This invention relates to coated abrasives, and more particularly to a new method of producing coated abrasive articles and the product resulting therefrom. The primary object of the invention is the production of coated abrasive products, such as sheets, strips, discs, and the like, which are characterized by a reduction or elimination of the usual tendency to curl or cup after the articles have been completed.

Hereinafter, in the manufacture of coated abrasives, such as sandpaper, it has been a common trouble to experience what is known as cupping of the coated abrasive sheets and belts. By cupping it is meant that the belt or sheet, as the case may be, does not lie flat after fabrication, but curls or cups on an axis either parallel or at right angles to the machine direction of the paper. This cupping or curling may occur:—

1. With the sand coating on the convex surface, and
2. With the sand coating on the concave surface.

Generally speaking, what is known as closed coats, or tight (closely arranged) grain coatings, curl with the sand on the convex surface, whereas open coatings, or coatings where there is considerable space between the grains, curl with the abrasive grains on the concave surface. In either event, serious difficulty arises in using the product since it is normally desired to sand a flat surface.

In the case of a belt with a sand concave curl, the tendency is to cut into the work deeply on the edges of the belt and to cut less deeply with the center of the belt. If the sand is on the convex surface, the situation is reversed, a deep cup being produced in the center of the belt and a more shallow cut being produced on the edges of the belt. Not only is this true, but breakage of belts often can be traced to curling of the coated belt.

In cases of sheets that are used for hand sanding operations, it is also desirable to have a flat surface, the handling of a curled sheet being very inconvenient and resulting in decreased production as well as a poorer quality of work.

In the manufacture of coated abrasives, it is common practice to apply a coat of adhesive, generally animal glue, to a paper backing (for belt use, normally cylinder paper) and then to apply a coat of abrasive grains, such, for instance, as Garnet or Alumina, partially dry the first adhesive coat and then apply a second or sizing coat of adhesive. After the second adhesive coat is applied, the coated web is dried and taken down in the form of rolls for subsequent slitting into belts or cutting into sheets.
or close coat of grain so as to resist wearing away of the abrasive edges and give the desired production. Paper belt or sheet of coated abrasives. On the contrary, soft, greasy leather should be sanded with an open coating of sand so as to leave plenty of clearance between the grains and prevent premature failing of the coated abrasive by the gritty bulk material that is being ground. Failure in such cases occurring as a result of filling between and over the grains. Thus, the many uses to which coated abrasives are put in the art require a wide variety of different types of coatings, and no single type of paper backing is suitable for all.

It is a primary object of the present invention to produce a complete line of coated abrasives having greatly improved non-curling characteristics. This object is accomplished by a new method of controlling the expansion-contraction characteristics of the paper backing sheet under moisture content changes, and relating those characteristics to the corresponding characteristic of the particular type of adhesive abrasive coating desired.

In the case of coated abrasive belts, strong rope papers made on a cylinder paper machine are normally used to meet the requirements for high longitudinal tensile strength and good tearing strength and to prevent the destruction of the belt on the machine. Long wood fibers have been used to some extent and it is common practice to employ some jute in the furnish. Various mixtures of rope, wood and jute are also used. In the manufacturing of papers especially on a cylinder machine as heretofore used, the fibers are oriented with the long direction of the fiber predominantly parallel to the running direction of the cylinder machine. The result is a relatively high length strength of the paper as compared with the cross strength of the papers.

I have discovered that, when an individual fiber expands or contracts with gain or loss of moisture, the resulting change in its dimensions is very largely a change in the diameter or short direction of the fiber, the length direction being changed to a much smaller degree. I have determined that it is the sum total of expansions and contractions of the individual fibers that determines the expansion-contraction characteristics of the paper. Thus, the proportion of transversely disposed fibers to longitudinally disposed fibers in the sheet not only controls the cross to length tensile strength ratio, but also, the ratio between transverse and longitudinal contraction and expansion characteristics of the sheet under changes in moisture content, such as may result from changes in the humidity of the surrounding atmosphere. As the proportion of cross fibers and relative transverse tensile strength is increased, the relative transverse contraction and expansion characteristic of the sheet is decreased.

If we consider, for example, 130 lb. rope cylinder paper, length strength usually varies from 130 to 150 lbs. per inch of width of paper, whereas as the cross strength, per inch of width of paper, will vary from about 50 to 75 lbs. Fourdriner papers have a much lower length strength and a somewhat increased relative cross strength.

Still Fourdriner papers are generally so suitable for belt work because of their low length tensile strengths.

If we consider any specific paper, either rope or Fourdriner, the orientation of the fibers is roughly indicated by the length and cross tension strengths. Cylinder papers as made in the past for coated abrasive work have had a cross to length tensile strength ratio falling between .31 and .52. Generally speaking, closed coats of sandpapers with a ratio of about .45 to .52 have only a moderate degree of curl. With open coatings, the curl may be quite bad, sand concave. With closed sand coats, papers with a cross to length ratio of .31 to .40 curl quite badly, sand convex. With open coatings, the tendency to curl sand concave is only moderate for papers showing a cross to length ratio of .31 to .37.

In addition to the cross to length relation, the expansion-contraction characteristics are controlled, somewhat, by the density of the paper. A less dense paper will expand and contract and curl less than a more dense paper, provided the paper is not so porous that substantial penetration of the adhesive into the paper occurs. This means that for a given basis weight of paper curling will be decreased by using a relatively thick (high caliper) paper instead of a thin (low caliper) paper. Thus, 130 lb. rope cylinder paper with a caliper of 11.5 mils will curl less than 130 lb. cylinder paper with a caliper of 9.0 mils. Generally speaking, the thick papers have a relatively rough surface and are not, therefore, so suitable for fine grits of coated abrasives.

For this reason, it is advisable to still further increase the cross to length tensile ratio and obtain a flat product with the smoother and more dense paper.

Herefore, the importance of control of fiber orientation has not been appreciated in the coated abrasive art. Moreover, even accidentally strong cylinder paper has not existed which met the requirements for belts and other severe machine operations, with a cross to length strength ratio in excess of .52; also, there has not been used in the paper backed abrasive industry, a coated abrasive paper backing with a cross to length ratio below .31. As a result of my discoveries and by the use of suitable equipment, such as the Stober Cylinder Machine, of the type disclosed in United States Patent 1,924,154, it is now possible to control the cross to length strength ratios within wide limits and produce backings for coated abrasives which have the desired cross to length tensile strengths and the desired transverse and longitudinal expansion and contraction characteristics under changes in moisture content.

Desirable cross to length strength ratios for closed coats of sandpaper intended for use as belts or machine covers, have been found to be preferably from .52 to .65, although in some cases there is an advantage in using a paper with a cross to length ratio in excess of .65. For very open sand coats for the same uses a desirable ratio range of cross to length strength is .25 to .31.

It should be understood that the curl found objectionable for Belts, drum covers and similar mechanical operations is the curl about an axis parallel with the running direction of the belt or cover, as the case may be. This is true since the belts or covers are handled in roll form, the roll being wound around an axis perpendicular to the long direction of the belt or cover. When belts or covers, however, run upon the machine, cupping or curling about an axis perpendicular to the running direction is prevented by the tension that is applied to the belt or cover.

Thus, it is of maximum importance to control the cross fibre content of the paper and the re-
resulting cross tensile strength, and transverse expansion and contraction characteristic of the sheet for belt use, so that the latter characteristic corresponds substantially with the expansion and contraction characteristic of the sheet as a whole. The requirement for longitudinal tensile strength is satisfied, if the paper is strong enough to withstand the tension under which it is used. Control of the cross fibre content and transverse expansion and contraction, to correspond to expansion and contraction of the glue-sand cold will prevent curling of the belt about an axis parallel to the length of the belt, which is the important consideration.

When we consider coated abrasives in sheet form, sometimes known as ream paper, the material is not necessarily kept under tension in use. As a matter of fact many of these sheets are used primarily for hand operations and no tension is applied. Likewise, the sheet may be used in any direction and there is no requirement for excess strength in one direction to the exclusion of strength in the other direction. For such uses as this, a superior product is produced by having equal strengths in all directions. In fact, the open cost sheet cut out of a cylinder paper with a low cross to length ratio, the sheet curtailed, sand concave, about an axis perpendicular to the machine direction of the original paper backing. Since the requirements for tensile strength are not so severe, so-called Fourdriner papers are used in many cases for goods that are to be cut into sheet form. In the case of Fourdriner paper, the balance between cross to length strength is better, ratios as high as 87 occurring in the case of Fourdriner papers. Such paper has not, however, eliminated the curling of sheet form coated abrasives. A common form of sheet is 9" x 11". As will be apparent, it is impossible to match the expansion and contraction of the paper with a sand cold coat because so long as the paper has an unbalanced structure and an unequal expansion and contraction in the two directions, it will change unequally with the humidity in the machine and cross directions. The ideal product would be one which would be flat under all conditions, such a product can only be made by producing a balanced paper with a cross to length strength ratio of, roughly, 1, and then matching the expansion and contraction of this paper with a definite sand-glue coat. As previously explained, no single sand weight coating will meet all the requirements of the trade. I have found that from the commercial standpoint, the most satisfactory solution for the sheet problem is to produce an appropriate backing with, roughly, cross to length ratio of 1, and then use the sand coat best suited for the operation in question. It is true that the product will often tend to curl on one axis or the other, or to maintain a spherically surface. The curl, however, on the average, is less than if the paper has unbalanced structure which in one direction gives a greater expansion or contraction and in the other a lower expansion or contraction with changes in humidity, than is the case in either direction if the paper backing has a balanced structure. This can be easily understood. Many of these sheets approach squares or in any case, have the long and short dimensions of the same order of magnitude. A curl on either axis may, therefore, occur with substantially equal facility, and the nearest approach to a flat sheet is one with a balanced structure of the backing having an equal expansion and contraction in the two directions with changes in humidity, since the alternate is a backing with one direction having a higher and the other direction a lower rate of change with changes in humidity than is the case in either direction with the balanced structure which has in both directions, equal but intermediate rates of change with humidity.

A balanced structure of backing for hand sheets has the further advantage of a uniform strength in all directions. With hand sheets the direction of rubbing in use is largely a matter of chance, hence ease of breakage is more often dependent upon the weakest direction of the paper. With a balanced structure of paper, the strength in any direction is less than that of the stronger direction of unbalanced paper, but is appreciably greater than that of the weaker direction. It is a common practice in the coated abrasive industry to form a backing by combining cloth and paper with an adhesive such as animal glue. I have found that the expansion characteristics of the paper with changes in humidity very largely determine the curl of coated abrasives made with this combination backing, in which the abrasive and adhesive coating is applied to either the paper or the cloth side of the combination. It has been found that a backing with improved curling characteristics is produced by selecting paper in accordance with the principles heretofore laid down for selecting paper backings. Where I refer to "a paper backing" in the specification and claims, I intend to cover a cloth paper combination backing, as well as a backing consisting solely of paper.

It is also common practice to use as a backing for coated abrasives, especially for discs that are to be used in leveling welds and projecting edges in metal work, a backing consisting either of vulcanized fibre or of vulcanized fibre combined with cloth, with an adhesive such as animal glue. By "vulcanized fibre" which I intend to include by the broad term "paper", is meant, a paper of commercially pure cellulose usually made of rags or of highly purified cellulose such as alpha fibre, which has been treated with zinc chloride, sulphuric acid, calcium sulphocyanate or similar solutions well known in the art, to produce a highly hydrated, relatively stiff, and dense product. I have found that discs made by coating either fibre or fibre-cloth combination, have a much smaller tendency to curl or cup if the fibre has a high cross to length tensile strength ratio. The improved by using fibre with a cross to length tensile strength ratio of substantially 1. Not only is such a ratio advantageous in preventing curl but since the material is used in the form of a disc, the requirements for tensile strength are the same in all directions. It has further been determined that the higher the cross to length tensile strength ratio of the paper used for making the vulcanized fibre, the higher the same ratio for the finished vulcanized fibre. While it is very difficult to produce a vulcanized fibre with a cross to length ratio equal to 1, it is possible to more closely approach this ratio than has been
the case in the past. Herefore, it has not been the practice to make vulcanized fibre with a cross to length tensile ratio in excess of .52. However, when the tested length ratio is .52, it has been found possible to produce vulcanized fibre with a ratio well in excess of .52. Where I refer to a vulcanized fibre backing in the specification and claims, I intend to cover a cloth-vulcanized fibre combination backing as well as a backing consisting solely of vulcanized fibre.

In cases where a synthetic phenolic resin or other relatively non-hygroscopic adhesive is used to replace the relatively hygroscopic adhesives, such as animal glues, the paper, combination, or fibre backing expands and contracts to an appreciable extent, i.e., substantially the usual extent, with changes in humidity, but the adhesive changes in dimensions to only a negligible extent with changes in humidity. In such cases, it is advantageous to use as a backing, or in making combination backing, paper or fibre with the lowest rate of change in dimensions with humidity (highest cross to length tensile ratio), consistent with other requirements, i.e., breaking tensile strength in length direction for belts and the like.

From the point of view of both method and article, the present invention has as its important bearing on coated abrasives which are made in accordance with the recently developed electrostatic and magnetic methods of depositing and orienting the abrasive grains upon an adhesively coated backing sheet. In these methods great pains are taken accurately and carefully to orient the grains on the sheet, in predetermined relation to each other, and with their major axes perpendicular to the sheet. Obviously, some of the advantages which might be expected to result from such orientation of the grains are lost, if their position with respect to the sheet and the work is subsequently changed. When an abrasive sheet curls in accordance with changes in atmospheric conditions, the relation of the grains to one another and to the backing sheet is necessarily altered. Such curling of the sheet and the changing of the angles of the grains is undesirable in specially oriented sandpaper abrasive.

Thus, the present invention, which results in a non-curling sandpaper, improves the product made by the recently developed electrostatic and magnetic depositing and orienting means, because it results in maintaining the orientation, and the predetermined positioning of the abrasive grains accomplished by such methods.

Where cross to length tensile strength ratio is used in these specifications, it should be understood that this ratio is obtained by dividing the cross tensile strength by the length tensile strength. The length direction is what is known as the machine direction. The cross tensile strength is obtained by testing 4" strips of paper cut perpendicular to the machine direction. The length tensile is obtained by testing 4" strips which are cut parallel to the machine direction. All tests are made at a relative humidity of 65% and a temperature of 70°F., after the paper has been conditioned at this humidity and temperature for at least two hours. A paper testing machine, motor driven, such as a Scott machine, is used. At least three samples are used for each determination. The testing machine is motor driven. The distance between jaws of the testing machine is 5", and the speed of travel of the testing machine is from 7 to 8 inches per minute. Samples that break in the jaws of the testing machine should be rejected. Results used as cross and length percentages are uniformly calculated, and are the average of three tests in each case.

It should also be understood that where the term "cylinder paper" is used, the paper may be formed on one cylinder to produce a one ply cylinder paper, or on two or more cylinders to produce a multiple ply cylinder paper.

I claim:—

1. A coated abrasive comprising a paper backing and an adhesive abrasive coating thereon, said paper backing having its fibres so selectively oriented that the selected resultant ratio of its length strength to its cross strength is such as to make the expansion and contraction differential between the paper and the adhesive abrasive coating in the presence of humidity changes so small that the coated abrasive is rendered substantially completely non-curling when exposed to variable humidities.

2. An open coated abrasive article comprising a paper backing and an adhesive abrasive coating thereon, said paper backing having its fibres so oriented that the ratio of its length strength to its cross strength is such as to make the expansion and contraction differential between the paper and the adhesive abrasive coating in the presence of humidity changes so small that the coated abrasive is rendered substantially completely non-curling when exposed to variable humidities.

3. A close coated abrasive article comprising a paper backing and an adhesive abrasive coating thereon, said paper backing having its fibres so oriented that the ratio of its length strength to its cross strength is such as to make the expansion and contraction differential between the paper and the adhesive abrasive coating in the presence of humidity changes so small that the coated abrasive is rendered substantially completely non-curling when exposed to variable humidities.

4. An abrasive belt comprising a paper backing and an adhesive abrasive coating thereon, said paper backing having its fibres so oriented that the ratio of its length strength to its cross strength is such as to make the expansion and contraction differential transversely of the belt between the paper and the adhesive abrasive coating in the presence of humidity changes so small that the coated abrasive is substantially completely non-curling transversely of the belt when exposed to variable humidities.

5. A coated abrasive comprising a paper backing and an adhesive abrasive coating thereon, said paper backing having its fibres oriented to produce substantial equality in cross to length strength ratio and in cross to length ratio of expansion-contraction characteristics under humidity changes, said composite adhesive abrasive coat having an expansion-contraction characteristic under humidity changes which is equal in all directions so that the expansion and contraction differential between the paper and the adhesive abrasive coating in the presence of humidity changes is so small that the coated abrasive is rendered relatively non-curling when exposed to variable humidities.

6. A coated abrasive article such as an elongated sandpaper belt comprising a backing sheet of cylinder paper and a close coat of abrasive grains adhesively united thereto, said paper backing having its fibres so oriented that the ratio
of its length strength to its cross strength is within the range of substantially 0.52 to 0.65 and is such as to make the expansion and contraction differential transversely of the belt between the paper and the adhesive abrasive coating in the presence of humidity changes so small that the coated abrasive is relatively non-curling transversely of the belt when exposed to variable humidities.

7. A coated abrasive article such as an elongated sandpaper belt comprising a backing sheet of paper and an open coat of abrasive grains adhesively united thereto, said paper backing having its fibres so oriented that the ratio of its length strength to its cross strength is within the range of substantially 0.52 to 0.65 and is such as to make the expansion and contraction differential transversely of the belt between the paper and the adhesive abrasive coating in the presence of humidity changes so small that the coated abrasive is relatively non-curling transversely of the belt when exposed to variable humidities.

8. A coated abrasive comprising a paper backing and an adhesive abrasive coating thereon, said paper backing having its fibres so oriented that the ratio of its length strength to its cross strength is within the range of substantially 0.70 and 1.0 and having transverse and longitudinal contraction and expansion characteristics which proportionately approach equality as to make the expansion and contraction differential between the paper and the adhesive abrasive coating in the presence of humidity changes so small that the coated abrasive is rendered relatively non-curling when exposed to variable humidities.

9. A coated abrasive having a paper backing comprising vulcanized fibre and an adhesive abrasive coating thereon, said paper backing having its fibres so oriented that the ratio of its length strength to its cross strength is in excess of 0.52 and is such as to make the expansion and contraction differential between the paper and the adhesive abrasive coating in the presence of humidity changes so small that the coated abrasive is relatively free from curling when exposed to variable humidities.

10. A coated abrasive comprising a paper backing and an adhesive abrasive coating thereon, said adhesive being non-hygroscopic, the paper backing having its fibres so oriented that the ratio of its length strength to its cross strength is substantially within the range of 0.70 and 1.0 and is such as to make the expansion and contraction differential between the paper and the adhesive abrasive coating in the presence of humidity changes so small that the coated abrasive is relatively free from curling in all directions when exposed to variable humidities.

11. A coated abrasive comprising a paper backing and a synthetic resin adhesive abrasive coating thereon, said adhesive being non-hygroscopic, the paper backing having its fibres so oriented that the ratio of its length strength to its cross strength is substantially within the range of 0.70 and 1.0 and is such as to make the expansion and contraction differential between the paper and the adhesive abrasive coating in the presence of humidity changes so small that the coated abrasive is relatively free from curling in all directions when exposed to variable humidities.

12. A coated abrasive comprising a paper backing and a synthetic resin adhesive abrasive coating thereon, said paper backing having its fibres so selectively oriented that the selected resultant ratio of its length strength to its cross strength is such as to make the expansion and contraction differential between the paper and the adhesive abrasive coating in the presence of humidity changes so predeterminedly small that the coated abrasive is rendered substantially completely noncurling when exposed to variable humidities.

13. An open coated abrasive article comprising a paper backing and an adhesive-abrasive coating thereon, said paper backing having its fibres so oriented that the ratio of its length strength to its cross strength is within the range of substantially 0.25 to 0.31 and is such as to make the expansion and contraction differential in the cross direction between the paper and the adhesive abrasive coating in the presence of humidity changes so small that the coated abrasive is rendered substantially completely noncurling on an axis parallel to the machine direction when exposed to variable humidities.

14. A close coated abrasive article comprising a paper backing of cylinder paper and an adhesive-abrasive coating thereon, said paper backing having its fibres so oriented that the ratio of its length strength to its cross strength is within the range of substantially 0.35 to 0.65 and is such as to make the expansion and contraction differential in the cross direction between the paper and the adhesive-abrasive coating in the presence of humidity changes so small that the coated abrasive is rendered substantially completely noncurling on an axis parallel to the machine direction when exposed to variable humidities.

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