

A METHOD OF PREPARING A GROOVED MASTER
USED IN THE PREPARATION OF AN EMBOSSING TOOL

The invention is directed to the field of continuous embossing of sheeting or webs and more particularly to methods and apparatus of producing large scale, flexible, and generally cylindrical embossing tools to emboss continuous plastic webs or the like with a highly accurate pattern of cube-corners useful in the manufacture of retroreflective sheeting.

Description of the Prior Art

Some presently employed techniques for the production of retroreflective sheeting include the casting of cube-corners on cylindrical drums, followed by an application of secondary material, whereby the cube-corner elements are adhered to a different back-up material (e.g., Rowland No. 3,935,359).

Sequential embossing of cube-corner type sheeting material has been suggested by using a series of tooled plates and molds. The web of material is embossed on one stroke of the press and then indexed to the next station for a further pressing operation (Rowland Patent. No. 4,244,683). This process, while operating on a continuous strip of material, is only sequential in nature and has all of the economic and manufacturing deficiencies inherent in such a process. Moreover, to be economically feasible, the width of film or sheeting to be produced, such as 48", requires extensive mold handling capability not contemplated by the Rowland '683 structure and process.

Small, rigid cylindrical rolls also are available for the general continuous embossing of webs of sheet material but, because of the high degree of optical

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accuracy required in reproducing cube-corner elements, this technique has not been used to produce continuous sheeting.

Continuous belt type embossing tools also have been disclosed for embossing non-optically critical patterns in thermoplastic or other materials, such as shown in Bussey et al, No. 3,966,383. It also is well known in the cube-corner reflector art to use electroformed tools for producing mold elements. However, the relatively small area encompassed by the typical reflective area permits the easy separation of the electroformed part from its "master" or from pins. To produce a tool required to emboss large areas of sheet, it would be possible to assemble larger and longer groups of masters, but minute seams would be found at the junction lines. Those seams in a final tool could produce stress risers, flash or fins, leaving the assembled tool with possible fatigue areas.

According to the invention, there is provided a method of preparing a ruled master with a precise pattern consisting of more than one ruled line, from a metal element having at least one planar surface, such master to be used in the production of embossing tools, comprising the steps of forming a first groove in a planar surface of the metal element; filling said first groove with a synthetic material of appropriate hardness and machinability; positioning said metal element to a second position; forming a second groove in said planar surface of said metal element, said second groove intersecting said first groove, and removing said fill material from the remainder of said first groove.

The method may further comprise additional steps of filling both said first and said second grooves with a synthetic material of appropriate hardness and machinability; positioning said metal element to a third

position; forming a third groove in said planar surface of said metal element, said third groove intersecting said first and second grooves; and removing said fill material from the remainder of said first and second
5 grooves.

The first, second and third grooves may be formed by cutting into said planar surface with a cutting tool having a triangular cross-section whereby the land between said first, second and third grooves is in the
10 shape of an equilateral triangle. Alternatively, the first, second and third grooves may be formed by cutting into said planar surface with a cutting tool having a v-shaped cross-section whereby the land between said first, second and third grooves is in the shape of an
15 isosceles triangle.

The invention further provides a method of preparing a ruled master from a metal element, having at least one planar surface to be used in the production of embossing tools comprising the steps of: forming a first series of
20 uniformly spaced parallel grooves in a planar surface of the metal element; filling said first series of grooves with a synthetic material of appropriate hardness and machinability; rotating said element to a position 120° from said first series of grooves; forming a second
25 series of uniformly spaced grooves in said planar surface of said metal element, said second series of grooves intersecting said first series of grooves; and removing said fill material from the remainder of said first series of grooves.

30 The method may further comprise the steps of filling both said first and second series of grooves with a material of appropriate hardness and machinability, rotating said element to a position 120° from said second series of grooves, forming a third series of uniformly
35 spaced grooves in said planar surface of said metal

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element, said third grooves intersecting said first and second series of grooves, and removing said fill material from the remainder of said first and second series of grooves.

5 The second and third series of grooves may be formed by cutting into said planar surface of said metal element with a cutting tool having a v-shaped cross-section whereby the lands defined by said first, said second and said third series of grooves produce a multiplicity of
10 tetrahedrons.

 The fill material may comprise a casting polyester or an epoxy.

 By way of example, embodiments of a method of preparing a ruled master according to the invention will
15 now be described with reference to the accompanying drawings, in which:-

 Figure 1 is a diagrammatic flow chart illustrating the various steps in producing a cylindrical embossing tool;

20 Figure 1A is a partial top plan view of a completed master for producing an embossing tool for embossing cube-corner sheeting, in which the master is prepared according to the method of the invention;

 Figure 2 is an elevational view of the master of
25 Figure 1A, partly in section, taken along the line 2-2 in Figure 1A;

 Figure 3 is a fragmentary top plan view of a partially completed master;

 Figure 4 is a top plan view of a series of blank
30 elements having different geometric shapes suitable for use as masters in accordance with the method of the invention; and

 Figure 5 is a top plan view of the ruled masters formed of the blanks of Figure 4, indicating how each of
35 the respective types of ruled masters can be organised into a cluster with like masters to provide contiguous and continuous surfaces without gaps therebetween.

Turning now to Figures 1 to 5, there are shown various aspects of a blank element which is the basic building element for producing large scale, flexible, seamless cylindrical embossing tools. The overall length and width of the element which becomes the ruled master usually is determined by the type of ruling device used to cut the master, and the element may be on the order of one to seven inches (2.54 to 17.78cm.) on a side. The outline shape of the element, as is shown in Figure 4, may be triangular, as at 20, square as at 23, or hexagonal as at 25. The three shapes of the elements as shown in Figure 4, as well as others, for example, the rectangle or the octagon, or other shapes and combinations also may be employed, but preferably the shape chosen should be a regular geometric figure which can be combined with other similar figures without permitting a gap to exist between adjacent sides of such figures. Figure 5 illustrates how a number of triangular ruled masters 21 can be arranged into a cluster 22. Similarly a number of square ruled masters 27 and hexagonal masters 29 can be positioned to form clusters 24 and 26 respectively.

Each element such as 20 is chosen of a thickness such that it remains rigid during the removal of metal while undergoing generation of the ruled master and during subsequent electro-forming processes. The element preferably is of aluminium or electro-deposited copper.

Ruling machines used in forming scribing grooves to provide a ruled master to make a tool for cube-corner sheeting are well known in the art. Such machines are capable of positioning the workpiece and a cutter within the optical tolerances necessary to scribe the grooves to optical requirements including proper depth, angle, spacing and a mirror finish. Typical groove spacings to form cube-corner type reflector elements range from 0.006" to 0.012" (0.145 to 0.29mm), with a depth ranging

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approximately from .003 to .0065 inches (0.073 to 0.157mm).

As used herein, the phrases "cube-corner", or "tri-hedral" or "tetrahedron" are art recognised terms for
5 retroreflective elements comprising three mutually perpendicular faces, without reference to the size or shape of the faces or the position of the optical axis of the cube-corner element so formed. Stamm U.S. Patent No. 3,712,706 discloses various scientific principles and
10 techniques for ruling a master.

The ruling device must be such that a groove uniform in angle and depth is created along its entire length, and that each successive groove also is properly spaced and uniform. The ruling device can be of the type where
15 the cutter is moved while the workpiece remains stationery or conversely, the workpiece is moved with respect to a stationery, usually a diamond tipped cutter. Further, the ruling device must be capable of accurately indexing to the second and third or more
20 cutting positions different from the initial set of grooves.

The element 20 for the ruled master 21 of Figure 3 is positioned upon a workpiece support of an appropriate ruling device (schematically at "A" in Figure 1) and the
25 cutter thereof set to cut a first series of parallel grooves 31, arbitrarily selected, along the axis in the direction of the arrow 32. The cutter has a v-shaped cutting edge of desired pitch and depth.

In accordance with one aspect of the invention,
30 before cutting of the second set of grooves 34, the first set of grooves 31 is filled along the axis 32 with a material of appropriate hardness and machinability to allow a second set of grooves 34 to be cut without interruption, as if the first set of grooves 31 did not
35 exist. This allows the material being removed during

cutting to be pushed directly ahead of the cutter instead of into the first set of grooves at each groove intersection, and thereby possibly distorting the intersections. The fill also serves to support the faces of the tetrahedral elements being created and prevents their distortion. Epoxy or curable polyesters can be used as the fill materials. As noted, a second set of grooves 34 is then cut along the axis in the direction of the arrow 35. The remaining fill material (i.e., that portion not at the intersections of the second grooves 34 with the first grooves 31) then is removed. Fill material then is applied to both sets of grooves 31 and 34 prior to the cutting of a third set of grooves. The element 20 (or tool) is then indexed to proper position to cut a third set of grooves. When the cutting of the third set of grooves is complete, all of the fill material is removed and the ruled master 21 is ready for the next step. One suitable material is a casting polyester known as Decra-Coat manufactured by Resco. A suitable epoxy is Hardman No. 8173.

Figures 1A and 2 show a complete ruled master 27 having a square configuration. A first set of grooves 31 was cut along the axes 32, followed by a second set 34 along the axes 35 and a third set of grooves along the axes of 38. The intersections of the three grooves creates a base 41 for each of the tetrahedrons or cube-corner elements 40, while the pitch of the cutting tool determines the slope of the three mutually perpendicular faces 42, 43 and 44 of the cube-corner elements 40. The intersection of the planes of the faces, 42, 43 and 44 is the apex 45 of the tetrahedron 40.

The ruling devices presently available to cut masters to the optical accuracy required for cube-corner retroreflectors are not capable of cutting a single master large enough to be used directly to emboss a web

of the desired width and of a length large enough to permit efficient operation. Accordingly, the master such as 21 or 27 must be used to produce copies which can be grouped together to form larger areas until a tool of the
5 desired dimensions is created. Two options are possible at this stage, and the further steps involved and options available (as shown in Figure 1) are described and claimed in Patent Application No. 8324681, and in divisional application Nos. 8524123 and 8524124.

10 While there have been shown and described and pointed out the fundamental novel features of the invention as applied to the preferred embodiments, it will be understood that various omissions and substitutions and changes of the form and details of the
15 devices illustrated and in their operation may be made by those skilled in the art, without departing from the scope of the invention.

Reference is made to our copending application No. 2127344A, entitled "Method and apparatus for
20 producing embossed sheeting" filed contemporaneously herewith.

The inventions claimed in copending application Nos. 8324681 from which this application is divided, and copending divisional application Nos. 8524123 and 8524124
25 are as follows:-

8324681: A method of making a seamless generally cylindrical embossing tool for continuous embossing of a web of material with a precise pattern, comprising the steps of forming at least one master element to the
30 precision pattern required; assembling a contiguous cluster of master elements, or copies of one or more master elements; replicating the assembled cluster to provide a number of flexible strips of contiguous pattern; assembling said strips on a cylindrical mandrel
35 and replicating such assembled strips to provide

5 cylindrical segments; assembling such segments to provide a cylinder of the desired dimensions corresponding to the width of web to be embossed; replicating such cylinder to provide a seamless master cylinder; replicating said master cylinder to produce a relatively thick seamless and metallurgically uniform mother cylinder; replicating said mother cylinder to produce a relatively thin, seamless, flexible, and generally cylindrical embossing tool having the precision pattern therein.

10 8524123: A method for the electro-deposition of a metal upon a substrate where the substrate is mounted on a mandrel and connected to a source of negative potential and the metal to be deposited is placed adjacent said substrate and connected to a source of positive
15 potential, the spacing of said metal from said substrate varying at different parts of the substrate, the entire electro-deposition taking place in a bath of electrolyte, the improvement comprising the steps of interposing a screen between such substrate and such metal to be
20 deposited; and successively incrementally changing the width of such screen to limit and direct the metal ions to selected portions of said substrate to provide for a uniform deposition of said metal upon said substrate.

8524124: A method of separating a thin, flexible
25 tubular electroform from within a tubular substrate upon which it is formed wherein said substrate and electroform have complementary engaging features precluding rotational or axial movement relative to one another, comprising the steps of inserting a support within said
30 substrate, said support having one or more selectively operable vacuum devices thereon; operating said vacuum devices to grip the electroform on said substrate and to separate said electroform from said substrate; collapsing said electroform inwardly; and removing said electroform
35 completely from said substrate.

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CLAIMS

1. A method of preparing a ruled master with a precise pattern consisting of more than one ruled line, from a metal element having at least one planar surface, such
5 master to be used in the production of embossing tools, comprising the steps of forming a first groove in a planar surface of the metal element; filling said first groove with a synthetic material of appropriate hardness and machinability; positioning said metal element to a
10 second position; forming a second groove in said planar surface of said metal element, said second groove intersecting said first groove, and removing said fill material from the remainder of said first groove.
2. The method of Claim 1, further comprising the
15 additional steps of filling both said first and said second grooves with a synthetic material of appropriate hardness and machinability; positioning said metal element to a third position; forming a third groove in said planar surface of said metal element, said third
20 groove intersecting said first and said second grooves; and removing said fill material from the remainder of said first and second grooves.
3. The method of Claim 2, wherein said first, second and third grooves are formed by cutting into said planar
25 surface with a cutting tool having a triangular cross-section whereby the land between the said first, second and third grooves is in the shape of an equilateral triangle.
4. The method of Claim 2, wherein said first, second
30 and third grooves are formed by cutting into said planar surface with a cutting tool having a v-shaped cross-section whereby the land between said first, second and third grooves is in the shape of an isosceles triangle.
- 35 5. A method of preparing a ruled master from a metal



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element, having at least one planar surface, to be used in the production of embossing tools comprising the steps of: forming a first series of uniformly spaced parallel grooves in a planar surface of the metal element; filling
5 said first series of grooves with a synthetic material of appropriate hardness and machinability; rotating said element to a position 120° from said first series of grooves; forming a second series of uniformly spaced grooves in said planar surface of said metal element,
10 said second series of grooves intersecting said first series of grooves; and removing said fill material from the remainder of said first series of grooves.

6. The method of Claim 5, further comprising the steps of: filling both said first and second series of grooves
15 with a material of appropriate hardness and machinability; rotating said element to a position 120° from said second series of grooves; forming a third series of uniformly spaced grooves in said planar surface of said metal element, said third grooves intersecting
20 said first and second series of grooves; and removing said fill material from the remainder of said first and second series of grooves.

7. The method of Claim 6, wherein said first, said second and said third series of grooves are formed by
25 cutting into said planar surface of said metal element with a cutting tool having a v-shaped cross-section whereby the lands defined by said first, said second and said third series of grooves produce a multiplicity of tetrahedrons.

30 8. The method set forth in any one of Claims 1 to 7, wherein said fill material comprises a casting polyester.

9. The method set forth in any one of Claims 1 to 7, wherein said fill material comprises an epoxy.

10. A method of preparing a ruled master substantially
35 as hereinbefore described with reference to the accompanying drawings.

