Fig. 3

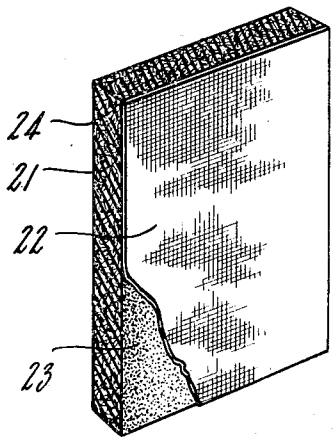
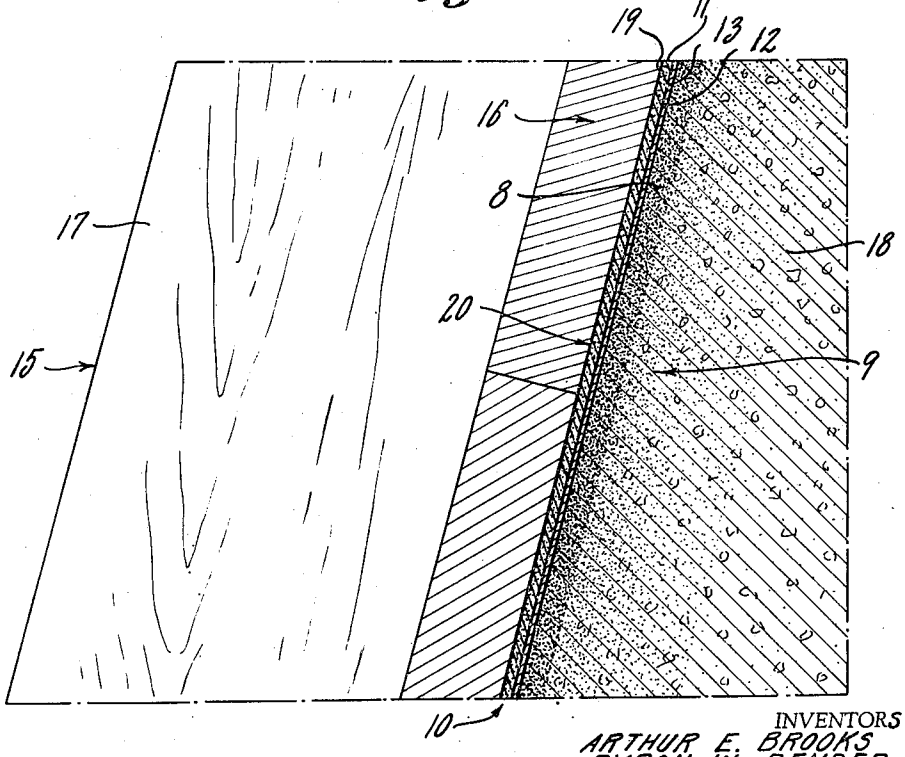


Fig. 2



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Fig. 4

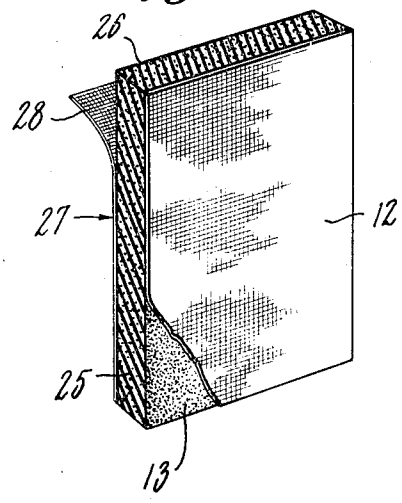


Fig. 5

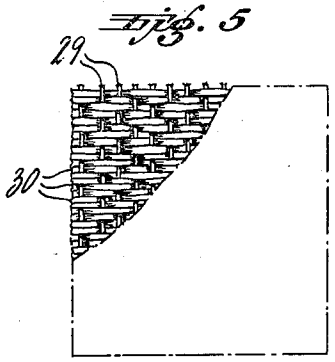


Fig. 6

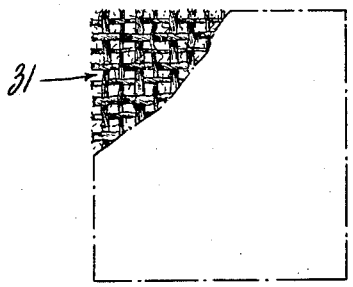
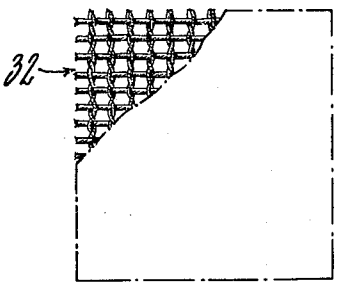


Fig. 7



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Patented Feb. 9, 1943 2,310,391

UNITED STATES PATENT OFFICE

2,310,391

ABSORPTIVE MOLD LINING

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Application June 28, 1941, Serial No. 400,238

15 Claims. (Cl. 25—122)

This invention relates to the fabrication of structures made of concrete and the like, and especially to molds and forms for use in the pouring or casting of such structures. More particularly, the invention relates to linings and lining materials for use upon the inner faces of such forms for producing smooth, hard, durable finished surfaces upon the exterior or exposed faces of the concrete structures cast or formed thereagainst.

The present application is a continuation-in-part of our application, Ser. No. 341,890, filed June 22, 1940.

In the casting or pouring of concrete foundations, dams, abutments and similar structures, it is very desirable that the exposed or external surfaces of the concrete be as hard, smooth and durable as possible. These qualities in concrete become particularly important in flumes and spillways where silt laden water, striking surfaces of the concrete at high velocities, produces excessive abrasive wear thereon.

One of the most common surface defects observed in cast concrete structures is a pitting of the surface. This pitting is believed to be caused by inclusions of air or water which have been entrapped in the concrete mix. During the vibration of the wet mix, these inclusions tend to collect on the inner surface of the form, and appear as voids in the concrete surface after the forms have been removed from the set concrete. There also seems to be a tendency for excess water to collect at the interface between the form and the concrete mix. The presence of this excess water during the hydration of the cement is believed to reduce the hardness of the surface.

Considerable attention has been directed toward developing means for eliminating these defects in concrete. It was early believed that the pitting due to air bubbles could be eliminated by providing between the form and the wet concrete mix a layer of material which would be pervious to air and impervious to cement particles, the idea being that the entrapped air would find its way through the pervious layer and escape upwardly between the pervious material and the form itself. This air-pervious material took the form of closely woven fabrics of wire, or of textiles which had been treated to render them non-absorbent of water. Many variations of this expedient have been tried, but while they have served in a measure to eliminate some of the defects due to air bubbles, they have not been widely adopted because of the failure to obtain with any of them consistently a smooth, wrinkle-free surface on the concrete.

Another attempt to reduce the formation of air bubbles involved the use of a piece of ordinary metal fly-screen covered with muslin. This was placed in the form with the cloth next to the concrete, and the wire screen next to the wooden form. This method did eliminate much of the pitting due to air bubbles but was considered too cumbersome for practical use.

Another proposed method of eliminating surface defects due to air bubbles was to use as a form lining an air-permeable absorptive material, such as a relatively inflexible fiberboard made from bagasse fiber, straw fiber or wood fiber. Such absorptive materials are sold as insulating or wallboards, and are commonly between one-quarter and one-half inch in thickness. For use as cement form linings these absorptive boards have certain objectionable features. There is a tendency of their surfaces to bond to the concrete, which not only makes it more difficult to strip the form lining from the cement, but in addition may result in small pieces of fiber being left embedded in the concrete surface. These embedded fibers detract from the appearance of the concrete and have a tendency to reduce the resistance of the surface of the concrete to abrasion. Attempts have been made to reduce this bonding by suitable surface treatment of the fiberboards, as by ironing or sizing the surface. The use of loose sheets of muslin in combination with thick absorptive fiberboard does eliminate the problem of bonding, but is not entirely satisfactory, due to the practical difficulties involved in the handling of large strips of loose cloth.

In an effort to develop a form lining which would be free from the objections raised against those of the prior art, we have invented a new and improved type which comprises as a facing element an absorptive textile fabric suitably adhered to a basic absorbent element which includes an absorptive flexible porous backing having a high wet strength. We have found that an absorptive textile fabric such as muslin, fine-woven rayon, or burlap, may be adhered to an absorptive porous material, such as a porous paperboard or microporous rubber, without materially decreasing the permeability of the fabric to air or water, and without materially decreasing the absorptive capacity of the porous backing.

In order to obtain proper pouring and compacting of a concrete mix, it is necessary to add water in excess of that required for the chemical hy-

dration of the cement. The linings of the present invention are such that from the concrete poured next to the lining they absorb much of this excess water, and thereby a concrete with harder, more durable, abrasion-resistant surfaces is obtained. The porous form linings of this invention are characterized by flexibility and by resistance to tearing, swelling or shrinking upon contact with water. These properties are valuable in form linings because they facilitate handling in the field and more readily permit fitting to irregular form surfaces. They also retain their original dimensions while wet and during the setting of the concrete and thus contribute to the formation of hard, durable, smooth finished concrete surfaces free from pits and cavities or marks which might otherwise result from wrinkling of the linings used.

The critical factors involved in preparing a suitable form lining in accordance with our invention may be enumerated as follows, with particular reference to the three essential components of our lining:

A. The Facing

The facing of the form lining is that portion of the lining which is ultimately to come in contact with the concrete. Our experience has shown that a satisfactory facing must meet certain criteria. First of all, it must not bond to the finished concrete. This is to enable the lining to be easily stripped from the cast concrete and to avoid leaving portions of the facing adhered to the surface of the finished concrete. As a corollary to the first criterion, the facing should have a high dry-and-wet tensile strength. The facing must also be water-permeable, and the material of which it is composed should be water-absorbent. We have found that fabrics woven or knitted from fibrous water-absorbent textiles, such as cotton, linen, rayon, hemp, jute, paper fiber, and the like, possess the properties requisite for a successful facing. Contrary to what might be predicted from what has been believed and taught in the prior-art, facings composed of fabrics fabricated from materials which are not water-absorbent or water-permeable, or which have been treated so as to render them non-absorbent or impermeable to water, are not suitable. Such materials as finely woven wire fabric or oil-impregnated cloth do not make satisfactory facings on form linings made according to our invention. The use of such facings greatly impairs or destroys the ability of the composite form lining to eliminate pitting due to inclusions of air and water trapped between the concrete and the form lining. The use of such facings also reduces the ability of the form lining to "case harden" the concrete by withdrawing water therefrom during pouring and vibrating.

Furthermore, contrary to what has been indicated by the prior art, it is not necessary that the facing be closely woven. We have made satisfactory form linings, using as the facings thereof such coarsely woven materials as burlap and square-woven paper-fiber cloth. Cement blocks cast against these form linings show an increase in surface hardness and freedom from surface defects, similar to the improvement shown by blocks cast against a form lining faced with more closely woven fabrics, such as muslin or rayon sheeting.

Provided that it possesses the requisite properties of strength, permeability, and absorptiveness, the choice of the fabric to be used as the facing of our form lining will be governed by the texture desired in the concrete surface. By the choice of suitable fabrics, a wide range of attractive surface textures may be obtained.

B. The Adhesive Layer

It is an important feature of our invention that the facing should be adhered to a porous absorptive backing. To be suitable, the adhesive should be water-insoluble and should not be affected by alkaline aqueous solutions. The adhesive bond between the facing and the backing should also be sufficiently stronger than any temporary bond between the concrete and the facing, so that when the form lining is stripped from the concrete, the facing will be removed with the form lining. The adhesive layer should be so applied as to reduce the over-all water absorption of the composite form lining as little as possible. This latter precaution is necessitated by the fact that our form lining functions to remove excess water from the layer of wet cement adjacent the lining, by the cooperative action of the permeable facing and the absorptive porous backing. An impermeable adhesive layer would therefore defeat the whole purpose of the lining.

We have found that we can obtain satisfactorily such a permeable adhesive layer by spraying one surface of either or both members with a liquid adhesive in such a manner that the adhesive does not form a continuous film, but is deposited in the form of discrete droplets. Suitable liquid adhesives include solutions of water-insoluble adhesive materials, such as resins, asphalt, or natural or synthetic rubber, in volatile organic liquids, or aqueous dispersions of such materials. We have found that one of the best adhesives for our purpose is a natural rubber latex which has been concentrated so as to have a total solids content of between 55 and 65%. To guide the operator in spraying the adhesive on the fabric facing and absorptive backing, we have found that it is a good idea to pigment the latex, as by adding a small amount of a carbon-black dispersion. When the facing and backing are both white or light colored, one can then tell from the relative grayness of the sprayed material just about how much of the adhesive has been applied, and the operator can thus avoid applying too much adhesive and thereby injuring the porosity of the adhesive layer.

A similar technique may be employed in using any of the suitable fluid adhesives enumerated previously.

The two surfaces, to at least one of which the adhesive has been applied, may be united by bringing them together and applying a slight pressure as by passing the facing and the backing between rolls.

C. The Absorptive Packing

The usefulness of the complete form lining will depend to a very large extent upon the nature of the absorptive backing. We have found that to be suitable for use as the backing of our form lining, an absorptive material must have an absorptive capacity sufficient to absorb not less than .05 lb. of water per square foot. Preferably the backing should be capable of absorbing between 0.1 and 0.4 lb. of water per square foot. Not only must the absorptive capacity of the backing be sufficiently high, but it must absorb rapidly enough so that the maximum absorption is reached in six hours or less. In addition to its water-absorbing properties, a satisfactory back-

ing must possess other physical characteristics. A suitable backing should preferably be somewhat flexible, so that the finished form lining may be easily bent to any shape necessary to conform to the contours of a concrete form. A satisfactory backing must have a fairly high wet and dry tensile strength to reduce the likelihood of its being torn during use. The backing material may have sufficient strength in its own right, or it may be treated in such a way as to increase its strength without detracting too much from its absorbent character. As an alternate method, the absorptive backing may be reinforced by a backing layer or stratum or higher-tensile-strength material which need not itself be absorbent.

Among the materials which possess the requisite properties of strength, flexibility, and absorbent character are various water-laid fibrous sheets, having a thickness of not less than 1/32 of an inch and composed in whole or in part of natural cellulosic fibers. Such fibrous materials may properly be described by the generic term "absorptive papers." The choice of any one material from this class, provided that its physical properties are suitable, will be governed primarily by questions of cost and availability. Paperboards having suitable physical properties are available to the trade under such names as chipboard, newsboard, unsized mounting board, bending chipboard, and kraft board. To the general public, these materials are commonly known as cardboard, and this term, when used in the description of our invention, is to be so interpreted.

Other types of absorptive paper which, upon test, exhibit the above desired properties for the intended use, are therefore suitable for our purpose, although not commonly included within the term "cardboard."

An example of another type of absorptive paper suitable for our invention, and not embraced within the term "cardboard," is the latex-bonded fibrous sheet material made by impregnating a highly absorptive paper sheet with a dilute rubber latex, coagulating the rubber in the latex, and drying the sheet. Such a material has a high degree of flexibility, a high wet and dry strength, and adequate water absorption.

A porous absorptive material which is suitable for our invention, though not of a fibrous nature, is microporous rubber, which possesses the necessary properties of flexibility, wet and dry strength, and adequate water absorption. Microporous sheet rubber similar to that described in the recently issued patent to A. E. Brooks No. 2,185,586, may be used advantageously as the absorptive backing for a form lining made in accordance with our invention.

Although we prefer to use as our backing or body material a flexible porous sheet, we may use relatively inflexible porous absorptive fiberboards, such as are known by the trade names of "Celotex" and "Firtex," and obtain an improved form lining which, though it has a lower flexibility and higher cost than our preferred lining, is still an improvement over linings that have previously been used. In general, the desired property is that of conformability to the supporting structure associated with the required absorption characteristic.

Because of the novelty of our form lining, we have found it advantageous to develop certain new methods of attaching the form lining to the face of the concrete form proper. Concrete forms are commonly constructed of wood, and it has been the practice when using thick, relatively inflexible absorptive fiberboards, such as are sold under the trade names "Celotex," "Firtex," and "Masonite," as form linings, to attach the sheets of these materials, which are commonly between 1/4" and 5/8" in thickness, by nailing or stapling them to the face of the wooden form. While such methods will serve in attaching our preferred form lining to the inner faces of wooden forms, we have found that to realize all of its potential advantages it is desirable to attach the form lining to the form by means of a suitable adhesive. In commercial use, form linings are apt to be rained on or otherwise subjected to water before being placed in contact with the concrete mix. It is therefore desirable that the adhesive should not be water-soluble.

In practical cement work it is often desirable to be able to use the forms several times. Consequently the adhesive applied between the forms and the form lining should be such that the lining can be stripped cleanly from the form. This places a further limitation upon the nature and magnitude of the adhesive bond between the form lining and the form. This limitation can best be expressed by stating simply that the strength of the bond between the adhesive layer and the form shall be less than that between the adhesive layer and the form lining, and also less than the delaminating strength of the form lining.

We have found that, by using a concentrated rubber latex as the adhesive, we can satisfactorily meet these requirements. The latex may be applied to the surface of the form and to the back of the lining by any convenient method. The dried latex films will then adhere to each other when placed in contact. In case the adhesive layer sticks too well to the wooden form, so that all or part of the adhesive is left on the form when the form lining is stripped off, the form itself may be treated to reduce its adhesion to the rubber layer by coating the form with a thin layer of paint, lacquer, or a wax emulsion before applying the latex adhesive.

Although rubber latex is our preferred adhesive, we have found that we can obtain satisfactory results with artificial dispersions of crude or reclaimed rubber, or with dispersions of other adhesive materials such as resins, asphalts, and the like.

We have found that it is sometimes desirable to coat the back of the form lining with a pressure-sensitive adhesive which, when dry, can be made to adhere to the wood or metal form by the application of pressure. Several pressure-sensitive adhesives are known to the art. A suitable one for our purpose is an aqueous dispersion of a mixture of reclaim rubber and cumar resin. The advantage of the use of a pressure-sensitive adhesive is that the form lining may be supplied to the ultimate user with the adhesive layer already applied, and protected by a readily separable material such as holland cloth.

The invention will be more readily understood from the following description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 illustrates in perspective a portion of a lining made in accordance with our invention;

Fig. 2 is a vertical sectional view showing a portion of a concrete dam or similar structure, employing the lining of Fig. 1 between the poured concrete and the form;

Fig. 3 is a view in perspective of a portion of a modified form of lining;

Fig. 4 is a perspective view of a portion of another modified form of lining; and

Figs. 5, 6 and 7 are face views of various modified forms of lining.

Referring more particularly to Fig. 1 of the drawings, we show a portion of lining material **10** for use on forms for casting concrete and like structures, comprising a highly absorbent backing or body layer **11** of porous, fibrous sheet material, which may be formed of any of a wide variety of desirable and suitable absorbent substances, such as chipboard, newsboard, unsized mounting board, bending chipboard, or kraftboard; or an absorptive paper, a latex-bonded fibrous sheet, or a microporous rubber sheet; upon one face of which is adhered a porous, absorbent facing layer **12** of any suitable material substantially nonadherent to concrete.

Fabrics, woven or knitted from a fibrous yarn or threads, or from filaments, such as cotton, linen, rayon, silk or hemp, jute, paper fiber, or the like facing layer **12**, may be integrated with the absorbent body layer **11**, as by an adhesive layer **13** between the body layer and facing layer, to constitute a unitary structural element **10**, the adhesive bonding layer **13** being water-permeable and composed preferably of solids deposited from an aqueous dispersion of rubber, in discrete particles, and of such character that a comparatively strong and permanent union is effected between the layers without materially diminishing the permeability of the lining material.

The lining element **10** may, if desired, be provided on its rear face with a layer of material having high wet-strength, high tear-resistance properties, but of relatively lower absorbent capacity, such as kraft paper, book paper, cloth or the like, as indicated at **14** in Fig. 1. This layer is not essential to the successful practice of the invention, and in Fig. 2 the lining **14** is omitted.

Fig. 2 illustrates the use of the absorbent liner or element **10**, of Fig. 1, disposed upon the inner face of an upright form **15** made of transverse wooden planks or strips **16**, mounted on upright studs **17**, for confining the plastic concrete mass **18** in proper position until the concrete has attained sufficient rigidity to retain its intended shape. The lining **10** is shown as attached to the face of the form elements **16** by means of a secondary bonding layer **19** which may be of the same nature as the primary bonding layer **13**, but need not be permeable to water.

The bonding layer **19** may, as illustrated, be applied to the inner face **20** of the planks **16** before the lining **10** is installed, or provision may be made of such a secondary bonding layer **24** as part of the structural element constituting the liner, (see Fig. 3) making use of any suitable adhesive, such as an adhesive activated by heat, or one adapted to be activated by a suitable solvent.

The material of the absorbent body layer **21** in Fig. 3 is made up of latex-impregnated fibers, and the facing **22**, of rayon taffeta sheeting, finely woven, is integrated with the body layer of absorbent material **21** by a permeable adhesive **23**.

In Figs. 1 and 3 it will be noted that the thickness of the body layer **11** and other layers is considerably increased over its natural size, for the sake of clearness in illustration, a preferred thickness of the layer **11** or **21** in practice ranging from $\frac{1}{32}$'' to $\frac{3}{32}$'', for reasons which will be set forth at length hereinafter. Accordingly, the thickness of the lining element **10** in Fig. 2 may be regarded as more nearly of actual size, while the planks **16** and studs **17** are disproportionately small. The lining **10**, thus positioned on the form, serves to remove excess water from the layer of plastic concrete adjacent to the face of the form lining. The form lining functions in this way, by withdrawing excess water through the wick-like action of the porous and absorbent facing **12** into the absorbent body layer **11**, so that the cement-to-water ratio in the adjacent concrete is increased, thereby resulting in a surface of increased hardness free from pits or imperfections caused by the presence of water or air inclusions. It should also be noted that applicants' linings possess the quality of retaining a sufficient amount of moisture within the lining to prevent drying out of the surface of the concrete before proper chemical hydration has taken place, and, accordingly, better and more uniform quality of concrete can be produced than in cases where the surfaces of the concrete are allowed to dry out rapidly.

Fig. 4 of the drawings shows a perspective view of a portion of a modified form of lining, which comprises a fabric facing **12**, a water-insoluble, water-permeable adhesive layer **13**, a porous absorptive body layer **25** of microporous rubber material, and a layer **26** of a pressure-sensitive adhesive. At **27** we have shown a layer of sheet material, such as holland linen, held by the adsive layer **26**, which it protects during handling, and from which it can be readily separated by pulling it away as indicated at **28**.

Figs. 5, 6 and 7 show face views of various form linings in which the relative fineness of the weave of the facing material is shown roughly to scale, thus exemplifying the range of fabrics suitable for our invention.

Fig. 5 shows a facing material made of jute warps **29**, and paper yarn weft **30**. Fig. 6 shows an open mesh burlap **31**. Fig. 7 shows a cotton leno weave fabric **32** of the order of 8 mesh.

The method of fabricating linings in accordance with our invention, and the benefits to be derived from the use of our lining, will be made more clear by a consideration of the following example:

Example

An absorbent form lining (as **10**, Fig. 1) was prepared, using as the facing **12** an 80 x 80 count muslin sheeting. This cloth had been de-sized and boiled off to remove the natural waxes and to increase its water absorption. The body layer **11** was a 60-gauge absorptive chipboard, weighing 0.2 lb. per square foot. One surface of the backing and one surface of the facing were sprayed with a 55% solids rubber latex which had been colored with 1% of carbon black. The amount of latex adhesive applied was sufficient to leave about 0.1 oz. of rubber per square foot of surface on both faces, so that the total rubber **13** would be 0.2 oz. per square foot of lining. The adhesive-coated surfaces of the facing and the backing were then placed in contact and pressed together by passing them between closely spaced rollers. The resulting form lining **10** had an absorptive capacity, measured against a standard concrete mix, of 0.4 lb. of water per square foot of lining, and absorbed this amount of water in between one and three hours. The muslin **12** alone had an absorptive capacity of about 0.03 lb. of water per square foot.

A portion of this form lining was attached to the inner face **20** of a conventional wooden form **15** by spraying the face of the form and the back

of the form lining with a rubber-latex adhesive, and then rolling the lining down on the face of the form. A retaining wall was made by casting against the form, thus lined, a conventional concrete mix 18 containing the usual proportions of Portland cement, sand, coarse aggregate, and water. The wet concrete was vibrated in the conventional manner while the form was being filled. At the same time a section of the form to which the lining had not been applied was similarly filled with a portion of the same concrete mix, using the same technique. When the forms were removed, after the concrete had undergone the necessary curing, our lining 10 stripped easily from the concrete, and it was observed that the surface cast against it was predominantly void-free, lacking any substantial pits, and had an even surface texture corresponding to the texture of the muslin facing. The surface was also found to have undergone a sort of "case hardening," in that it was denser and more resistant to abrasion than was the surface cast against the wooden form alone. The void-free zone, as indicated at 9 in Fig. 2, included the surface 8 of the concrete mass and extended for a substantial distance from the surface into the concrete mass, say two inches, as indicated.

On the other hand the surface cast against the wooden form was not only softer but it contained a very large number of pits, ranging in size up to over ¼" in diameter.

To demonstrate more clearly the advantages of the "case-hardening" effect produced by our form lining, we made a series of 3-inch cubes, some in plain wooden forms, lined with the absorptive fiberboard known as "Celotex" without a cloth facing adhered thereto, and some in forms lined with our form lining. All the blocks were made with the the same concrete mix and according to the same technique. After being removed from the forms, the blocks were allowed to cure two weeks at 100% humidity in the conventional manner. After curing, drying, and weighing, each block was placed in a one-gallon ball mill together with 7 lbs. of ¾" flint pebbles, and the ball mills were rotated at 80 R. P. M. for two hours. The blocks were again weighed after removal from the ball mills. The blocks cast against wood had lost, on the avorage, 11% of their original weight. Those cast against "Celotex" had lost 4.4% of their original weight, whereas the blocks cast against our improved lining had lost only 2.2% of their original weight.

A further indication of the advantages of the "case-hardening" effect produced by our form lining may be obtained by measuring the water absorption of blocks cast against our lining. The water absorption of a concrete block is an indication of its porosity and, hence, may be taken as a measure of the density and strength of the block, a high water absorption indicating low density, and vice versa. Blocks cast against our form lining and blocks cast against wood were soaked in water for ten hours, wiped dry, and weighed. Those cast against our lining had absorbed only 5% water, while those cast against wood had absorbed 8%.

The effectiveness of our form lining in increasing the strength and density of concrete is not confined to the surface of the concrete, although the effect is greatest at the surface. To determine the depth to which the "case-hardening" effect is effective, an experiment was carried out in which a cement mortar was cast against a sheet of our form lining, and sections were taken at various depths from the form lining; and after curing at 100% humidity and drying, the water absorptions of these various sections were measured. The results showed that the minimum water absorption occurred at the surface cast in contact with the lining and was equal to about 5.7%. Within the first half-inch from the lining, the water absorption had risen to 6.75%. From there on, the water absorption rose gradually until, at a distance of 2 inches from the lining, it had reached a value of 7.7%, which is somewhat below the water absorption for a block of the same mix cast against wood or metal. One may consider the density and strength of the cured mortar as being an inverse function of its water absorption, so we can see that the "case hardening" due to the lining is effective up to a depth of at least 2 inches.

In order to get a better understanding of the physical action whereby our form lining improves the surface of cast concrete, as determined either by surface hardness or freedom from pitting due to inclusions, we have carried out a series of experiments in which small sections of our form lining were adhered to the center of metal plates which were larger in area than the samples of lining, and concrete blocks were cast against these plates. The samples of form lining were removed at successive intervals of time, and the amount of water absorbed per unit area determined. It was found that by the end of three hours the lining had absorbed the maximum amount of water—0.4 lb. per square foot. After the initial three-hour period the concrete began to absorb water from the lining, so that at the end of 18 hours the water content of the lining had dropped to 0.2 lb. per square foot, and at the end of 72 hours its water content had dropped to 0.14 per square foot. It was further observed that, whereas the sections of the blocks which had been cast against the form lining were all dense, being even in texture and free from surface pits, the surrounding sections which had been cast against the metal were not only softer but were badly pitted as well.

These results indicate that our lining functions to eliminate air pits, not by allowing the air to escape through the lining, since under the conditions of the above experiment this would be obviously impossible, but rather through some physical action dependent upon its absorptive capacity.

While we do not wish to be held to any particular theory as to the mode of operation of our lining, we believe that the following explanation is consistent with the facts as presented above. Due to its absorptive nature, the lining absorbs water from the wet cement while the cement is still in a highly plastic condition. As a result of this absorption of the water by the lining, the cement mix adjacent the lining becomes more compact and denser. This forces any air bubbles toward a less dense or less compact portion of the concrete mix. The vibration of the cement during pouring will facilitate the migration of the bubbles. Consequently, whenever air bubbles are present in the cement, they would tend to be localized at some distance from the form lining. It is also likely that a great deal of the elimination of air bubbles is due to the fact that, when air bubbles are formed at the junction of the top surface 8 of the concrete and the form lining during vibration and pouring, the lining tends to remove water from the film surrounding the air bubble, with the re-

sult that the bubble breaks before the concrete being poured can flow up around it and fix it in position against the form lining. This latter effect has actually been noticed in the casting of concrete against our form linings.

It should be emphasized that the cloth facing does not in itself have sufficient absorptive capacity to function in a satisfactory manner as a form lining, and this we have verified by casting concrete blocks against a sheet of the facing used in the example, backed up with a layer of relatively non-absorbent material, such as wood or metal.

The cloth facing, as mentioned above, serves two functions: it acts as a sort of wick to transmit water from the cement mix to the absorptive backing, and it also serves to reinforce the lining and to prevent the lining from bonding to the concrete. The chipboard backing 11 of the example, will not alone function satisfactorily as a form lining, since if it is used to line the form, the concrete will bond to the chipboard, so that when the lining is removed, small pieces of the lining will be left adhered to the concrete. This results in an unsightly and weakened surface.

Other facings which have been substituted for the 80 x 80 count muslin used in the example are as follows: (Fig. 3) 60 x 130 count rayon-taffeta sheeting; (Fig. 6) 6-oz. burlap; (Fig. 7) an 8-mesh cotton leno weave; and a woven fiber having jute warp and a paper-yarn filler (Fig. 5).

The methods of preparing these linings were identical with those appearing in the example, and the concrete surfaces cast against them were all hard and free from surfacee defects. They differed only in the texture of the surface. In each case this texture corresponded to a negative of the fabric facing. The use of a very open fabric, such as the leno weave, gives a very desirable, roughened surface which is especially fitted for use in casting interior walls over which it is desired to plaster, since the protuberances, corresponding to the openings in the cloth of the form lining, provide an anchorage for the plaster coating. The following materials have been found satisfactory as substitutes for the chipboard used in the example:

1. Various absorptive cardboards or absorbent paper.

2. Microporous rubber sheeting, approximately 70 gauge, made according to U. S. Patent No. 2,185,568, and having a water absorption of .05 lb. per square foot (see Fig. 4).

3. A latex-impregnated paper, known to the trade as "774–A Lexide," having a dry gauge of 55 and an absorptive capacity equal to 0.14 lb. per square foot, as shown in Fig. 3.

In addition, there may be substituted for the chipboard used in the example such materials as "Cellotex," "Firtex," or other types of fibrous building boards having relatively high-water-absorption. Our experience has shown that only the first ⅛ inch of any of these materials is effective in absorbing water from wet concrete. Consequently, the additional thickness of such materials as "Celotex," "Firtex," etc., when used as a component of our improved form lining, has no effect on the water-absorption properties of the lining, but serves only to give increased strength and rigidity.

From the foregoing it can be seen that by the use of our form lining, which comprises in combination an absorptive textile fabric facing, a water-insoluble, water permeable adhesive layer, and a porous absorptive backing, very much improved cast concrete surfaces can be produced which are free from defects commonly associated with such surfaces. The surfaces made against a form lining of our invention are not only uniform in appearance, but are also hard and durable under severe ocnditions of use.

There may be such variation in the extent of the period during which the form 15 and lining 10 are left in contact with the mass of concrete as may be consistent with approved practice, and with the exigencies of particular installations, especially with regard to economy in the use of the same form structure 15 in the molding of successive masses of concrete.

While it is not intended to exclude the maintenance of the form 15 and lining 10 in place as illustrated for longer periods after the concrete shall have reached the condition when it will retain its shape after having been poured, it has been found in practice that the form and lining may be removed from the set concrete at any time upon the elapse, after pouring, of a period of say three hours to several days, or longer if desired.

The exposed concrete may then be sprayed in the conventional manner, to maintain a desirably wet environment for several days.

Having thus described our invention, what we claim and desire to protect by Letters Patent is:

1. A lining for concrete forms and the like, comprising a body layer formed in part at least of highly absorbent material, a layer of porous fabric material, substantially non-adherent to concrete, and a bonding medium between said layers for uniting said layers, said bonding medium being insoluble in water and possessing such porosity that air and moisture may pass readily through the medium from the fabric material to an adjacent absorbent surface of the body layer.

2. A lining for concrete forms and the like, comprising a body layer of highly absorbent porous sheet material, having a thickness adequate to resist flexure yieldingly, a layer of fabric material secured thereto, substantially non-adherent to concrete, and an adhesive means between said body layer and fabric material for forming the securing medium therebetween, said means being insoluble in water and sufficiently porous to allow water to pass readily therethrough, said absorbent body layer constituting, in combination with said non-adherent fabric layer and said securing medium, a self-sustaining unitary structure capable of storage, transportation and application as such, and also being removable, as a unitary structure, from a mass of concrete formed thereagainst, and adapted for application to a form for use in producing another mass of concrete.

3. A lining material for concrete forms and the like, comprising a layer of pervious fibrous material, a layer of porous fabric material secured thereto, constituting a non-adherent facing to be contacted by the concrete, and an adhesive means made of water-insoluble material, between said layers for securing said layers together, said means being of such character that a comparatively strong and permanent union is formed between the layers without materially diminishing the permeability of the lining material.

4. A lining material for concrete forms, and the like, comprising a relatively thick porous layer of rubber composition, a layer of porous fabric material secured thereto and a water-in-

soluble adhesive material between said layers for bonding said layers together, said adhesive material being sufficiently porous to allow air and moisture to pass readily therethrough from the fabric to the porous rubber composition.

5. A lining material for concrete molds, and the like, comprising a relatively stiff supporting layer of porous latex bonded fibrous material, a layer of porous fabric secured thereto, and a water insoluble adhesive means between said layers for securing said layers together, said means being of such character that a comparatively durable union is formed between the layers without appreciably diminishing the porosity of the lining, whereby air or moisture entering the lining may pass readily through the fabric and adhesive means and into the supporting layer.

6. As a new article of manufacture, a structural entity comprising a facing layer made of absorbent porous fabric non-adherent to concrete, and a body layer of highly absorbent material united to said facing layer by a pervious layer of water-insoluble adhesive medium, said combined layers constituting a hydrophilous form-lining for use in the formation of concrete and the like.

7. As a new article of manufacture, a lining for concrete forms and the like, comprising a body layer of highly absorbent material, a facing layer of absorbent porous material substantially non-adherent to concrete, and a bonding layer of a water-insoluble adhesive medium between said body layer and said facing layer, so disposed as to be pervious to moisture.

8. As a new article of manufacture, a lining for concrete forms and the like, comprising a body layer of absorbent cardboard, a facing layer of porous material substantially non-adherent to concrete, and a bonding layer of a water-insoluble adhesive medium pervious to moisture and acting to integrate said body layer and facing layer permanently in a unitary structural element designed to be stored, transported and erected as such.

9. As a new article of manufacture, a lining for concrete forms and the like, comprising a body layer of absorbent cardboard, a facing layer of porous fabric material substantially non-adherent to concrete, and a bonding layer of a water-insoluble adhesive medium, pervious to moisture and acting to integrate said body layer and facing layer in a unitary structural element.

10. As a new article of manufacture, a structural entity comprising a facing layer made of absorbent porous material substantially non-adherent to concrete, and a body layer of highly absorbent latex-impregnated fibrous material having a dry gauge of the order of 55 thousandths of an inch, and an absorptive capacity of the order of 0.14 pound of water per square foot, united to said facing layer by a pervious layer of water-insoluble adhesive medium, said combined layers constituting an absorbent form-lining for use in the formation of concrete and the like.

11. As a new article of manufacture, a structural entity comprising a facing layer made of absorbent porous material substantially non-adherent to concrete, and a body layer of highly absorbent fibrous material comprising cellulosic fibers having at least $\frac{1}{32}$ inch of thickness effective in absorbing water from freshly poured concrete, said body layer being united to said facing layer by a pervious layer of water-insoluble adhesive medium, said combined layers constituting an absorbent form-lining for use in the formation of concrete and the like.

12. As a new article of manufacture, a structural entity comprising a facing layer made of absorbent porous material substantially non-adherent to concrete, and a body layer of highly absorbent microporous rubber sheeting, having a water absorption of the order of .05 pound of water per square foot, united to said facing layer by a pervious layer of water-insoluble adhesive medium, said combined layers constituting an absorbent form-lining for use in the formation of concrete and the like.

13. As a new article of manufacture, a lining for concrete forms and the like, comprising a body layer of highly absorbent material yieldingly resistant to flexure, a facing layer of porous absorbent fabric substantially non-adherent to concrete, and a bonding layer of a water-insoluble adhesive medium pervious to moisture, acting to integrate said body layer and facing layer permanently in a unitary structural element designed to be stored, transported and applied as such.

14. As a new article of manufacture, a structural entity comprising a facing layer of absorbent porous material substantially non-adherent to concrete, and a body layer of highly absorbent material united to said facing layer by a pervious layer of water-insoluble adhesive medium, said combined layers constituting an absorbent form-lining yieldingly resistant to flexure for use in the formation of concrete and the like.

15. As a new article of manufacture, a lining for concrete forms and the like, comprising a body layer of absorbent fibrous material, having a thickness between $\frac{1}{32}$" and $\frac{5}{32}$", a facing layer of absorbent porous fabric, substantially non-adherent to concrete, and a bonding layer of a water-insoluble adhesive medium, pervious to moisture and acting to integrate said body layer and facing layer in a durable unitary structural element.

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