laminated element and then pressed into the surface of the photohardenable layer **14** as in FIG. **2***c* using pressure means **121** to form an embossed surface **22**.

Before the stamper **20** is removed from the embossed surface **22**, the photohardenable layer **14** is photohardened as in FIG. **2***d* by exposure to actinic radiation passing through the disc substrate **10** from a radiation source **123**. Any source of actinic radiation can be used to expose and cure the layer provided the source is matched to the photohardenable system being used. Photopolymerizable and photocrosslinkable systems typically are sensitive to radiation in the near ultraviolet light range and into the visible portion of the spectrum. The primary requirement of the actinic radiation/-photohardenable system is that the radiation used be capable of initiating hardening in the system and that residual initiators in the photohardened layer do not adversely interfere with optical characteristics of the element. Encompassed in the process of this invention are ultraviolet and visible radiation, particularly in the near ultraviolet region. The source of actinic radiation may be any of a number of commercially available systems, e.g., Douthitt VIOLUX metal halide light system, Olec OLITE halide printing light, and the like, or may be a dedicated system manufactured from conventional components.

After photohardening or curing is complete, the stamper **20** is removed from the embossed surface **22** to produce an embossed disc as in FIG. **2***e* having a high aspect ratio relief hologram.

The high aspect ratio of the holograms made by the method of the invention can be seen in FIG. **2***f*, which is an enlarged view of Area A of the element cross section shown in FIG. **2***e*.

Referring to FIG. **2***f*, the aspect ratio of the relief image is the ratio of the height of the groove/peak, H, to its width, W. In this context, a high aspect ratio is considered to be at least 3:1. In a preferred aspect of the invention, an aspect ratio of 10:1 or higher can be achieved with faithful reproduction of the holographic relief.

Turning now to FIG. **3** of the Drawing, an alternative embodiment of the process of this invention is depicted wherein a single blank sheet is used to prepare several elements. In this embodiment, a blank sheet substrate **10** is introduced into the nip of a roll laminator **118** along with a sheet or web of a dry photohardenable film element **12** wherein the photohardenable layer **14** is laminated and adhered to the top surface of the blank sheet substrate **10**. After lamination, the temporary support film **16** of the photohardenable element **12** is removed. An embossing die or stamper **20** is positioned in register over a portion of the laminated sheet with a light source **123** positioned thereunder. The stamper **20** is then pressed into the surface of the photohardenable layer **14** to form an embossed surface followed immediately by exposure to actinic radiation to photoharden or cure the layer **14** before the stamper **20** is removed. After exposure, the stamper **20** is removed and along with the radiation source **123** moves to another portion of the laminated sheet whereupon the embossing and exposure steps are repeated. This step-embossing/exposure procedure may be used repeatedly to form disc information reliefs on the remaining portions of the laminated sheet. Alternatively, an array of stampers **20** may be used in conjunction with a suitable radiation source(s) **123** simultaneously to form disc information reliefs in a number of portions of the photohardenable layer **14** of the sheet laminate. The array may cover the entire useable portion of the sheet substrate or may be a linear array across the width of the sheet which is then stepped along the length of the sheet laminate. Either before application of the protective layer or preferably after, each element is cut or punched from the array in registry with the information relief by means of an appropriate punch or cutter (not depicted). While this invention has been described with respect to the manufacture of disc-shaped elements, it can also be used for other configurations such as cards, webs, tapes, drums or other such shapes.

## EXAMPLES

### EXAMPLE 1

This example illustrates the preparation of a holographic optical element for use in an optical scanner using preformed substrates as shown in FIG. **1** of the Drawing.

The substrate, which serves as a mechanical support, is a 1.2 mm thick, 120 mm diameter injection/compression-molded poly (methal methacrylate) disc with a 15 mm cylindrical center hole.

The embossable layer is applied to the substrate in the form of a dry film by hot roll lamination. A dry film photopolymer element is prepared by machine coating a methylene chloride solution, the photopolymerizable composition described below onto 12.7 micron (0.0005 inch) polyethylene terephthalate film; a 25.4 micron (0.001 inch) polyethylene film is used as a temporary interleaf. The dried photopolymerizable layer is 25.4 micrometers thick.

The composition of the dry film photopolymer element is as follows:

### GLOSSARY

Brij ® 30: Polyoxyethylene (4)lauryl ether Brij ® is a registered trademark of ICI Americas, Inc., Wilmington, Del.

Cyasorb ® UV-24: (2-Hydroxy-4-methoxyphenyl)(2-hydroxyphenyl) methanone; CAS 131-53-3 Cyasorb ® is a registered trademark of American Cyanamid Co., Wayne, N.J.

Tinopal ® PCR 2-(Stibyl-4")-(naphto-1',2'4,5)-1,2,3-triazol-2"-sulfonic acid phenyl ester; Benzenesulfonic acid, 5-(2H-naphtho<1,2-D>-trizole-2-ly)-2-(2-phenylethyl)-, phenyl ester; CAS 6994-51-0; Tinopal ® is a registered trademark of Ciba Geigy Corporation, Howthorne, N.Y.

Tinopal ® SFG 3-Phenyl-7-[2'-(4'-N,N-Diethylamino-6-chloro-1',3',5'-triazinylaminol-coumarin; Ciba-Geigy

TMPTMA: Trimethylolpropane trimethacrylate: 2-ethyl-2-(hydroxymethyl)-1,3-propanediol trimethacrylate; CAS 3290-92-4

TEOTA: Triacrylate ester of ethoxylated trimethylolpropane

o-Cl-HABI: 1,1'-Biimidazole, 2,2'-bis [o-chlorophenyl]-4,4',5,5'-tetraphenyl-; CAS 1707-68-2

Elvacite ® 2051; Poly(methyl methacrylate); MW=350,000 Evlacite ® is a registered trademark of E. I. duPont de Nemours and Co., Wilmington, Del.

Vinac ® B-15 Poly(vinyl acetate); M.W. 90,000; CAS 9003-20-7; Vinac ® is a registered trademark of Air Products and Chemicals Corp., Allentown, Pa.