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THERMAL INSULATION AND METHOD OF MANUFACTURE

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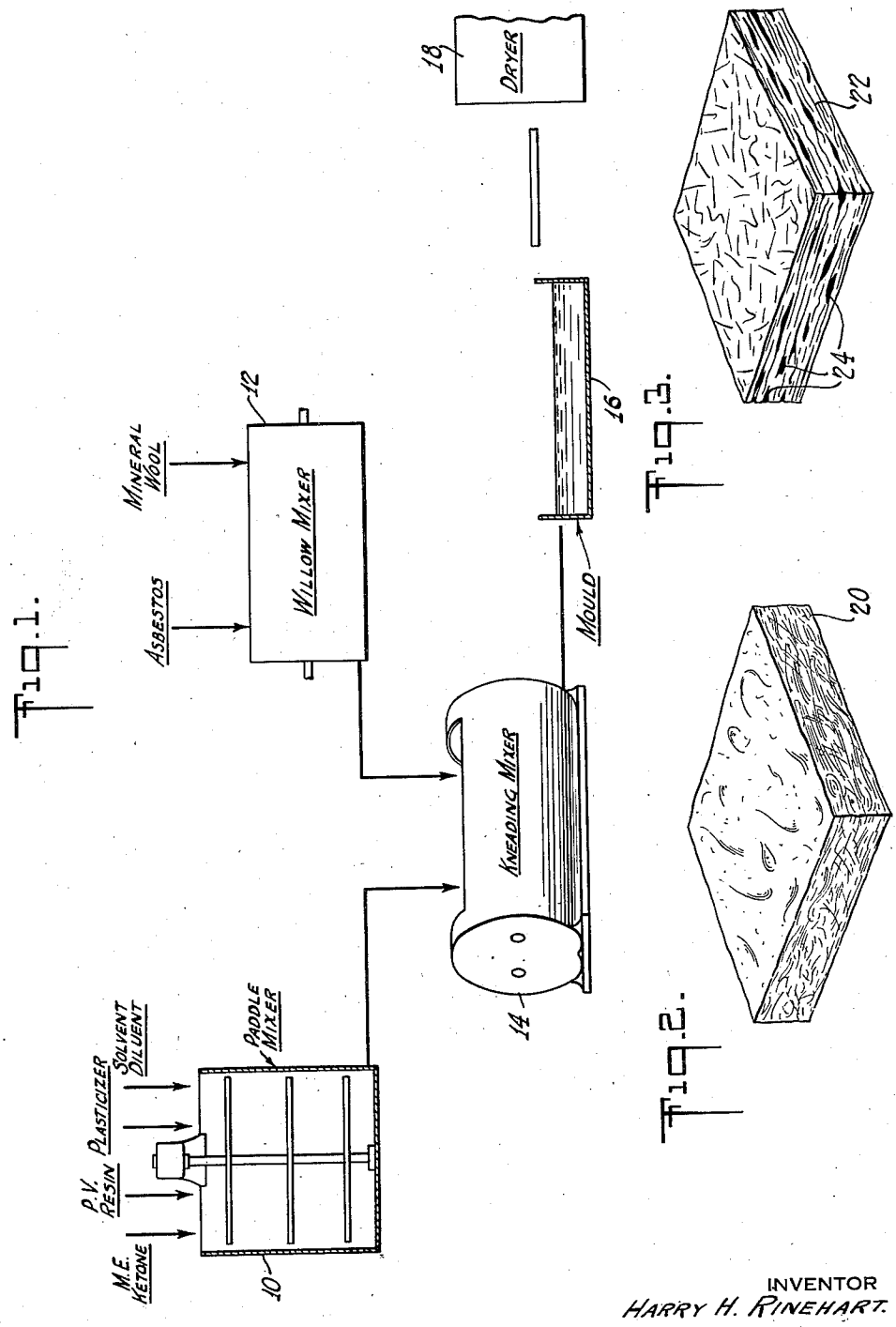


Fig. 1.

Fig. 3.

Fig. 2.

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THERMAL INSULATION AND METHOD OF MANUFACTURE

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12 Claims. (Cl. 260—36)

The present invention relates to thermal insulating compositions, and is particularly directed to improved fiber-binder insulating compositions and method of manufacturing same.

An object of the invention is to provide a thermal and acoustical insulating composition suitable for lining airplanes and combat tanks whereby to increase the comfort of the operating crew.

Another object is to provide a thermal insulating composition having a firm, soft, flexible, rubber-like structure and good resilience adapting it for lining combat tanks to afford protection for the operating crew from bruises and injuries when traveling over rough terrain.

Other objects of the invention are to provide fiber-binder insulating compositions which are sufficiently tough and strong as to absorb repeated vibrations and jarring shocks and strains without injury, and which are at the same time non-inflammable and resistant to deterioration by contact with oil, water and gasoline.

Still another object is to provide a fiber-binder composition in which the binder in plastic state has sufficient wet cohesive strength and sufficient plasticity as to permit of molding or otherwise shaping the composition to precise dimensions, either by conventional molding methods or by extrusion or application by troweling.

Another object is to provide a fiber-binder composition in which the binder, after removal of solvent, possesses sufficient dry adhesive strength and stability as to retain resilience and inherent strength throughout operating temperature ranges between —50° F. and 300° F.

Still another object is to provide a fiber-binder composition which is curable under moderate heating or drying conditions to such a stable product.

A further object of the invention is to provide a method whereby a flame-proof and oil-proof insulating shape having the properties of high flexibility and resilience, high tensile strength and cellular texture can be produced in an economical and efficient manner.

In order that the completely cured product or shape may have the necessary cellular structure and low density to provide suitable thermal and acoustical insulating properties (for example, a density range from 5–35 lbs. per cubic ft.) it has been found that the fiber component of the product should constitute at least 60–75% by weight of the product. It is also desirable that a major proportion of the fiber constituents consist of inorganic fibers such as asbestos and rock wool, or mixtures thereof.

Since the proportion of binder in the composition does not normally exceed 40% by weight of the cured product, and may comprise substantially less than that maximum proportion, it is essential that there be a strong physical bond between the reinforcing fibers and the binder. It is equally essential that the bonding agent retain flexibility and strength over a comparatively wide operating temperature range. Since asbestos fibers and rock wool or other mineral fibers are the preferred reinforcing elements, the choice of binder must take into consideration certain particular properties of such products.

Asbestos fibers such as are visible without magnification, are constituted of bundles of elongated microscopic crystals which are partly separated from each other, as, for example, at a frayed exterior end or portion of a fiber such as is produced by the usual milling methods applied to asbestos ore. Asbestos fibers of a given kind become weaker the more the crystals therethroughout are separated. The crystal structure of asbestos fibers is such as not to adsorb or coat readily with organic binders, and the individual crystals are not readily wetted or impregnated by organic solvents of the type normally employed for synthetic resins and plastics.

Rock wool or other mineral wool fibers also offers difficulties because of their glass-like crystalline structure. Rock wool fibers do not contain the capillary passages which are present in natural vegetable fibers, and consequently rock wool and other similar mineral fibers cannot adsorb organic solvents and possess a comparatively smooth exterior surface which offers considerable resistance to coating or cementing by organic bonding media.

For the above reasons, one of the important features of the present invention involves the special technique developed to produce a strong, tenacious and flexible bond between the asbestos and rock wool reinforcing fibers and the organic plastic binder. Such technique is required to overcome the difficulties resulting from the apparent incompatibility of such fibers and most organic bonding agents, and their complete resistance to softening by or absorption of organic solvents, preventing penetration of the solvent into the fibers and thereby materially increasing the difficulties of securing adequate adhesion between the fibers and the bonding media.

Another object of the present invention is, therefore, to secure uniform admixture and dis-

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tribution of inorganic reinforcing fibers and organic binder, and to develop a stable, flexible, strong, and tenacious bond between these materials. A still further object is to develop a bonding medium having a high degree of adherence for mineral fibers both in the cured product and in the uncured plastic composition from which the final sheet or other insulation shape is produced.

With the above and other objects and features in view, the invention consists of the improved fiber-binder insulating composition and method of manufacture which is hereinafter described and more particularly defined in the appended claims.

In the following description reference will be made to the accompanying drawing as presenting illustrative examples of fiber-binder insulating shapes and of the method employed in their manufacture.

In the drawing: Fig. 1 presents in diagrammatic flow sheet form the principal steps involved in producing fiber-binder insulating shapes in accordance with the present invention; Fig. 2 is a perspective view of a fiber-binder insulating sheet particularly adapted as a lining for airplanes and combat tanks; and Fig. 3 is a perspective view of another fiber-binder insulating sheet of tough, highly porous texture.

A binder suitable for imparting the indicated desirable properties of high adhesive strength, toughness, resilience, oil and water resistance and non-flammability, can be best produced from synthetic plastics of the polyvinyl type, including particularly such rubber-like plastics as polychloroprene or butadiene-acrylonitrile or butadiene-styrene plastics and copolymers of vinyl-chloride with vinyl acetate or vinylidene chloride. Such rubber-like plastics must be highly plasticized, preferably with flame proofing plasticizers of the type of tricresyl phosphate or chlorinated diphenyl. To impart the degrees of plasticity, wet strength and adhesion to the binder which are necessary for producing a plastic fiber-binder composition suitable for molding or extruding to shapes of precise dimensions, it has been found that the resin component of the binder must be reduced in consistency by employing a semi-solvent which is incapable of placing the resin in true solution and which is capable of forming with the resin a colloidal adhesive gel. An example of a semi-solvent which has been used for reducing to fluid consistency a vinyl chloride-vinyl acetate copolymer of approximately 90% vinyl chloride content, consists of a mixture of methyl ethyl ketone and a modified petroleum solvent sold under the trade name "Solvesso #1," in the proportions of about 50 parts Solvesso #1 and about 25 parts methyl ethyl ketone.

The following formula is one which has been found suitable for preparing insulation compositions in accordance with the present invention:

Ingredient	Formula #1, parts by weight
Mineral wool	10.7
Asbestos fiber	5
Methyl ethyl ketone	24.8
"Solvesso #1"	49.7
Vinyl chloride-vinyl acetate co-polymer (90–95% vinyl chloride)	3.6
Tricresyl phosphate	6.2

The composition is prepared in a plastic form suitable for molding or for application to surfaces by troweling, by first forming a highly adhesive cement. The cement is prepared in a paddle type mixer 10 by effecting colloidal solution of the vinyl copolymer resin and the plasticizer with the ketone and modified petroleum solvents in the proportions indicated by the formula, until a highly fluid gel is obtained. This operation of reducing the solid components of the binder to gel form requires rather prolonged agitation of the solid and solvent constituents, particularly since it is preferably carried out at substantially room temperature. After the cement has thus been worked up to a substantially uniform fluid gel consistency, the mineral wool and asbestos fibers, after being thoroughly mixed in a willow type mixer 12, are gradually added to the cement in a kneading mixer 14 while continuing the agitation until each individual fiber of the mass has been coated with the cement and the whole mass has been reduced to a plastic mixture of uniform texture and high internal adhesive strength somewhat resembling putty in consistency. In this condition the resulting plastic insulation cement can be molded, or applied to irregular surfaces by troweling. The usual practice is to mold the product in a pan mold 16 into flat sheets, which can then be cured either by drying in a drier 18 for about 12 to 16 hours at a temperature of 200° F.–300° F., or by drying for several days at substantially room temperature. During this drying operation the solvent (or semi-solvent) portion of the composition vaporizes, and the product develops its stable, cured form 20 (Fig. 2).

In the indicated preferred composition, the fiber content of the cured product makes up about 62% by weight of the product and consists of about 2 parts mineral wool (i. e., rock or slag wool) and about 1 part asbestos fiber. A sheet 22 (Fig. 3) of high tensile strength and of low density has been made in accordance with the following formula, in which the fiber content of the mixture consists entirely of asbestos fibers:

Ingredient	Formula #2, parts by weight
Asbestos fiber	63.8
Methyl ethyl ketone	61.5
Vinyl chloride-vinyl acetate co-polymer (93% vinyl chloride)	8.8
Tricresyl phosphate plasticizer	15.4

Insulating sheets which have been molded under substantially atmospheric pressure and baked in accordance with the process and formulas herein described, have high tensile and compressive strengths and high tear resistance. For example, a test strip made from a composition corresponding to Formula 2 above and having a minimum cross-sectional dimension of 1" x ¼" exhibited a tensile strength of 278 lbs. per square inch, with an elongation before failure of .026" per inch of length. A sheet of the same composition exhibited a tear resistance strength of 132 lbs., and a compressive strength and resilience such as to snap back to 100% original dimension after being compressed to less than ½ its original thickness under a load approximating 100 lbs. per square inch. A sheet of the same composition of ¾" thickness, 1½" width and 11" length, when subjected to twisting between grips spaced 9" apart, exhibited a torsional strength equivalent to an angular deflection of 540° before failure under a load of 20 lbs. The modulus of rigidity of this sheet was therefore 194, and the ratio of

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torsional strength or angular deflection to thermal conductivity was exceptionally high, i. e.

$$\frac{540}{.5}=1080$$

Shapes made in accordance with either of the formulas resist deterioration at temperatures up to 300° F. and are not weakened or made brittle by temperatures as low as —50° F. The cured products have densities which usually range between 20 and 40 lbs. per cubic ft., and have a cellular structure 24 (Fig. 3) such as to form an efficient thermal insulant. The thermal conductivity of the product does not normally exceed 0.6 B. t. u./(hr.) (sq. ft.) (°F. per inch) and may be substantially less. By puncturing the surfaces of cured sheets of the product at closely spaced uniform intervals, there is imparted to the product good acoustical insulation properties. Also, because of the chemical and dimensional stability of the cured product, and because of the plasticity and workability of the plastic uncured composition, it is particularly adapted as a plastic insulation for troweling on liquid refrigerant-transfer pipes and fittings, and for insulating other surfaces exposed to sub-zero temperature. It also has wide application as a shock absorbent, as well as for thermal insulation, because of its resilient, rubber-like properties and high strength and toughness. Shapes of high density in the range 35–70 lbs. per cubic ft. have higher thermal conductivity up to 1 B. t. u./(hr.) (sq. ft.) (°F. per inch) and are firmer and stronger.

Preferred binders for the compositions which are given in the foregoing tables are vinyl chloride-vinyl acetate copolymer resins containing 90–95% vinyl chloride by weight and having high molecular weights. Tricresyl phosphate is the preferred plasticizer for this type of resin, and it is preferably employed in amounts representing at least 1.5–2 parts by weight for each unit weight of resin in the binder. Methyl ethyl ketone has been found to be the most practical solvent for producing the amount of gelling of the copolymer vinyl chloride-vinyl acetate resin which is necessary to give the plasticized resin the desired wet and dry adhesive strength and cohesion. It has been found that solvents which form a true solution with these resins develop cements with insufficient wet adhesion. Experience has shown that the properties of methyl ethyl ketone in this respect are improved by incorporating therewith as a diluent a substantial proportion of a modified petroleum solvent of a type sold under the trade term "Solvesso #1."

Products of lower strength and resilience may be prepared in which the preferred vinyl chloride-vinyl acetate resin is replaced by other polyvinyl halide copolymer resins of lower vinyl chloride content, or by vinyl acetate resins or chloroprene. When polyvinyl acetate resins are used, a preferred solvent is isopropyl alcohol to which has been added about ½% by weight of water. For chloroprene polymer resins of the "Neoprene G. N." type, a suitable solvent is that previously mentioned as sold under the trade name "Solvesso #1," and a chlorinated diphenyl may be used as plasticizer. Neoprene latex may also be used.

A fiber-binder composition of the type herein described, containing mineral fibers which are individually coated and bonded together by the binder, has high flexibility and toughness chiefly by reason of its high content of mineral fibers and of plasticizers. The fiber content is 4–8 parts for each dry weight part of binder, and the binder is itself very highly plasticized. In its uncured plastic putty-like state the composition retains sufficient solvent to facilitate troweling, and to yield a sheet of comparatively porous or cellular insulation after drying. Such applied layer or sheet is adjustable as to its porosity and density by application of varying pressure thereto, either in the course of drying or afterwards. Shapes may be produced with lower densities in the range 3–35 lbs. per cubic ft.

In order that the plastic composition shall have the required degree of plasticity and inherent wet strength or adhesion to permit of application by troweling, it is essential that the various constituents of the binder or cement be thoroughly plasticized and homogenized during the periods prior to and after addition of the fibers in the mixing operation. It is only by thorough mixing and churning of the composition that the desired smooth plastic consistency is realized.

As previously indicated, the optimum composition heretofore described may be departed from by substituting other binder components in cases where less resilient products are desired. In some cases the mineral fiber content may also be varied, as for example, by replacing at least some of the asbestos or mineral wool content with vegetable fibers. One of the most important features of the present invention is the fact that it is possible to incorporate into the fiber-binder composition much larger amounts of mineral fiber and plasticizer than have heretofore been considered feasible for fiber-binder compositions having equivalent insulating properties, flexibility, resilience and tensile strength.

The uncured or plastic composition of the present invention has high wet adhesive strength or cohesion and may be shaped to any particular form and dimensions while in the plastic state. It retains such form and dimensions during drying and afterwards, unless distorted by pressure or other outside applied forces. It is this property of the plastic composition which permits of its use both for molding sheet products of varying thickness, density and porosity, and also for the manufacture of extruded products and for application to pipes or irregular surfaces by troweling. The plasticity and wet adhesion strength of the binder is such that long and harsh reinforcing fibers of mineral wool may be employed in the composition without adverse effect on the homogeneous texture and ready troweling ability of the plastic composition. By the use of such long and harsh fibers there is imparted to the composition a high degree of toughness, together with high tear resistance and tensile strength. In speaking of the products resulting from molding the plastic composition herein referred to as being uniformly textured, it is meant that the fibers are uniformly distributed throughout the product and are in random alignment or lay, so that the resulting products or shapes are substantially uniform in strength, toughness, and tear resistance at all points and in all directions.

Since many variations may be made from the illustrative details given, without departing from the scope of the invention, it is intended that the invention should be limited only by the terms of the claims interpreted as broadly as consistent with novelty over the prior art.

What I claim is:

1. A process which comprises, thoroughly mixing and churning 1 part of thermo-plastic polyvinyl resin with at least 1½ parts of flame proofing plasticizer and with a solvent to produce a

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fluid cement comprising a colloidal gel-like suspension of said resin, admixing mineral fibers with the cement in amount representing 60%–75% by weight of the mixture exclusive of solvent, and working up the mixture to effect uniform coating of the fibers and distribution of the fibers throughout the mixture, and agitating the mixture to impart a plastic consistency thereto.

2. A process which comprises forming a mixture of approximately 1 part vinyl chloride-vinyl acetate copolymer and about 1½–2 parts tricresyl phosphate plasticizer, suspending said mixture in a solvent and working up the mixture to form a fluid cement consisting of a colloidal gel-like suspension, incorporating into the cement 4–8 parts mineral fibers and working up the mixture to a uniform plastic consistency in which the individual fibers are thoroughly coated with the cement, molding the plastic mixture to pre-determined shape and dimensions, and drying the molded shape to vaporize the solvent and to effect stabilization of the plastic binder.

3. A method of forming a uniformly textured plastic trowelable insulating composition which comprises, forming a gel-like suspension of approximately 1 part of polyvinyl resin and 1½–2 parts tricresyl phosphate plasticizer, together with a solvent in amount adapted to form said gel suspension, said resin resulting from the conjoint polymerization of 90–95 parts by weight of vinyl-chloride and 5–10 parts by weight of vinyl-acetate, incorporating in said suspension mineral fibers in amount representing 4–8 parts by weight of fiber for each part of resin, and agitating and churning the mixture thus formed until the plasticized vinyl resin and mineral fibers are substantially uniformly dispersed throughout the mixture.

4. A method of forming a uniformly textured plastic trowelable insulating composition which comprises, forming a fluid gel-like suspension containing about 1 part of polyvinyl resin and about 1.5–2 parts of tricresyl phosphate plasticizer together with a solvent, gradually admixing with said suspension about 4–8 parts by weight of mineral wool and asbestos fibers, and continuing agitation of the mixture to effect substantially uniform disperson of the resin and fibers therethroughout.

5. A method of forming strong, tough and resilient thermal insulating sheets which comprises, forming a gel-like cement containing approximately 1 part of polyvinyl resin and about 1.5–2 parts tricresyl phosphate plasticizer suspended in about 20 parts of volatile solvent, admixing with the cement about 4–5 parts rock wool and asbestos fibers in the proportions of about 2 to 1 by weight, agitating the mixture until the fibers are individually coated with the cement and a uniformly textured trowelable mixture results, shaping the mixture into sheet form, and heating the sheet to vaporize the solvent and complete stabilization of the resin.

6. A substantially uniformly textured, tough and resilient insulating sheet comprising 60%–75% by weight of reinforcing fibers including long and harsh mineral wool fibers and approximately 25%–40% of a flexible binder enveloping and bonding the fibers said binder retaining resilience and strength over a temperature range of —50°–300° F., and comprising approximately 1 part of polyvinyl resin and 1½–2 parts flameproofing plasticizer.

7. A flexible thermal insulating sheet of substantially uniform texture throughout comprising 60%–75% by weight of mineral fibers and 25–40% of a flexible binder individually coating and bonding said fibers, said binder comprising approximately 1 part polyvinyl resin and 1½–2 parts flameproofing plasticizer, and said sheet having a density of 20–40 lbs. per cubic foot, and a thermal conductivity of 4.–.6 B. t. u./(hr.) (sq. ft.) (°F. per inch).

8. A uniformly textured, tough and resilient insulating pad having a density of 5–35 lbs. per cubic ft. and a tensile strength of at least 200 lbs. per square inch comprising, 60%–75% by weight of mineral fibers, 10%–15% of polyvinyl resin binder, and 15%–25% tricresyl phosphate plasticizer.

9. A plastic fiber-binder composition consisting essentially of a mass of reinforcing fibers including long and harsh mineral wool fibers and polyvinyl resin binder enveloping said fibers and bonding them together with sufficient cohesion to retain substantially any form imparted thereto, said composition including a vaporizable solvent adapted to form with the binder a colloidal adhesive gel and having a non-vaporizable binder content approximating 25%–40% of the dry weight of the fibers and said binder comprising approximately 1 part polyvinyl resin and 1½–2 parts flameproofing plasticizer.

10. A plastic fiber-binder composition having a consistency suitable for application by troweling comprising 60%–75% by weight of rock wool and asbestos fibers, 10%–15% by weight of polyvinyl halide-acetate copolymer containing upwards of 90% polyvinyl halide, and 15%–25% tricresyl phosphate plasticizer, said composition being further plasticized and adapted for working up to uniform consistency by the presence therein of a solvent adapted to form with the copolymer and plasticizer a colloidal adhesive gel.

11. A uniformly textured plastic insulating cement having a consistency suitable for application by troweling consisting essentially of, 4–8 parts by weight of mineral fibers, 1 part of polyvinyl resin binder, 1½–2 parts tricresyl phosphate plasticizer, and approximately 40%–75% by weight of the mixture of a volatile solvent adapted to form with the binder a colloidal adhesive gel.

12. A uniformly textured plastic insulating cement having a consistency suitable for application by troweling consisting essentially of, 1 part by weight of polyvinyl resin, 1½–2 parts of tricresyl phosphate plasticizer, 4–8 parts by weight of harsh and long mineral fibers, and sufficient volatile solvent to impart the indicated consistency to the product, said solvent being adapted to form with the resin and plasticizer a colloidal adhesive gel.

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Certificate of Correction

Patent No. 2,389,460. November 20, 1945.

HARRY H. RINEHART

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, second column, line 15, claim 7, for "4.–.6" read *.4–.6*; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 4th day of June, A. D. 1946.

[SEAL]

LESLIE FRAZER,
First Assistant Commissioner of Patents.

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