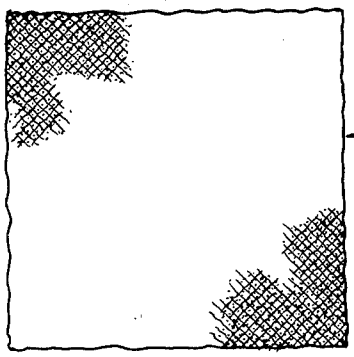
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CONFORMABLE ABRASIVE-COATED SHEET MATERIAL

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Fig. 1



Abrasive sheet material comprising abrasive grits bonded to a resin-impregnated multilaterally stretchable fibrous base sheet.

Fig. 2



Abrasive grits in resinous binder.

Doubly creped paper treated with a resinous impregnating and strengthening agent.

Fig. 3



Abrasive grits in resinous binder.

Resinous surface coating.

Doubly creped paper treated with a resinous impregnating and strengthening agent.

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CONFORMABLE ABRASIVE-COATED SHEET MATERIAL

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This invention relates to abrasive-coated sheet material of the nature of sandpaper, and in particular to sandpaper distinguished by improved conformability and flexibility in both the wet and the dry state. Coated abrasive sheet material prepared according to this invention may be hand-moulded to conform closely to such articles as metal balls, door-knobs, and the like, without wrinkling and tearing, and is therefore particularly useful in the operations of abrading and polishing these and other curved or irregularly shaped objects. The abrasive sheet may be used either in the presence or absence of water or of aqueous lubricants or cleansers.

A particular advantage of the improved abrasive sheet material of this invention is that it is substantially as conformable in the dry state as it is after soaking in water. The sheet at all times has a leathery feel and is flexible and yieldable.

Another important advantage over prior art coated abrasives which is a feature of the new abrasive structure is the improvement possible in the abrasive action or "cut" of the sheet during abrading or polishing operations in the presence of water. The effect is possible because the new construction permits the use of harder varieties of abrasive grit binding materials than can be tolerated in less flexible sheets. Since the backing itself is initially fully flexible and at the same time substantially completely waterproof, it is not necessary to employ soft and flexible binders for additional waterproofness. Instead, hard rigid types of resinous binders, which hold the abrasive grain firmly oriented for maximum cutting action, may be used where such cutting action is desired.

These and other advantages are obtained in the sheet abrasive products of the present invention by employing as the flexible backing material an impregnated and water-proof fibrous base sheet material having a leather-like feel and a universal stretch characteristic. Waterproofness and toughness or tear resistance in the product are obtained by impregnation of the fibrous sheet with suitable resinous compositions, examples of which will hereinafter be set forth. The universal stretch characteristic results in large measure from the use of an unwoven fibrous backing, such as a porous paper, having multi-lateral stretchability.

In the accompanying drawing,

Figure 1 represents in plan view a portion of a sheet of my conformable abrasive-coated sheet material comprising abrasive grits bonded to a

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resin-impregnated multilaterally stretchable fibrous base sheet, and

Figures 2 and 3 represent in enlarged cross-section two modifications of my conformable abrasive-coated sheet material.

In Figure 2, the resinous layer containing the abrasive grits is bonded directly to the impregnated doubly creped paper base sheet.

In Figure 3, the impregnated doubly crepe paper is provided with a resinous surface film or coating, over which is applied the resinous-bonded abrasive grit layer.

Paper having the required stretch characteristic is conveniently prepared by a double creping operation, involving a first creping of the paper to form a set of substantially parallel creping crinkles, and a second creping to form another similar set of crinkles at right angles to the first set. In the creping operation, the flat stock paper base, temporarily lightly adhered to the creping roll, is compressed or crowded back on itself as the roll revolves toward the doctor knife. The paper may be wet-creped, i. e. moistened with water and held to the creping roll by virtue of the moisture present. More advantageously, the paper may be given a light surface application of a thermoplastic adhesive material, sufficient to hold the sheet to the roll prior to contact with the doctor knife.

A preferred procedure combines the above two methods. The paper is first coated with a very light surface coat of a thermoplastic adhesive, which supplies the required temporary adhesion to the creping roll, and is also wetted with water prior to contact with the doctor knife. The creping roll is maintained at an elevated temperature sufficient to activate the thermoplastic adhesive when the coated paper is pressed against the roll surface. The wet, partially creped paper coming from the first operation is transferred to the second creping roll under minimum tension so as to avoid removing any great percentage of the crepe. After the second creping operation, the paper is dried. The product is universally stretchy, i. e. may be stretched in all directions, and is soft and porous.

In the above procedure, the thermoplastic adhesive may be applied from solution in an organic solvent, as an aqueous dispersion, or in any other convenient form. It may be applied directly to the paper, or pre-coated on the creping drum. Where a dispersion is used, the amount of water subsequently to be added may be greatly decreased or entirely eliminated.

Still another variation involves the prelimi-

nary impregnation of the uncreped paper with the resinous water-proofing agent applied in solution form, drying to a suitably adherent state, and double creping of the impregnated web. The remainder of the solvent is then removed. However, creping of the unsaturated paper in the wet state is ordinarily preferred, since such creping operation provides for a more open or porous sheet as well as a sheet which maintains its stretchiness when dried.

Small sheets of paper, of a size suitable for individual sheets of sandpaper, may be cross-creped by hand operations in a direction which is independent of the fiber orientation of the paper. For example, a flat sheet of paper may be lightly adhered to a flat glass or metal panel, as by means of a resinous thermoplastic adhesive, and removed in creped form by lifting from a metal straight-edge forced across the panel and against any edge or corner of the sheet, the process then being repeated with the straight-edge placed at right angles to the first direction relative to the paper.

In commercial operations on continuous paper strips or sheets, with the paper being creped on steel rolls or belts, the two sets of parallel crepe marks or crinklings are commonly formed at substantially 45 degree angles with the major axis of the web.

Cross-creped or X-creped papers as above produced have a universal stretch characteristic, and may be so controlled as to have a fine, uniform surface texture. Where the surface is less uniform than desired, as where the crepe lines are undesirably large or far apart or the creped paper is undulating or cockled, the sheet may be improved for use as an abrasive base by calendering. The action of the calender evens out many of the surface irregularities, but should be so controlled as not to remove any appreciable percentage of the stretchiness imparted during the creping operation.

A typical cross-creped sheet which has provided an excellent base for my novel abrasive sheet material is a 60-pound kraft paper, doubly creped substantially at 45° to the longitudinal axis of the web as hereinabove described. The creped sheet has a caliper of 18–20 mils and a basis weight of 120–130 pounds (per ream of 320 square yards). When placed under tension in any direction, the sheet will stretch at least one-third of its original length before breaking. Lengthwise and crosswise tensile strengths are about 6–8 and 8–10 lbs./inch respectively. The paper is quite porous, having a porosity value of 4–5 seconds (single thickness, 400 cc. of air) when tested in the Gurley Densometer. Even with the lightweight coating of thermoplastic creping adhesive on one side thereof, the paper is rapidly and completely wetted by water, and when soaked in water soon weakens and disintegrates.

The above-described paper exemplifies the type of product here contemplated as a base sheet in the preparation of the novel abrasive products of this invention. However, the invention is not to be limited to the specific doubly-creped paper here described, but is generic to this general class of products having a universal stretch characteristic and a high degree of flexibility in addition to the required tensile strength, caliper, regularity of structure, porosity, and the like.

The creped base sheet is first impregnated with a suitable flexible waterproofing and strengthening composition having high adhesion to the paper fibers, and which may comprise a thermoplastic film-forming synthetic resin dissolved in a volatile solvent. Vinyl resins such as polyvinyl acetate or polyvinyl acetals, cellulosic derivatives such as ethyl cellulose or cellulose acetate, rubbery polymers such as neoprene or Thiokol (polyalkylene polysulfide polymer), acrylate polymers, and the like may provide the major component, preferably in combination with minor proportions of suitable plasticizers, pigments, resins, or other modifiers. A typical formula consists of 50 parts by weight of polyvinyl acetate resin, e. g., Vinylite AYAT; 15 part of compatible phenolic varnish resin such as Bakelite No. 254 oil-soluble phenolic resin; 30 parts of plasticizer, e. g. tricresyl phosphate; and 15 parts of "Dicalite," a diatomaceous earth mineral filler; all in a solvent mixture of 100 parts of ethyl alcohol and 100 parts of xylol.

Cross-creped paper as above identified was impregnated with a total of 15 grains dry weight (per 24 square inches) of this plasticized polyvinyl acetate composition, applied in two passes through the solution with intermediate drying. An additional coating of 2 grains of the unmodified polyvinyl acetate, applied in solution in a similar solvent mixture, was then applied to the surface of the sheet which was later to carry the abrasive grit. This resinous coating provides a desirable water-resistant adherent sub-surface for the grit binder coating; however it is not an essential component of the sheet. On the ream basis, the corresponding values are: paper, 120–130 lbs.; impregnation, 35–40 lbs.; and surface coating, 4–6 lbs. The impregnant is equal to at least about one-third the weight of the untreated paper. Larger amounts may be incorporated, up to complete filling of the porous paper, but the amount indicated has been found to give adequate waterproofness with desired flexibility and economy.

The sub-surface film or coating helps to fill or impregnate any remaining surface pores or irregularities, to prevent penetration of water into the impregnated paper through cracks or breaks in the abrasive coating, and to provide improved bonding between the abrasive grit layer and the impregnated paper. A similar coating may be applied to the back surface of the treated paper if desired. These coatings may be applied from solution or suspension, by calendering at elevated temperatures (i. e., by a "hot melt" procedure), or as pre-formed self-supporting films. The latter type of coating may be applied either by hot pressing, if the film is thermoplastic, or by means of an intermediate adhesive coating.

Any of the conventional water-proof flexible abrasive binder compositions may be used in bonding abrasive grits to the sized surface of the impregnated flexible backing. Such binders may, for example, consist of oleoresinous varnishes or of oil-modified alkyd resins. Similar compositions may also be used as sandsize coatings, applied over the layer of abrasive grid to provide additional bonding properties.

Specifically, the above-described impregnated and coated creped paper base sheet was coated with 2 grains per 24 sq. in., dry basis, of alkyd resin binder made from polybasic acid, polyhydric alcohol, and drying oil free fatty acid, dissolved in xylol to a coatable viscosity. An excess of Grit 320 silicon carbide abrasive grain was applied, and the portion not bonded by the binder coating was shaken off. The binder was then dried in an oven, and a sandsize coating was applied over the partially bonded grit. This coat-

ing consisted of 4–6 grains, dry weight, of oleoresinous varnish made from wood oil and phenolic resin and having an oil:resin ratio of 3:1. The sheet was dried and baked at elevated temperature to complete the cure of the binder and sandsize coats.

Other abrasive grains, e. g. aluminous oxide, and other grit sizes may replace the specific grit here used. Increased amounts of abrasive bond are ordinarily required with larger grit sizes. The abrasive grain may be surface treated, if desired, to provide improved specific adhesion between binder and grain.

When completed, the abrasive paper was flexible and pliable, and had a leathery or chamois-like feel. It could be stretched in all directions so as to conform to various irregular surfaces. For example, sheets of a size suitable for hand-sanding operations were used in smoothing and polishing objects such as metal door-knobs and metal faucets; contact of abrasive with metal could be established over a large proportion of the total metal area, without wrinkling or tearing the sheet. The extent of stretch possible was shown by stretching a narrow lengthwise strip of the abrasive product. A 2-inch measured strip, when stretched to 2⅞ inches and released, showed a recovery of ⅛ inch, i. e. to 2¾ inches; the strip broke when stretched to 3 inches.

In wet sanding operations, the abrasive sheet did not crack up nor disintegrate even after prolonged use, but maintained a good rate of cut until the abrasive grit was largely worn away.

Long-oil varnishes, i. e. varnishes containing about three parts of drying oil for each part by weight of resin, are quite soft and flexible in the form of thin films or coatings. Binders or sandsizes of this type are commonly used in conjunction with the usual dense and stiff kraft flat stock paper in the production of coated abrasive products. Their softness and flexibility improves the flexibility of the sheet and aids in maintaining an effective water barrier. But soft abrasive bonds (binder and sandsize coatings) allow the abrasive grains to be easily moved or displaced in the abrasive layer, and reduced the cutting efficiency of the sheet. Harder coatings, being more brittle, are found to crack and break up when the abrasive sheet is flexed in use. Penetration of water through the cracks into the interior of the sheet then causes rapid softening and degradation of the paper base, with the result that the abrasive sheet must be discarded long before the abrasive coating has given full service.

In the present invention, much harder binder and sandsize compositions may safely be employed, resulting in improved performance of the abrasive sheet with respect to abrading or cutting qualities. The individual grains are held more firmly in position, and cut into the work surface rather than sliding over it. Due to the superior flexibility of the underlying backing, the abrasive sheet retains sufficient flexibility so that it readily conforms to irregularly shaped surfaces. Thus, when for the long-oil varnish of the above example there was substituted a much harder product having an oil:resin ratio of 1:1, the cut of the abrasive product was improved without any noticeable decrease in the conformability of the sheet during abrading operations.

Where only a polishing action is desired, it is customary to employ binders and sandsizes which are even less hard than the compositions of 3:1 oil:resin ratio.

In addition to the oleoresinous and alkyd resin compositions, plasticized cellulosic derivatives, vinyl resins, and other suitable waterproof bonding and sizing materials may be so employed.

The untreated creped paper used in the practice of my invention takes up water quite rapidly. Unless preliminarily treated so as to improve the wet strength, e. g. with small amounts of in situ-regenerated cellulose, or melamine-formaldehyde resin, or other suitable material, the paper rapidly weakens and starts to fall apart when soaked in water. In contrast, paper of equivalent basis weight and caliper which has not had an equivalent creping operation is quite dense and requires relatively prolonged soaking in water before disintegration occurs. Particularly in view of this difference, the results which I obtain are quite unexpected and surprising. Employing substantially identical grit binding and sizing compositions as are employed in the waterproof coated abrasive art, I obtain an abrasive sheet material which is initially, and without preliminary soaking in water, desirably flexible and yieldable, yet has high cutting and polishing efficiency. After prolonged soaking of the sheet in water, as is unavoidably experienced in many wet sanding operations, my improved abrasive product still retains substantially all of its initial strength and handling properties, whereas initially less flexible sheets having an uncreped paper base of equivalent weight and caliper rapidly become weakened and may even begin to disintegrate under the same conditions.

In addition, I may employ binder and sandsize compositions of increased hardness, thus obtaining high cutting efficiency as compared to prior known waterproof flexible abrasive sheet material, while still maintaining superior flexibility and conformability.

What I claim is:

1. A waterproof flexible abrasive sheet material of high initial flexibility and of high efficiency in the presence of water, having a degree of stretch at break in any direction equivalent to at least about one-third of the initial length and capable of conforming to irregular surfaces by substantial universal stretching under tension both in the dry state and after prolonged immersion in water, said sheet comprising: a multilaterally stretchable fibrous base sheet characterized by a plurality of crossing sets of creping crinkles; a resinous impregnating and strengthening agent for said sheet comprising a thermoplastic film-forming waterproof synthetic resin; a resinous binder coat; and a layer of abrasive grits embedded in said binder coat.

2. A waterproof flexible abrasive sheet material of high initial flexibility and of high efficiency in the presence of water, having a degree of stretch at break in any direction equivalent to at least about one-third of the initial length, and comprising: a doubly creped paper base sheet having a universal stretch characteristic; a resinous impregnating and strengthening agent for said paper base sheet comprising a plasticized waterproof film-forming polyvinyl resin; a resinous binder coat; a layer of abrasive grits embedded in said binder coat; and a resinous sandsize coat.

3. A waterproof flexible abrasive sheet material having a leathery feel, having a degree of stretch at break in any direction equivalent to at least about one-third of the initial length, and being capable of conforming to irregular surfaces without wrinkling or tearing, by substantial universal stretching under tension, both in

the dry state and after prolonged immersion in water, said sheet comprising: a multi-laterally stretchable fibrous base sheet characterized by superposed, substantially oppositely disposed diagonal sets of creping crinkles; a resinous impregnating and strengthening agent for said sheet comprising a thermoplastic film-forming waterproof synthetic resin; a flexible surface film bonded to the impregnated base sheet and comprising a synthetic resin; a resinous binder coat; a layer of abrasive grits embedded in said binder coat; and a resinous sandsize coat.

4. A waterproof flexible abrasive sheet material having a leathery feel and being capable of conforming to irregular surfaces without wrinkling or tearing, by substantial universal stretching under tension, both in the dry state and after prolonged immersion in water, said sheet consisting of a flexible waterproof backing and a layer of abrasive grits bonded thereto, and said backing comprising a multi-laterally stretchable paper base sheet characterized by superposed, substantially oppositely disposed diagonal sets of creping crinkles, impregnated with at least about one-third its weight of plasticized polyvinyl acetate, and coated on at least one surface with a continuous film of polyvinyl acetate, and said abrasive sheet product being capable of a degree of stretch at break, in any direction along the sheet, of at least 30% of the original length.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,241,738	Klatte et al.	Oct. 2, 1917
1,775,631	Carlton	Sept. 16, 1930
2,343,930	Rowe	Mar. 14, 1944

FOREIGN PATENTS

Number	Country	Date
417,177	Great Britain	Sept. 24, 1934
417,234	Great Britain	Sept. 24, 1934