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FLEXIBLE COMPOSITIONS WITH RIGID SETTING PROPERTIES

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18 Claims. (Cl. 156—71)

This invention relates to gypsum sheets for building constructions and the method of producing the same. More specifically, the invention is directed to flexible gypsum building sheets which are pliant and conformable in all dimensions or planes, their manufacture and a method of providing and/or applying conforming gypsum surfaces or overlays in a number of applications.

Building sheets or boards of large or broad dimensions comprising gypsum sheet rock, wall or plaster board, plywood, asbestos-cement sheets and the like substantially rigid or structural products have found utility in a wide variety of building applications such as in the construction or formation of interior walls and ceilings, exterior sheathing and finishes, concrete and masonry retaining forms, etc. The extensive application of this class of materials is primarily due to their convenience and economy of rapid installation in contrast to wet plaster or masonry constructions, board of conventional lumber, etc. However, although flexible or yielding to varying degrees whereby they can normally be bent somewhat in one dimension or plane, common gypsum wall or plaster board, plywood, asbestos-cement sheets, etc., products are not normally sufficiently pliable or conformable to adapt to contiguously to the contour of many surfaces such as rounded corners of short radiuses, close or tight arcs and bows, structural members such as I, T, channel, etc., beams or the like structural shapes, or contoured or undulating constructions or surfaces of one or more dimensions or planes now commonly found in current architectural designs and in cast concrete bodies or structures. Moreover, these conventional sheet or board products typicaly require complex and costly measures such as spackling, filling, coating, taping, etc. to join and/or seal their abutting joints or seams and cover the same, and to cover or conceal the securing means such as nails, screws, staples, or bolt, etc. heads.

It is a primary object of this invention to provide a pliant and conformable, integratable gypsum sheet or board which can be tightly rolled upon itself for convenient handling, transporting and/or storing, and can be applied and contiguously conformed to a foundation body or substructure of substantially any configuration or surface design and upon application converted to a rigid plaster-like consistency or state.

It is also an object of this invention to provide a pliable and yielding, formative, coherent gypsum sheet, mat or blanket which can be shaped or contoured in one or more dimensions or planes, then hydration cured or set by wetting with water, producing a continuous and smooth, hard, durable, rigid slag-like body or surface overlay of plaster-like material.

It is a further object of this invention to provide a pliant and conformable gypsum sheet, wall or plaster boardlike product for wall construction or surfacing which can be easily and economically applied from a roll or slag form or package to conform to virtually any wall configuration regardless of the dimensions or planes, conveniently nailed or stapled, etc. to conventional studding, masonry or block and the like constructions or subsurfaces with simple butt or lap joints, the door or window and the like openings cut out or made therein with usual cutting tools such as knives, scissors, etc., and upon wetting thereof is of such a plastic or flowable and cohesive consistency as to be self-adhering and self-joining at the abutting joints or seams and to enable concealing of the seams and nail, staple, etc. heads and/or holes, and upon drying or setting results in a smooth, unbroken, firm, hard plaster-like surface forming a wall, ceiling or facing without the necessity of subsequent treatments such as taping, spackling, plaster, etc., and which is ready for decoration as by painting, papering, and the like usual means.

It is a further object of this invention to provide a novel and useful material for the construction of concrete or masonry shaping and retaining forms comprising pliant and conformable, coherent sheets or mats either without or with strengthening reinforcement which can be conveniently manipulated to produce a mold or form of desired configuration and then immobilized or set to provide an effective unyielding retainer or form for the pouring or casting of concrete, masonry, etc., or employed as an adaptable overlay on wire mesh, woven or fabricated, etc. skeletal forms and the like means providing a shell or base for the pouring or casting of concrete in the manner of the common construction of concrete floors and the so-called "thin shell" concrete roofs.

It is a still further object of this invention to provide an effective fire retarding barrier and thermal insulation for the fireproofing and insulating of building constructions, etc., and in particular structural bodies and members such as wood and steel beams and rafters, which is highly pliable and yielding and can be conformed with ease to all surfaces in uninterrupted contiguous relation and in situ cured or set merely by applying water to produce a firm unbroken monolithic fire retarding and insulating shell, body or casing which protects the building construction or structural body or member.

These and other objects and advantages of this invention will become more apparent from the hereinafter detailed description.

This invention essentially comprises a sheet or blanket-like body composed of an admixture or combination of asbestos or other reinforcing fibrous material, optionally lightweight aggregate, and partially dehydrated gypsum, with the fiber and gypsum so proportioned and conditioned as to effect a unique combination of properties including: effective coherency and integrity of the mass or body comprising a sheet or blanket providing strength and handleability; a high degree of pliancy and adaptability permitting conforming and wrapping in substantially any shape or configuration and dimension or plane; and hydration or water induced setting or curing producing a hydrated or cured, hard, rigid, durable unbroken plaster-like, monolithic mass or surface; as well as means of producing and applying this product to provide a finished wall, masonry form, insulating sheathing, etc.

The effective practice of this invention entailing providing products of the foregoing properties and features can, in general, be achieved by combining or admixing in an aqueous medium, in approximate percentages by weight of the over-all solids of the admixture, about 20 to 40% of retaining and reinforcing, skeletal body forming discrete fiber, 0 to about 20% of lightweight aggregate filler, and about 60 to 80% of particulate gypsum, in a substantially homogeneous or uniform mass, shaping and/or consolidating the resulting wet mass, then thermally driving off or dehydrating a substantial quantity, i.e., at least about 50% up to and preferably about 75%, of the water of crystallization of the gypsum component whereby a handleable and flexible product is produced which, upon application, can be rehydrated and set. A typical formulation would comprise approximately 30% by weight of asbestos fiber and approximately 70% by weight of gypsum.

The fibrous component preferably consists of asbestos fiber but may comprise various types of staple reinforcing grades of either natural or synthetic mineral, or organic fibers, such as, for example, mineral or rock wools and glass fibers, preferably pretreated as with acid or other means to roughen their surface enhancing their retaining capacity, cotton and the synthetic fibers such as viscose or acetate rayon, polyamine or polyacrylic. When the products of this invention are to be employed as thermal insulations or in areas of possible exposure to high temperature conditions, the fibrous materials, or at least a major portion thereof, should be of a mineral or inorganic composition. Also, extensive exposure to moisture or similar deteriorating conditions may restrict the use of natural organic fibers. The inclusion of the fibrous component in amounts of at least about 20% by weight of the product is required as substantially lesser amounts result in the loss of flexibility of the product and in turn its ability to fully conform to various shaped surfaces. Although woven or continuous fibrous structures such as scrims, etc. can be incorporated within the product, the foregoing fibrous component consists of discrete or staple fibers.

Although not essential, products of optimum characteristics for many applications are produced by including small amounts ranging up to about 20% by weight of lightweight aggregate, preferably expanded and milled perlite. For example, the presence of small quantities of expanded and milled perlite of about 2 to 6% by weight result in a product that sets or hydrates to a particularly smooth and more readily paintable or decoratable surface. Other lightweight aggregates consist of materials substantially or effectively inert in the contemplated media or environment of gypsum and fiber, etc., and weighing at least less than 100 lbs./cu. ft., and preferably less than about 50 lbs./cut. ft., comprising expanded perlite, diatomaceous earth, calcium silicates, expanded volcanic glasses, perlite, exfoliated vermiculite, fuel ash (fly ash), pumice, clinker, foamed slag, expanded clay, shale and slate, foamed or cellular resin bodies or spheres.

Gypsum or the like available source of $CaSO_4.2H_2O$ is employed in relatively finely divided particulate size, i.e., substantially all smaller than 300 microns in diameter and preferably all smaller than 250 microns with an optimum size of at least about 50% and preferably about 70% within the range of approximately 20 to 60 microns, for effective blending and slurrying or suspending in water and reaction. Moreover, the gypsum or content must comprise at least about 60% by weight of the initial solids to result in a finished product which will properly set into a hard and durable body or surface.

These basic and essential components, viz., discrete fiber, lightweight aggregate if employed, and gypsum, can be admixed dry and subsequently thoroughly wet to implement their consolidation and integration as in the dry process manufacturing and formation of asbestos-cement articles. Preferably the components are dispersed liquid media by filtering either batch-wise on a filter press or continuously as in a wet process asbestos-cement manufacturing or forming procedure wherein the sheet is built up on an accumulating roller or means as a lamination of thin sheets or layers of stock from the transfer felt or belt. This latter procedure or technique is illustrated by the Hatschek U.S. Letters Patent No. 769,078 or Reissue 12,594 and more recent U.S. Letters Patent No. 1,687,681, in a dilute aqueous slurry and then collected from the

$CaSO_4.2H_2O$

and No. 2,182,353 and numerous other patents familiar to the art.

Formed sheets or similar bodies of the wet consolidated material, upon suitable flattening or other apt shaping if formed on a cylinder roll, etc., are dried at temperatures of from about 300 to 375° F., preferably within the range of approximately 340±25° F. for periods typically of

from about ½ to 6 hours, the time being more or less inversely proportional to the temperature, to drive off any retained or physically entrained moisture and to dehydrate the gypsum component. The thermal dehydration must be continued to the point of converting a majority of the gypsum contents of the material to soluble calcium sulfates ranging from the soluble anhydride $CaSO_4$ up to $CaSO_4.H_2O$ and preferably converting at least 50%, or optimumly about 75%, of the gypsum contents from the hydrated form—$CaSO_4.2H_2O$—to the soluble hemihydrate—$CaSO_4.½H_2O$. Or in other words, to thermally eliminate at least about 50% by weight of the total water of crystallization of the gypsum material and more effectively about 75% by weight of the over all water of crystallization. Thus dried and/or dehydrated there results a dry, flexible or yielding and conformable or pliant, handleable coherent sheet or blanket or similar body containing an active form of partially dehydrated calcium sulfate which, when subsequently wet, as simply by means of a water spray or other convenient means, hydrated and re-forms gypsum

$(CaSO_4.2H_2O)$

thereby setting into a hard, rigid and durable unbroken "plaster like" or monolithic material or mass.

The conditions of the thermal drying or dehydration must be rigidly controlled as excessive temperatures and/or periods thereof may result in an over dehydrated calcium sulfate material which does not rehydrate readily whereby relatively simple or convenient means of wetting, as by simply spraying an applied sheet or body of water, will not produce a hard and rigid material or mass. As indicated, optimum dehydration conditions comprise the conversion of substantially all, or at least a majority of the gypsum contents of the material to the soluble hemihydrate $CaSO_4 \cdot ½H_2O$, or to a soluble form of calcium sulfate compounds comprising the soluble anhydrate $CaSO_4$ up to $CaSO_4 \cdot H_2O$. However, prolonged exposure to humid conditions will of course increase the water of hydration or crystallization of the dehydrated gypsum material and the dehydrated or active form of these products should be protected from highly humid environments or excessive moisture conditions. For instance, subjecting the products of this invention in their active or dehydrated state to an atmosphere of relatively normal moisture content, viz., an average 50 to 75% R.H. with summer and winter extremes extending to 85 to 90 and to 15 to 20 R.H., for one year did not incur any difficulties or adverse effects in the subsequent hydration or setting the material or in the characteristics of the resulting cured products and upon termination of this period the dehydrated gypsum contents were found to consist of $CaSO_4 \cdot 0.8$ to 1.0 H_2O which constituted a small moisture increase. Nevertheless, like dehydrated samples were found to completely hydrate to $CaSO_4 \cdot 2H_2O$ when exposed to 100% R.H. over a period of 20 days. Accordingly, when conditions of high humidity or exposure to water are likely to be encountered or inevitable, the dehydrated form of these materials should be protected as by storing and shipping in vapor impermeable plastic or impregnated paper wraps similar, for example, to the handling of plaster of Paris.

The application of dehydrated sheets or the like shapes of the products of this invention to form wall surfaces, masonry forms, insulating coverings, etc., can be carried out either by installing or forming the dehydrated material followed by wetting the material in situ, or by first wetting or activating the dehydrated gypsum and subsequently but promptly applying or conforming the material. However, in that the dry dehydrated form of the product or sheets thereof are very flexible or pliant and of ample strength to be easily handled whereas the wetted sheets are considerably heavier and require much greater care in handling since they are more susceptible to rupture and tearing, it is usually more expedient to install

or shape the product initially and then activate it by wetting. Hydration to instigate the setting or curing can, of course, be carried in subsantially any convenient manner of applying water thereto as for example, spraying brushing, or immersing. The amount of water should be sufficient to effect a substantially complete hydration of the calcium sulfate or conversion thereof to gypsum ($CaSO_4 \cdot 2H_2O$) and as a rule of thumb for workmen water can be applied to the point where it appears on the surface and is no longer rapidly absorbed into the material.

In addition to ease of handling, the good coherency and strength of the aptly formulated, dehydrated dry, or even wet products of this invention enable their installation with ordinary techniques and securing means comprising standard dry wall or gypsum board nails, staples, screws, nuts and bolts, etc. When applied to a wooden subsurface such as wood sheathing or conventional wall studs the sheets can be secured into place with nails or other apt means and in the case of masonry subsurfaces the contacting or adjoining structure can be wetted before contact to effect a bond with the product which is adequate to secure the sheet thereto. The dry or recently wet material can be cut with conventional means comprising a knife or scissors either prior or subsequent to application to fit it or provide cut-outs such as windows or doors, etc. Also, when wet the material is sufficiently plastic or workable as to permit the uniting and securing of joints and the covering and concealing of nail etc. heads and joints.

The following comprises specific illustrations or examples of preferred and typical means or conditions, products and techniques of producing and applying the novel constructions of this invention and demonstrates the pronounced advantages and utility thereof. It is to be appreciated, however, that the specific formulations and/or means employed in preparing and in applying these products, or given hereinafter are primarily exemplary and are not to be construed as limiting the invention to any particular composition(s) or method(s) of the examples.

Flexible, plaster-like sheets or wall board products of this invention were produced from the following formulations:

	Examples		
	I	II	III
Gypsum ($CaSO_4.2H_2O$, Ben Franklyn Agricultural Gypsum), 70% having a particle size in the range of 20 to 60 microns, pound	70	70	70
Asbestos (grade 4, Quebec Standard), pound	27	27	27
Filler:			
Expanded milled perlite, 12 p.c.f., pound	-------	3	-------
Expanded perlite, 6 p.c.f., pound	-------	-------	3
Water, gallon	287	287	287

Batches of the above ingredients were thoroughly mixed for 15 minutes producing relatively dilute slurries or dispersions and each employed in the formation of sheets on a wet process asbestos-cement forming machine which consists of vacuum collecting and filtering out the dispersed solids onto a screen on the face of a rotating cylinder, continuously transferring the collected solids from the rotating cylinder screen to a rotating mandrel by means of a porous felt belt, and accumulating the collected thin layer of solids by convoluting it upon itself on the rotating mandrel while consolidating the convoluted layers, integrating them until a sheet of the desired thickness is built up or accumulated whereupon the formed sheet or mat is cut from the mandrel and straightened or conformed to whatever shape appropriate. This technique of course is a conventional forming means illustrated by the hereinbefore cited patents. Moreover, other common sheet forming means can be utilized to perform this conventional step, e.g., filter molding a less dilute slurry or dispersion of the admixed solids.

Sheets of each of the given compositions were formed in dimensions of 60 in. in lentgh, 15 in. in width, and thicknesses of 3/16 and 1/4 in. The sheets were dried in an oven by heating them to 350° F. (177° C.), actual sample temperature, and maintaining this temperature within the sheets for 2½ hours. The dry densities of the sheets of Examples I and II were about 56 to 57 p.c.f., and Example III or the expanded perlite containing sheets were about 40 to 47 p.c.f.

The calcium sulfate or dehydrated gypsum content of representative samples of these sheets was examined and found to average about $CaSO_4 \cdot 0.5H_2O$ with one sample having a calcium sulfate composition of $CaSO_4 \cdot 0.1H_2O$.

Sample sections of each of the foregoing types of sheets were nailed to conventional 2 in. x 4 in. wall studs, wet with a water spray until water appeared on the surface and no longer rapidly absorbed, and abutting seams or joints between sections and the nail heads were united and concealed by working small amounts of the wet plaster material on the surface of the sheets into and over the seams and nail heads providing a relatively smooth continuous or unbroken surface. Further sample sections of like compositions were applied and secured to both masonry brick and cinder block walls by first wetting the wall, applying the sample sections and pressing the same to the wall to effect good contact, then wetting the adhering sheets with a water spray as before. In all cases the sample sheets set up or hydrated providing durable, serviceable plaster-like walls or surfaces which have endured for in excess of two years without any discernible sagging or parting, cracking, or other deleterious effects.

It will be understood that the foregoing details are given for purposes of illustration and not restriction, and that variations within the spirit of this invention are to be included within the scope of the appended claims.

We claim:

1. An article of manufacture consisting of a pliant and conformable, coherent sheet of an integrated, hydration setting admixture comprising approximately 20 to 40 parts by weight of fiber and approximately 60 to 80 parts by weight of gypsum having an initial particle size less than about 300 microns in diameter, the said gypsum having been dehydrated to remove at least about 50% of the combined water of crystallization thereof.

2. An article of manufacture consisting of a pliant and conformable, coherent sheet of an integrated, hydration setting admixture comprising approximately 20 to 40 parts by weight of fiber, lightweight aggregate in amount up to approximately 20 parts by weight, and approximately 60 to 80 parts by weight of gypsum having an initial particle size less than about 300 microns in diameter, the said gypsum having been dehydrated to remove at least about 50% of the combined water of crystallization thereof.

3. The article of claim 2 wherein lightweight aggregate is selected from the group consisting of diatomaceous earth, calcium silicates, expanded volcanic glasses, exfoliated vermiculite, pumice, clinker, pulverized fuel ash, foamed slag, expanded clay, expanded shales, and expanded slates, and mixtures thereof.

4. An article of manufacture consisting of a pliant and conformable, coherent sheet of an integrated, hydration setting admixture comprising approximately 30 parts by weight of asbestos fiber and approximately 70 parts by weight of gypsum, the said gypsum having been dried to a dehydration product containing less than approximately 50% by weight thereof of combined water of crystallization.

5. The method of manufacturing a pliant and conformable, coherent hydration setting sheet of dehydrated gypsum comprising forming an admixture of water with approximately 20 to 40 parts by weight of fiber and approximately 60 to 80 parts by weight of particulate gypsum substantially all sized less than about 300 microns in diameter, consolidating the admixture of water

and solids into a coherent sheet, drying the sheet at tempeartures within the approximate range of 300 to 375° F. for a period of ½ to 6 hours, dehydrating the gypsum to remove at least about 50% of the combined water of crystallization thereof and thereby providing a hydration setting, coherent sheet which is pliant and conformable and handleable.

6. The method of claim **5** wherein the admixture of water and solids and in turn the resulting sheet contains lightweight aggregate in amount up to approximately 20 parts by weight.

7. The method of manufacturing a pliant and conformable, coherent hydration setting sheet of dehydrated gypsum comprising forming a dilute aqueous slurry with approximately 20 to 40 parts by weight of asbestos fiber and approximately 60 to 80 parts by weight of particulate gypsum substantially all sized less than about 300 microns in diameter, consolidating the solids of the slurry into a coherent sheet by filtering, drying the consolidated sheet at temperatures within the approximate range of 315 to 365° F. for a period of ½ to 6 hours, dehydrating the gypsum to remove at least about 50% of the combined water of crystallization thereof and thereby providing a hydration setting, coherent sheet which is pliant and conformable and handleable.

8. The method of claim **7** wherein the drying temperature is approximately 340° F.

9. The method of manufacturing a pliant and conformable, coherent hydrating setting sheet of dehydrated gypsum comprising forming a dilute aqueous slurry with approximately 20 to 40 parts by weight of asbestos fiber, lightweight aggregate in amount up to approximately 20 parts by weight, and approximately 60 to 80 parts by weight of particulate gypsum substantially all sized less than about 250 microns in diameter, consolidating the solids of the slurry into a coherent sheet by filtering, drying the consolidated sheet at temperatures within the approximate range of 315 to 365° F. for a period of ½ to 6 hours, dehydrating the gypsum to remove at least about 50% of the combined water of crystallization theref and thereby providing a hydrating setting, coherent sheet which is pliant and conformable and handleable.

10. The method of manufacturing a pliant and conformable, coherent hydration setting sheet of dehydrated gypsum comprising forming a dilute aqueous slurry with approbimately 20 to 40 parts by weight of asbestos fiber and approximately 40 to 60 parts by weight of particulate gypsum substantially all sized less than about 250 microns in diameter, consolidating the solids of the slurry into a coherent sheet by filtering, drying the consolidated sheet at temperatures within the range of approximately 300 to 375° F. for a period of about ½ to 6 hours to dehydrate the gypsum removing at least about 50% by weight thereof of its combined water of crystallization and thereby providing a hydration setting, coherent sheet which is pliant and conformable and handleable.

11. The method of claim **10** wherein lightweight aggregate in amount up to approximately 20 parts by weight is added to the aqueous slurry of asbestos and gypsum and in turn is incorporated within the resulting sheet.

12. The method of manufacturing a pliant and conformable, coherent hydration setting sheet of dehydrated bypsum comprising forming a dilute aqueous slurry with approximately 20 to 40 parts by weight of asbestos fiber and approximately 60 to 80 parts by weight of particulate gypsum at least about 50% of which is sized within the range of approximately 20 to 60 microns, consolidating the solids of the slurry into a coherent

sheet by filtering, drying the consilidated sheet at temperatures within the approximate range of 315 to 365° F. for a period of about ½ to 6 hours to dehydrate the gypsum removing at least about 75% by weight of its combined water of crystallization and thereby providing a hydration setting, coherent sheet which is pliant and conformable and handleable.

13. The method of claim **12** wherein lightweight aggregate in amount up to approximately 20 parts by weight is added to the aqueous slurry of asbestos and gypsum and in turn is incorporated within the resulting sheet.

14. The method of applying a coherent, hydration setting gypsum sheet comprising forming a dilute aqueous slurry with approximately 20 to 40 parts by weight of asbestos fiber and approximately 60 to 80 parts by weight of particulate gypsum substantially all sized less than abut 300 microns in diameter, consolidating the solids of the slurry into a coherent sheet by filtering, drying the consolidated sheet at temperatures within the range of approximately 300 to 375° F. for a period of about ½ to 6 hours, dehydrating the gypsum to remove at least about 50% of the combined water of crystallization thereof and, applying and conforming the resulting pliant and conformable and handleable, coherent dehydrated gypsum sheet to the area to be surfaced, and wetting the sheet to hydrate the dehydrated gypsum and set the sheet into a hard, rigid surface.

15. The method of claim **14** wherein lightweight aggregate in amount of approximately 20 parts by weight is added to the aqueous slurry of asbestos and gypsum and in turn is incorporated within the resulting sheet.

16. The method of applying a coherent, hydration setting gypsum sheet comprising forming a dilute aqueous slurry with approximately 20 to 40 parts by weight of asbestos fiber and approximately 60 to 80 parts by weight of particulate gypsum substantially all sized less than about 250 microns in diameter, consolidating the solids of the slurry into a coherent sheet by filtering, drying the consolidated sheet at temperatures within the approximate range of 300 to 375° F. for a period of about ½ to 6 hours to dehydrate the gypsum, removing at least about 50% by weight thereof of its combined water of crystallization, applying and conforming the resulting pliant and conformable and handleable, coherent dehydrated gypsum sheet to the area to be surfaced, and wetting the sheet to hydrate the dehydrated gypsum and set the sheet into a hard, rigid surface.

17. The method of claim **16** wherein the drying temperatures are within the approximate range of 315 to 365° F.

18. The method of claim **17** wherein lightweight aggregate in amount up to approximately 20 parts by weight is added to the aqueous slurry of asbestos and gypsum and in turn is incorporated within the resulting sheet.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,311,516 March 28, 1967

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It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 32, strike out "to", second occurrence; column 3, line 48, after "gypsum or" insert -- $CaSO_4.2H_2O$ --; line 57, after "dispersed" insert -- in a dilute aqueous slurry and then collected from the --; lines 66 and 67, strike out "in a dilute aqueous slurry and then collected from the $CaSO_4.2H_2O$"; column 7, line 64, for "bypsum" read -- gypsum --; column 8, line 17, for "abut" read -- about --.

Signed and sealed this 18th day of June 1968.

(SEAL)

Attest:

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Attesting Officer

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Commissioner of Patents