FIRST NOVEL INVENTION OF IN-LINE WEB FED ROLL PRINT MANUFACTURING PRODUCTION OF ANIMATED / THREE DIMENSIONAL IMAGED PRINT PRODUCTS INCORPORATING ADVANCED LENTICULAR TRANSPARENT SUBSTRATE…ITS ADVANTAGES AND THE COMPARISON / CONTRAST ORDER ANALYSIS TO PRIOR U.S.P.T.O. PATENTED ART

A Dissertation

Presented to the Faculty of the School of Engineering

Kennedy-Western University

In Partial Fulfillment

Of the Requirements for the Degree of

Doctor of Philosophy in

Engineering Management

By

Gary A. Jacobsen

Itasca, Illinois USA

2004

Abstract of Dissertation

FIRST NOVEL INVENTION OF IN-LINE WEB FED ROLL PRINT MANUFACTURING PRODUCTION OF ANIMATED / THREE DIMENSIONAL IMAGED PRINT PRODUCTS INCORPORATING ADVANCED LENTICULAR TRANSPARENT SUBSTRATE…ITS ADVANTAGES AND THE COMPARISON / CONTRAST ORDER ANALYSIS TO PRIOR U.S.P.T.O. PATENTED ART

By

Gary A. Jacobsen

Itasca, IL USA

2004

Kennedy-Western University

Cheyenne, Wyoming USA

THE PROBLEM

Prior to the lenticular printing industries first of its kind invention of Jacobsen Patents # 5,560,799, (1996) and # 5,753,344, (1998) granted within the United States Patent and Trademark Office (USPTO), there were only seven other (USPTO) categories of prior art records indicating:

1) Lenticular prepatory (prepress) interlacing

2) Inefficient multi-step lenticular (printing processes),

3) Related consumer products that have been developed to fabricate (photographically) created lenticular images,

4) Sequentially stepped non-lenticular (printed layers of transparent material) to simulate dimension and distance of printed images,

5) (Multiple step process) single roll lenticular web fed offset printing requiring numerous and separate multiple off-line post production finishing procedures,

6) (Sheet fed lenticular printed products) manufactured at one sheet at a time that display a virtual illustrative printed image which appears to be three dimensional (3-D) or animated (moving sequential images) when viewed by the naked human eye.

7) Lenticular lens design and lenticular lens array manufacturing methods.

As in one example, in prior US Patent # 5,181,745, (1993), inventor Jacobsen discloses a print manufacturing process having different segments of an image printed by an in-line system on sequentially stepped transparent layers of material, with one segment of the image, such as the background for example, printed on a paper stock material which forms the bottom layer of the finished product. The final image produces the appearance of depth since the various segments of the printed image are actually placed on different separate planes, and are slightly stepped at a distance from each other on transparent substrate layers, thus portraying a distant three-dimensional visual effect.

Additionally, virtual three-dimensional images have been formed using a combination of lenticular transparent through which a line formed image, printed on opaque paper or other sheet stock is viewed. Specially designed *photographic* techniques are used to produce a line formed image of the subject matter to be displayed, and the array of line formed images that are printed are perceived as a single image when viewed through the lenticular transparent sheet when the lenses of the transparent sheet and the printed line formed images are in proper alignment.

U.S. Patent # 5,028,950 (1991) and earlier patents referred to therein, disclose apparatus and methods for forming such line formed images by "*non-continuous single sheet fed, one at a time, print process",* as compared to the *"continuous in-line web fed printing process*" which Jacobsen describes in US Patent's # 5,560,799 (1996), and # 5,753,344 (1998).

The problem producing in a *"non-continuous single sheet fed, one at a time print process" have* been found to be unsuitable for producing high volume lenticular printed products such as required for mass mailings or other mass distribution, magazine or newspaper inserts, labels for packaging and the like, due to the higher production costs and lengthy time required for such "*one at a time made processes*". In the high volume advertising mass printing production industries, rapid turn around time is essential.

In another example, prior U.S. Patent # 5,028,950 (1991) discloses a "*photography based system"* for forming a latent line formed image on extruded plastic lenticular transparent photography-based continuous print film from a set of frames of negative images. The printer has an edit station at which images from a number of frames of negatives are generated and visually displayed, and selected data signals for the images are processed to produce key subject identifier signals indicative of the content and location of areas. These signals are compared with signals from other frames. A photographic print station separately projects the image of each frame onto print film.

The photographic print method disclosed in U.S. Patent # 5,028,950 (1991) does not provide a "continuous single in-line web fed offset, flexographic, rotogravure, or letterpress ink printing process having various screen values or a method of mass producing inexpensively a printed image" as provided by the Jacobsen U.S. Patents, # 5,560,799 (1996) , or # 5,753,344 (1998).

In this last partial example illustrated within this introduction section, inventor Quadracci U.S. Patent # 5,108,531, (1992), teaches a method of printing using a web offset press, particularly suited for stereographic printing. Consistent reproductions of a composite image are produced directly on a paper web, and registry between the image and a separate embossed lenticular screen is maintained, by preshrinking (e.g., reducing the moisture content of) the paper prior to printing the composite image on the paper web. Preshrinking the paper prevents the subsequent ink drying operation from causing shrinkage of the paper and comitant variations in the image, permitting inline formation of a screen in accurate registry with the image. The method described within the Quadracci patent requires a print production manufacturing system utilizing minimally three different and completely separate manufacturing steps before becoming a finished printed lenticular product which illustrates three dimensional imagery.

In a brief comparison of the Quadracci patent above to Jacobsen U.S. Patents # 5,560,799, (1996) and # 5,753,344, (1998), it accurately demonstrates the inefficiency of the prior art by requiring minimally three or more separate manufacturing steps before product completion, as compared to Jacobsen's "continuous in-line lenticular print manufacturing method utilizing a one pass rotary web fed printing process", which creates an illusion of three dimensional depth, or animation in the perception of the viewer.

Therefore, the first problem existed for a solution to a lower cost, higher speed, and efficient high volume printing production system which supplies large quantities of virtual three-dimensional and animated image printed products utilizing techniques and materials which incorporate *lenticular transparent* and *line formed printed screened, i.e.: dotted or spotted, images printed* in proper register beneath the array of lenses found in the lenticular transparent material.

Secondly, the problem existed and continued with a need to create an efficient, new and novel, *lower cost*, *high speed*, *continuous in-line lenticular print manufacturing method* utilizing a one pass rotary web fed printing process which would create an illusion of depth, or animation in the perception of the viewer of the image as compared to any other prior art recorded within the United States Patent & Trademark Office.

Thirdly, the problem existed and continued for a need to provide a *continuous in-line roll fed printing process incorporating roll fed lenticular transparent, preferably made of transparent plastic, and roll fed opaque paper stock substrate, wherein line formed images are printed on the lenticular substrate, on the paper substrate, or both substrates simultaneously in one embodiment.* The lamination and combination of two printed substrates together created within one press pass would create a finished three-dimensional or animated printed product ready for consumer viewing. This manufacturing technique would save precious time from creative development and design to market and be available to advertisers at a lower cost due to highly efficient manufacturing procedures.

Very last, the fourth problem existed for a printing process that must be rapid enough to meet the quick delivery deadline requirements of advertisers, and also be required to be capable of manufacturing a new unseen before range of three dimensional and animated lenticular print products that could be used by the packaging, advertising and promotional industries.

Therefore to help solve these problems, it is the objective of this study to explore the use of available specialized inventions, engineering and lenticular print manufacturing production, utilizing double web rolls simultaneously for either: offset lithography, flexographic, gravure and letterpress, resulting in the construction formation of paper/lenticular combined printed products, using advanced in-line printing and finishing processes to produce unique, low cost, all machine manufactured paper/lenticular printed products. This research study to follow will present the facts necessary to support the implied stated thesis within the abstract of this dissertation, describe the problems, establish the researchers claim of "first in industry to invent" status and demonstrate the solutions to the problems indicated in the conclusion findings. Also within this dissertation study, the researcher will thoroughly forensic audit, dissect and analyze the remaining prior art by utilizing the comparison/contrast order research analysis method to the referenced U.S. Patents (prior art), conclude the findings, recommend and summarize the referenced materials herein against the Jacobsen's first to conceptualize, and first to invent, lenticular web fed process printing patents. Finally by solving the problem, the research will support the claims and the importance the Jacobsen patents and contributions of its teaching bring to the lenticular printing industry and advertising industries world over.

METHOD

The research method and writing style to be used within this dissertation paper will consist of and be presented in the scientific/technical expository written nature in the pure applied form, utilizing the comparison/contrast analysis order research method. Further more; the dissertation is to be written in the American Psychological Association (APA) style format.

The researcher will review, analyze and focus on the thirty (30) related, closest related and other semi related literature (patents) from the United States Patent & Trademark Office, thus being the *"prior art"*, i.e., granted utility and product patents pertaining to three-dimensional or animated (stereographic) processes, including but not limited to the following areas: *lenticular prepress, lenticular printing*, *lenticular lens design and material manufacturing, and the printed end use products of lenticular* *technology*. In addition, six (6) various published literatures will be reviewed and analyzed, obtained from major industrial printing publications, and other published articles written within the promotional, label and plastics industries. Many of the published articles reference, acknowledge and promote the use of the Jacobsen lenticular patents due to the extreme advantages in manufacturing, resulting in lower product costs. As a final point, the Jacobsen patents also brings new novel enhanced lenticular printed consumable lenticular advertising product advancements to the mass distributed consumables industries.

<u>FINDINGS:</u>

The researcher did not uncover any similar studies or inventions relating to this papers title, thesis and abstract: “First Novel Invention Of In-Line Web Fed Roll Print Manufacturing Production Of Animated / Three-Dimensional Imaged Print Products Incorporating Lenticular Transparent Substrate...Its Advantages And The Comparison / Contrast Order Analysis To Prior U.S.P.T.O. Patented Art”. Therefore, the study has an inherent uniqueness and originality in its approach to the topic. This is not to say the review of literature did not reveal issues relating to other persons or corporations attempting to explore, reverse engineer or advance the said topics technology, however, when found to exist, it appears to have occurred "after" the public made disclosure by the (USPTO) of the original Jacobsen (1996 & 1998) U.S. Patents. This fact alone will support the papers claim of "first to invent" and further more supports the papers novel ness of the invention.

CONCLUSION:

The researcher has concluded and determined that the Jacobsen patents (1996 & 1998) solves the problems that existed for a solution to a lower cost, higher speed, and more efficient high volume printing production system which supplies large quantities of virtual three-dimensional and animated image printed products utilizing techniques and materials which incorporate lenticular transparent and *line formed printed screened, i.e.: dotted or spotted, images printed* in proper register beneath the array of lenses found in the lenticular transparent material.

Secondly, it has been determined that the Jacobsen patents (1996 & 1998) solves the second problem that existed and continued for a need to create an efficient, new and novel, *lower cost*, *high speed*, *continuous in-*

line lenticular print manufacturing method utilizing a one pass rotary web fed printing process which would create an illusion of depth, or animation in the perception of the viewer of the image as compared to any other prior art recorded within the United States Patent & Trademark Office.

Thirdly, it has been determined that the Jacobsen patents (1996 & 1998) solves the third problem that existed for a need to provide a *continuous in-line roll fed printing process incorporating roll fed lenticular transparent, preferably made of transparent plastic, and roll fed opaque paper stock substrate, wherein line formed images are printed on the lenticular stock, on the paper stock, or both simultaneously in one embodiment.* The lamination and combination of two printed substrates together created within one press pass creates a finished three-dimensional or animated printed product ready for consumer viewing. This manufacturing technique saves precious time from creative development and design time to market and is available to advertisers at a lower cost due to highly efficient manufacturing procedures.

Very last, it has been determined that the Jacobsen patents (1996 & 1998) solves the fourth problem that existed for a printing process that must also be rapid enough to meet the quick delivery deadline requirements of advertisers, and be required to also be capable of manufacturing a new unseen before range of three dimensional and animated lenticular print products that could be used by the packaging, advertising and promotional industries.

Therefore it is of the researcher’s final summary and conclusion that the Jacobsen patents (1996 & 1998) solves the aforementioned problems.

TABLE OF CONTENTS

Acknowledgments

The author wishes to express his love and heartfelt gratitude, especially to my great wife, Mary Jo Jacobsen (a true loyal supporter and believer), in addition to my three magnificent children, Stephanie, Steven and Scott for their full support and understanding of this important extended research and writing assignment, and for allowing the five plus years of writing time it took me away from our family.

Most notably, the writer extends his explicit love and gratitude to his wonderful parents, Darlene M. Jacobsen and Roger V. Jacobsen. Darlene M. Jacobsen, a great loving mother and professional educator, taught me the important values of family and for the need of acquiring a proper education.

In memoriam, Roger V. Jacobsen, (September 23, 1928 – March 26, 2004) an amazing person, loving father, loyal friend, true grand master of the printing trade, caring, ethical and wise businessman; the researcher desires to express thanks to his marvelous father for leading his son into the graphic arts industry and schooling him in the highly technical trade. Having worked together for over 20 wonderful years has been extremely

delightful, fun and productive. A proud son and continuing second generation printer, the family name and tradition carries forward. Our entire family will miss him greatly.

In addition, my appreciation goes to Dr. John Byrne, Associate Professor, School of Business at St. Ambrose University, Davenport, Iowa; and Adjunct Professor of Kennedy-Western University, Cheyenne, Wyoming, for his approval of this papers complicated topic, and scholarly suggestions made to help improve the quality of this paper through his suggestions of utilizing advanced research and writing techniques, resulting finally to this formally accepted written dissertation.

Furthermore, special thanks to my good friends and business associates,

First, to James R. Schirott, my great friend, personal attorney, and WCG's Vice President and General In-House Corporate Counsel, for all his support, guidance, cheer leading, and belief in this papers topic and assistance in developing a strategic business plan, while also helping to reduce this academic dissertation topic to actual industry practice.

Secondly, special thanks to John G. Leonard, Proprietor of The Granville Group, WCG's advertising and public relations firm, for all his substantial contributions made to help get the word out on our new patent pending LentiClear Lenticular Lens, patented web fed printing processes and finally to his help announcing the great novel advanced lenticular print products we now offer the advertising, promotion and packaging industries.

Thirdly, thank you to the many members of the school administration for their important input, advise and help during the past four years of my graduate doctoral research studies at Kennedy-Western University.

Last but not least, very special thanks to the following people and company's that have helped me and The Web Communications Group, Inc. & Companies during the past 14 years and many that continues on today. Several of the mentioned here are both suppliers and customers of WCG and are participants that have contributed to the behalf of WCG's lenticular research, study and development. The following are remarkably recognized as industry leaders as well as academic leaders whom have offered their various individual lenticular based specialized contributions, ranging from: advise, and promoting of the WCG's lenticular processes and products; performed lenticular prepress interlacing, provided in-plant live lenticular on press testing, lenticular lens material manufacturing, lenticular product development, and offered overall general support to the cause of advancing the state of the lenticular industry.

Many thanks to:

CCL Label, Inc. (Don Klein)

Dixonweb Printing Company (Dr. Ake Dahlquist, VP & Chief Engineer)

Goex Corporation (Josh Gray, Dick Hamlin)

Professor R. Barry Johnson

MagiColor Graphics 2000, Inc. (Tom Fernandez, Brian Ulricksen)

Outlook Group, Inc. (Joe Baksha, Tim Traub)

Pacur, Inc. (Ron Johnson, Rick Knapp)

Moore/Wallace/Post Printing an R.R. Donnelly Company (James Nordquist)

Quad Graphics, Inc. (Thomas Quadracci, Bill Grove, Dave Morris)

Rochester Institute of Technology (RIT) - (Dr. Bruce E. Kahn), Department

of Imaging and Photographic Technology – Materials Science &

Engineering - Lenticular Imaging

VPI Corporation (Debra Wente, Kerry Winans)

Also, to the countless many of great people behind the scenes that are to numerous to credit personally, thanks to you too.

Chapter 1

Introduction

Background (The Author's Organization)

Founded and incorporated by Gary A. Jacobsen in June of 1984, The Web Communications Group, Inc. (WCG), simply began as a commercial printing brokerage company providing traditional high volume paper based printing products and services. Shortly thereafter, WCG began to specialize in the research, invention, testing, engineering and project management for the manufacturing print production of custom specialty rotary web offset lithography, flexographic, gravure and letterpress; creating paper/plastic printed products using advanced in-line printing and finishing processes to produce unique, low cost, all machine manufactured paper and or paper/plastic printed products. This advanced print technology was designed particularly for the use in major domestic and international consumer and business-to-business promotional print campaigns.

Today, The Web Communications Group, Inc. has expanded and has formed three new companies (Animated Printing & Packaging Company, LentiClear Lenticular Lens, Inc., and Jacobsen Lenticular Tool & Cylinder Engraving Technologies Company) to support the new research, study, invention and implementation of advanced in-line lenticular printing and finishing methods, as well as providing optical diamond tool fabrication, diamond turning and cylinder engraving. In addition, The WCG Companies strive for continual improvement and development of specialized lenticular optical lens designs and the manufacturing technologies for advanced printable and non-printable optical lenticular lens array materials.

Four of the Jacobsen company's websites are available for review at the following http addresses:

1) Web Communications Group, Inc. – www.webcommgroup.com

2) Animated Printing & Packaging Company – www.apap-inc.com

3) LentiClear Lenticular Lens, Inc. – www.lenticlearlens.com

4) Jacobsen Lenticular Tool & Cylinder Engraving Technologies Company – www.lenticlearlens.com

Statement of the Problem

Prior to the lenticular printing industries first of its kind invention of Jacobsen US Patents # 5,560,799, (1996) and # 5,753,344, (1998) that were granted within the United States Patent and Trademark Office (USPTO), there were only seven other (USPTO) categories of unrelated or near related prior art records indicating various lenticular manufacturing processes that included:

1) Lenticular prepatory (prepress) interlacing

2) Inefficient multi-step lenticular (printing processes)

3) Related consumer products that have been developed to fabricate (photographically) created lenticular images,

4) Sequentially stepped non-lenticular (printed layers of transparent material) to simulate dimension and distance of two dimension printed images,

5) (Multiple step process) single web lenticular web fed offset printing requiring separate post production finishing procedures,

6) (Sheet fed lenticular printed products) that is manufactured by a "one single sheet at a time process", that displays a virtual illustrative printed image which appears to be three dimensional (3-D) or animated (moving sequential images) when viewed by the naked human eye.

7) Lenticular optical lens design and lenticular lens array material manufacturing.

Therefore, a multi-faceted problem existed for solutions to a lower cost, higher speed, and more efficient high volume lenticular print manufacturing production system which would supply large quantities of virtual three-dimensional and animated image printed products utilizing techniques and materials which incorporate lenticular transparent using *line formed printed screened, i.e.: dotted or spotted, images printed* in proper register beneath the array of lenses found in the lenticular transparent material.

Secondly, the problem existed and continued with a need to create an efficient, new and novel, *continuous in-line lenticular print manufacturing method,* utilizing a *one machine pass rotary web fed printing process* which would create an illusion of depth, or animation in the perception of the viewer of the image as compared to any other prior art recorded within the United States Patent & Trademark Office.

Thirdly, the problem existed and continued for a need to provide a *continuous in-line roll fed printing manufacturing process incorporating roll fed lenticular transparent, preferably made of transparent plastic, and roll fed opaque paper stock substrate, wherein line formed images are printed on the lenticular stock, on the paper stock, or both simultaneously in one embodiment.* The lamination and combination of two printed substrates together created within one press pass would create a finished three-dimensional or animated printed product ready for consumer viewing. This manufacturing technique would save precious time from creative development and design to market, and would be made available to advertisers at a lower cost due to highly efficient manufacturing procedures.

Very last, the problem existed for a printing process that must also be rapid enough to meet the quick delivery deadline requirements of advertisers, and also be required to be capable of manufacturing a new unseen before range of three dimensional and animated lenticular print products that could be used by the packaging, direct mail, advertising and promotional industries.

Purpose of the Study

The purpose of the study herein will be to present the facts necessary to support the implied stated thesis written within the abstract of this dissertation, describe the problems, establish the researcher's claim of "first within industry to invent" status and demonstrate the solutions indicated in the findings. Also within this dissertation study, the researcher will thoroughly forensic audit, dissect and analyze the remaining prior art included within the study, compare/contrast the referenced literature of U.S. Patents, conclude findings, recommend and summarize the referenced materials herein against the Jacobsen's first to conceptualize, and first to invent lenticular web fed print manufacturing process and product patent's. Finally, the research will support the claim of "first to invent" within the lenticular printing industry, and the importance the Jacobsen patents and contributions of its teaching bring to the lenticular printing industry and advertising industries world over.

Importance of the Study

The importance and novelty of the study will be to investigate the multi-faceted problems described herein that have not yet been investigated or solved. The study will condense literary lessons taught through the U.S. Patent Office's patented "prior art" which was recorded over ten decades such teachings of novel inventions were made public; and finally it will be augmented with insights gained from the comparison/contrast study of the prior art to the Jacobsen inventions introduced and to the problems solved.

Scope of the Study

Within the lenticular printing manufacturing industry of both yesterday and today, continued research and testing is continually performed by practicing manufacturing participants to expand product offerings, perfect the applied printing techniques and reduce the manufacturing steps necessary to provide quality driven lenticular printed products, as well in addition, attempt to reduce the overall costs associated with such production. The scope of this study will focus on, and be limited to this ideology.

Rationale of the Study

The rationale of the study is that once it is determined which lenticular print manufacturing method(s) is most efficient and cost effective; this information can then be utilized by the lenticular printing industry, and such advantageous findings can then practiced by the lenticular print manufacturers, which in turn will then be offering such beneficial technology to the lenticular product buying customers.

Overview of the Study

The overview of the study is to academically explore and compare the inventions, and to compare/contrast engineering and print manufacturing production techniques of custom specialty sheet-fed, single web-fed and double web-fed rotary offset lithography, flexographic, gravure and letterpress paper/plastic printed products using advanced in-line printing and finishing processes to produce unique, low cost, all machine manufactured paper printed products. The research study herein will present the facts necessary to support the implied stated thesis within the abstract of this dissertation, describe the problems, establish the researchers claim of “first in industry to invent” status and demonstrate the solutions to the problems that will be indicated in the findings. Also within this study, the researcher will thoroughly forensic audit, dissect and analyze the remaining prior art, compare/contrast the referenced U.S. Patents and remaining published literature, conclude findings, recommend and summarize the referenced materials herein against the Jacobsen’s first to conceptualize, and first to invent lenticular web fed printing process patents. Finally, the research will support the importance the Jacobsen patents and contributions its teaching bring to the lenticular printing industry and advertising industries world over.

Chapter II

Review of Related Literature

Introduction

Background & History of Stereographic Recorded Images and Later Lenticular Sheet Fed and Web Fed Printing Technologies

Throughout history, man has tried to define, draw and record the world around him. The advanced state of a society is often judged by how well these recordings are made. In A.D. 280 Euclid defined depth perception and during the renaissance, artists added perspective to their work. Some early trails of *artificial* three-dimensional imagery were stereoscopic drawings devised by Grovanni Battista della Porta around the year 1600.

In the latter part of the 19^{th} century and into the early 20^{th} century, photographic stereo imaging shot by camera found new popularity. In 1838 Sir Charles Wheatstone proposed the first of several stereo viewers. Inventors like Sir David Brewster advanced the Wheatstone viewer concepts and Oliver Wendell Holmes added convex lenses as eyepieces. Pictures, either *hand drawn* or *photographically* created with specific parallax separation were viewed with hand held stereoscopes to give the illusion of three-dimensional depths. After the introduction of the commercial hand held stereoscopic viewer in the 1950's, scenes from around the world, as well as images from movie studios such as Walt Disney Studios were brought into homes as "stereoscope images".

Later during the 1950's, advances in motion picture brought "anaglyphic" red-and-green polarized eyeglasses that conjured up horror of multi-dimensional images, such as in the film: "Creature From The Black Lagoon".

These (anaglyphic) red-and-green eye glasses then later became used to view specially created art work that was then printed in collectible comic books to create the illusion of three-dimensional depth.

During the later years of 1990's, video camcorders were made available for viewers who prefer video experience in stereo, even if it requires wearing special liquid crystal goggles.

In addition of today, holographic or volumetric images have been used in amusement parks, casinos, museum exhibits, and in other art forms. These images can be viewed without the assistance of supplemental viewing devices, but lack the printed quality necessary for mass commercial usage. In addition, the high cost to produce such images for volume based commercial advertising usage prohibits continual use by advertisers. The least expensive form of holographic imagery appears frequently on consumer credit cards, but appears to lack substantial quality.

Lenticular technology which predates back into the early 1900's, recently have made great in roads as competition to the aforementioned visual technologies. Since lenticular printing is less costly to manufacture; and can illustrate both three-dimension and several styles of animated visual effects *without* the requirement of wearing special viewing glasses, handheld viewing stereo devices or using lighted stereo projectors, it is a technology that has attracted the use by many advertisers worldwide.

Depth Perception Principles Of Stereo Viewers

Depth perception is indeed a precious gift. In human vision, depth perception starts out as flat; two-dimensional images received through a lens, collected and transmitted to the brain, a super computer. The retina of an eye collects only two-dimensional data because it consists of a single layer of sensors-albeit spherical in shape. Cues of a third dimension (depth) can only be obtained through analysis by the brain of the retinal images from both eyes. While a series of minor cues (accommodation, convergence, size gradient, etc.) provide some variable depth information, by far the most dominant cue comes from the effect called binocular disparity or binocular parallax. While avoiding an in-depth analysis of this cue, suffice it to say that horizontal displacement of the two human eyes (average interpupillary distance of 6.5 cm.) produces two slightly different simultaneous retinal images. These two-dimensional images differ because each eye records the scene being viewed from a scant different angle resulting in horizontal shifts of image points in planes in front of or behind an arbitrary reference plane. These two dissimilar images are called a stereo-pair and are the major contributor to depth perception.

Such a stereo-pair can be produced photographically by recording a scene from two horizontally displaced vantage points. Thirty-five millimeter transparencies taken with special two-lens cameras, then shown through a stereoscopic stereo viewer are familiar to the general public, but have slide back in popularity due to recent advancements in lenticular printing technology.

Lenticular Sheet Fed Printing

The art of basic lenticular-sheet three dimensional and animated images has made great progress in the past decade. The major advantage of lenticular sheet fed printing is that the three dimensional or animated images are presented to the viewer *without the need for a supplementary hand held viewing device* and can be economically produced using low-speed, "*single sheet*" at a time production output via sheet fed offset printing presses, as compared to expensively created, one by one production of photographically prepared stereo-pair images viewed through hand held stereoscopes; or single photographically, or digitally prepared lenticular imaged prints.

Lenticular Web Fed Printing

With the introduction of web fed printing, a new major manufacturing advantage occurred compared to sheet fed printing. In addition, as described with sheet fed printing, lenticular web fed printing occurs *without the need for a supplementary hand held viewing device*. Web printing is high speed; continual and non-interrupted print manufacturing, which is printed onto continuous web rolls of lenticular material. The web printing process now takes lenticular printing and the products it can create to a new higher advanced level never made possible before with the previous prior art technologies.

Optical Imaging Principles of Lenticular Material

The optical lenticular sheets or rolls described in this research paper are defined as a fine linear array of convex lenses with specific optical viewing characteristics commonly known as "lenticular".

Lenticular material can be made in either single sheets or continuous web rolls containing over 8,000 lineal feet of material in one web roll.

This lenticular material is produced either by extrusion, embossing, molding or casting processes via sheet or continuous webs using optical quality APET, PETG, PVC or other suitable plastic materials with spatial frequencies from 15 to 500 lenses per inch (LPI).

As the lenticular material is printed upon, it becomes a high-resolution three-dimensional recording medium for presenting dimensional or animated images to the viewer *without* the use of additional viewing devices.

The principles of lenticular imaging are quite simple. The object, scene or images are first recorded as a series of two or more dimensional (2D) images taken from a series of two or more horizontally displaced vantage points. Assume “n” equal the number of 2D images taken. For composition of most three-dimensional (3D) images, “n” is four (4) to sixteen (16) 2D images. These images are then “line-formed” behind the lenticules; i.e. “n” fine lines are recorded behind each linear convex lens on the lenticular material with each line containing only the image content of a single 2D image. When the final composite image is seen by the viewer, each eye sees only a single 2D image. Due to the fact each eye receives a different 2D image (the two comprise a stereo-pair); depth is perceived in the scene.

An individual lenticule within the lenticular material (linear convex lens) images in only one direction. If a point source of light is placed in front of such a lens, the point will be imaged into a single line parallel to the long axis of the lens.

Another technique that works well with lenticular material is commonly referred as “animation”. Two, three or four or more totally different 2D images are recorded in differing recording (and viewing) zones.

As an example, consider two conventional 2D images and lenticular print material with a 32-degree viewing angle. One 2D image is recorded on the lenticular material from a +16 to 0 degree viewing angle, while the second image is recorded on the lenticular material from 0 degree to – 16 degree viewing angle. When the viewer is positioned in the respective viewing zone or when holding the printed lenticular material at a particular tilted viewing angle, only one of the images will be visible. The lenticular material being a linear single element convex lens is not perfect. When combining images behind the lenses on the lenticular material, some ghosting can appear due to misregisration, or aberrations of the lenticules itself.

Lenticular Printed Images vs. Holographic Images & Comparisons:

Creating stereoscopic (three-dimensional) 3D projected imagery can be accomplished several ways, with the two most popular being *lenticular* and *holographic* imaging. Although they are not similar in how they appear as 3D formats, they are commonly mistaken for one another.

Lenticular images can be recognized by the plastic-ridged cylindrical lens covering the printed or photographic image. Lenticular images, either printed or produced photographically tend to appear much more life-like than holograms.

Holographic created images, commonly referred as "*holograms",* are created using a laser and a special optics table that records the image. Although holograms are made using photosensitive emulsions, lenses and darkroom equipment, the holographic recording process requires no cameras. To create a hologram, the desired subject is illuminated with laser light, which records the three-dimensional information. Optical lenses, optical mirrors and the film plate holder are carefully aligned and positioned around the object so that the distances of all the laser beams used to record the image are the same length. Once the camera set-up is complete, lasers capture a three-dimensional replica of the objects shape onto holographic film. Unlike photographic prints, a hologram does not involve any paper, inks, or pigments. This holographic film is developed and then illuminated with either a clear, incandescent bulb or sunlight. When properly illuminated, the film reflects the light into a 3-D reconstruction of the original object.

Since holographic images are not printed, they seem to appear as surreal art, or somehow artificial. In addition, since the overall thicknesses of holograms are extremely thin in nature, they must be mounted or laminated onto a sturdy carrier for final presentation.

Today, holograms are used quite frequently on consumer's credit cards. The holographic images placed within the credit card are usually images of the issuing credit card company's corporate logo. Holograms are being utilized more as an advertising tool, in addition to scientific usages.

Advantages of Using Jacobsen's Two Web In-Line Lenticular Print Manufacturing vs. the Prior Art, i.e., Single Roll Web, and Sheet-Fed Print Processes

Until the introduction of Jacobsen patents, U.S. Patents # 5,560,799 (1996), and 5,753,344 (1998), the mass production of large eye-catching 3D and animated printed advertising products for major consumer promotions has been too expensive and too time-consuming. Advertisers had to on a combination of traditional sheet fed printing and slow, multiple off-line finishing manufacturing steps to produce various 3D and animated print advertising products.

Jacobsen's 3D and animated web fed printing processes which include complete in-line finishing processes that are performed concurrently and simultaneously with the print process solve this problem. The new dual web fed printing technologies give advertisers far greater flexibility to create more interesting and complex 3D and animated advertising, promotional, direct mail, packaging, or pressure sensitive label products, in addition with the advantage of substantial cost savings and the ability to deliver product with much tighter timelines.

To better understand and illustrate how the Jacobsen patents accomplish the aforementioned advantageous claims, a (sample theoretical print project) will be presented in layman terms, moving away temporarily from the highly technical terminology that has been used up to this moment.

The (sample theoretical print project) will be illustrated in two ways:

1) Manufacturing by using traditional sheet fed manufacturing steps, which could also include printing via single roll web fed print process (prior arts)

2) Compare/contrast the traditional sheet fed and single roll web fed print process methods to the Jacobsen patented dual roll web fed printing and in-line finishing processes.

Sample Theoretical Project:

An advertiser needs a special catalog for a large quantity direct mail program. The catalog must be unique and make a strong, memorable impact with the advertisers target prospects. The flat finished size needs to be 5” wide x 11” tall in order to qualify for the lowest USPS automated bulk mail rate. The elements would include: a stunning 3D lenticular printed image (as large as possible) as well as a 14 page, 4 color brochure with multiple perforated coupons. The catalog also needs to be a completely self-contained mailer with an outside cover die-cut window to reveal part of the catalogs interior, to which the 3D lenticular image is attached, to lure the readers inside the direct mail catalog. The advertiser seeks to print a quantity of 5,000,000 units and mail through out the United States.

OPTION 1: TRADITIONAL PRIOR ART SHEET FED OR SINGLE ROLL WEB FED PRINTING WITH OFF-LINE FINISHING:

Manufacturing (7) steps to include:

1) Print: The 4 color 3D/Animated image onto the lenticular plastic substrate, “one sheet at a time” using sheet fed printing, or print via single roll web fed and deliver to full single press sheets

2) Off-line: Trim and cut out the 3D lenticular unit to proper size from the pre-printed lenticular press sheets

3) Off-line: Print separately the 4 color, 14 page paper brochure/mailable carrier by single sheet fed or single roll web fed print processes

4) Off line: Die-cut a window opening into the paper carrier

5) Off-line: Perforate all paper based coupons within the 14 internal body pages

6) Off-line: Cut, fold and saddle stitch the 4 color, 14 page brochure/carrier

7) Off-line: Tip-in and permanently affix the 3D lenticular plastic unit into the paper brochure/carrier so that the 3D image shows through the die cut window opening, refold the catalog, and wafer seal the catalog closed, ready to mail to consumer.

OPTION 2: PREFERRED METHOD USING JACOBSEN PATENTS:

Manufacturing (1) step to include:

1) Utilize all in-line rotary web fed continuous production: Web print simultaneously onto dual rolls A) the 4 color image onto the lenticular plastic, B) web print the 4 color paper brochure, then laminate the 3D lenticular unit into brochure, plow fold, spine glue the 11" backbone, die cut cover window opening, rotary trim and seal the carrier, ready to mail.

Preliminary Conclusion:

The entire combined four color printed 3D lenticular and paper direct mail catalog is produced all in (one) continual machine press pass vs. the (seven) manufacturing steps required to produce the same sample theoretical printed catalog product, using traditional (prior art) single sheet fed or single roll web fed printing methods with off-line finishing processes.

New Lenticular Enhanced Print Products Available To The Advertising Industry For Marketing Usage Due To Novel Invention

Background: Advertising Printing Market:

Information about company's products and services is normally presented to the end customer in printed form. This information can be divided into classes, such as advertising mail/direct mail, brochures, direct distribution advertising, inserts, and flyers and so on. The country with the largest market in the advertising printing industry is the United States with a volume of approximately US $ 46 billion, followed by Germany with a volume US $ 6.6 billion (figures from 1998) as reported by Handbook of Print Media, H. Kippan (2001) - (ISBN 3-540-67326-1). In terms of volume, direct mail advertising is the most important within the entire advertising printing market, and it is this *direct mail advertising* in particular that will gain importance. Direct mail can either contain specific information requested by the customer or simply unsolicited information.

Background: The Packaging Market:

The market for *packaging printing* is huge. Every kind of packaging requires print of some kind. In the past, the packaging industry has proven stabile in the face of economic fluctuation. According to international experts' estimates, growth of 4.5% p.a. can be expected for the next half decade. In Southeast Asia and China, double growth rates could also be achieved in this field. Relative to the 1997 level, the worldwide volume of the packaging industry will have doubled by the year 2003 if the worldwide per capita packaging consumption is just half that of Europe. These figures clearly demonstrate the potential of the packaging printing industry. Due to changing lifestyles, the introduction of new products (e.g., the increasing amount of ready mails and microwave meals in the food industry) and the rising qualitative and creative demands of the consumer market, this market also remains attractive for the future. This positive out-look not only stimulates future printing onto paper or board but also increases printing of the most diverse materials. In the eyes of the researcher, the mass production and use of lenticular printed packaging products remain a strong possibility.

In a special class of itself since 1996, the market for "*intelligent packaging*" has been displaying the greatest growth rates in the entire field of packaging printing but is, however, at a very low level. "Intelligent packaging" is classed as *packaging* or *labeling* that fulfills *additional functions* alongside providing the actual product information. The label contains variable information about when and where the product was produced, its "best before" date, or whether the correct consumption temperature has been reached. Latest developments in the field of material and labeling technology make it possible for a label to display whether a wine is at the correct temperature or a deep freeze product is fully frozen, for example. With the addition of lenticular animation and 3D print imagery, substantial new products can be co-developed and co-mingled to include both technologies to create a new class of advertising, the researcher will term as "*animated interactive/intelligent lenticular products*". Since electronic media does not play any significant role in this segment of printing, a fact not set to change in the future, leads the researcher to believe this specialty packaging label segment (including the use of lenticular) will gain much industry momentum and continual use by the packaging advertisers.

New Proposed Lenticular Enhanced Print Products Include:

Overview:

The Jacobsen (1996 & 1998) patented inventions provide a (one step) continual and non-interrupted roll web fed lenticular printing method via (web offset lithography, flexographic, rotogravure, and letterpress) processes that are produced by either screened or stochastic values replicating 3D or animated lenticular imaging. The single lenticular roll or dual web - lenticular/opaque paper rolls either deliver as single roll to roll; single roll to flat product; or as double web rolls to final sheeted product, or preferably to in-line finished lenticular printed product ready for consumable advertising usages. Examples immediately follow:

Products & Lenticular Applications Could Include:

Corporate Brand Identity Packaging:

- Brand Product Identification
- Entire Outer Packaging Enhancements (Box Overwraps)
- Segmented Applied Lenticular Coverage To Outer Packaging
- Pressure-Sensitive & Self-Adhesive Lenticular Products
- Multi-Ply, Multi-Substrate Peel Open Pressure Sensitive Labels

• Lenticular Laminated To Paperboard Products

In-Packs & On-Packs (FDA direct food contact approved)

Beverage Cups: Decorative Partial Or Full Wraps

Video, DVD, CD Disc Cover Lenticular Treatments.

Promotional Products and Applications Could Include:

• Pressure Sensitive Adhesive Labels

• Magazine Inserts and FSI's

• Mini-Catalogs and Mini-Comic Books

• Brochures

• Direct Mail

• Postcards

• Structural Pop-Ups

• Huge Back-Lit and Reflective Posters

• Kid's Premiums and Trading Cards

• Spinning Wheels and Slide Charts

• Security Game Pieces and Punch Out Puzzles

• Scratch-Offs, Fragrance Scents, Special Inks

• Ink Jet Variable Imaging of Data

Depending upon the desired format, it is possible to add-on many other special effect options in-line on press, including: rotary die-cutting and removing web material, die cutting contour shapes, perforating for coupons and tear-offs, remoistenable glue for bounce backs, reply envelopes, T-shirt iron-on color printed transfers, pop-out puzzles, structural paper rising pop-ups, unusual fold sequences and format constructions, latex scratch rub-offs, ink jet imaging variable data or consecutive numbering for contests, plus special coatings, inks, papers and plastic substrates—many of which can be applied or created in just one press pass.

Preliminary Conclusion:

Now, for the first time ever, compelling new animated & 3D printed lenticular formats can be mass-produced for major advertising campaigns and promotions. The Jacobsen (1996 & 1998) patented, advanced all in-line rotary web, flexographic, gravure, letter press and digital imaging print methods and in-line finishing systems cut the costs, and time that is associated with traditional sheet fed printing that requires additional post off-line, multi-step converting. The result is: faster job turnaround, on-time delivery, more-competitive pricing and lastly, the ability to create new-never-seen-before sophisticated lenticular finished advertising, promotional or packaging based products.

Jacobsen Patent's: (First To Invent, Documented Originality & Dominant Leading Industry Position)

Prior to the researcher's decision to apply for U.S. Patent applications for the currently granted Jacobsen U.S. Patent # 5,560,799 (1996) and U.S. Patent # 5,753,344 (1998), a thorough formal prior art search was conducted by WCG's previous patent counsel (Welsh & Katz) of Chicago, IL, in conjunction with the prior art search services offered through the United States Patent & Trade Mark Office. It was discovered after the initial search phase was completed; it appeared there were no other inventions granted previously to the type of lenticular technology that Jacobsen sought to patent. This fact will serve to compliment the researcher's claim of *"first to invent", and "documented originality".*

In the year 2001, a second analysis was requested by WCG to WCG's current patent counsel, (King & Spalding) of Atlanta, GA, to compare and contrast the Jacobsen lenticular printing patents to the Quadracci lenticular printing patents, both of which will be discussed within the review of related literature section of this paper. Since the opinion of counsel is privileged attorney work product, and is a privileged client/attorney communication, and quite confidential, the actual work and conclusions cannot be sighted herein. However, the researcher will highlight some basic inherent facts between the two patents, which will demonstrate and help support within this research paper, the claims of the researcher: *"first to invent", "documented originality"* and finally, *"dominant leading industry position"* in respect to the Jacobsen inventions and claims within the actual patents reviewed.

Jacobsen Patents Manufacturing Highlights Include (Partial Only) See Actual Patents For Complete Claims:

1) Single roll web printing upon lenticular material rewound back to roll, or delivering to individual unit, or variable sized sheeted products.

2) Double web roll printing to both lenticular and opaque substrate simultaneously while laminating two-roll substrates together in-line on press.

3) Printing either by wet trap or dry trap methods with one process, or via hybrid combinations of offset, flexo, gravure or letterpress methods.

4) Printing by dry trap method with one or more plurality of dry trap printing images and plurality of dry trap opaque white barriers. Option to print additional plurality of conventional images on top of dry trapped opaque white barrier.

5) Printing to either lenticular, or to opaque substrate separately or to both substrates simultaneously.

6) In-line finishing processes is performed consecutively after printing one or two webs including: plow folding or slitting the dual webs into multiple ribbons or combinations thereof to create the proper format construction; laminating said dual webs together to create a sandwiched two ply web construction; die cutting away areas of the web, contour die cutting special shapes, applying backbone glue, wet flap glue, remoistable glue, pressure sensitive glue, repositionable glue for stickers, bead strip gluing, glue tacking, applying scratch off inks, ink jet imaging, cutting web into individual units, stacking weighing and packing to cartons/skids, or optionally delivering to ¼, ½, ¾, or full press impression sheets.

7) Optionally off-line finishing the webs at a post-production printing in-line finishing system.

The descriptions of methods and products presented are merely a condensed version of the said patents. Complete descriptions and actual claims within said patents represent the actual manufacturing processes and end products possible when utilizing the Jacobsen patents, and should be relied upon exclusively when evaluating the intellectual properties presented.

Quad/Graphics (Q/G) U.S. Patent # 5,457,515 Issued Oct. 10, 1995:

During subsequent prior art searches, it was determined that Q/G was issued a lenticular print patent, which has application to direct printing to the pre-formed lenticular lens via (one) single web roll, as either roll to roll, or roll to sheet delivery. For requirements of only single web application, the following Quad/Graphics patent possibly overlays with Jacobsen patents – but strictly in this instance only. As to this ambiguous overlapping area, the researcher determines certain aspects of the relevant Q/G patent and area of a remote possible overlay is:

1) Single web printing direct to the lenticular lens. Both Quadracci and Jacobsen require this common function in certain instances.

2) Quadracci's requirement of "printing at an angle" to correspond with the spiral pitch of the lens, however, Jacobsen patents do not require this function.

3) Quadracci patent prints only as a single web roll application, which does not allow for manufacturing as two webs with in-line finishing systems occurring concurrently with the printing as Jacobsen patents claim. This fact is definitely not to be considered a possible ambiguous overlay of the Jacobsen patents.

Intellectual Property: Legal Basis & Essential Characteristics Of Patents:

Intellectual Property typically refers to patents, copyrights, trade secrets and trademarks that are used to protect the innovative efforts of an organization. For the researchers' purpose, the following material will only pertain to the patent area of the intellectual property (IP).

The purposes of patents are to protect certain novel, useful and non-obvious inventions.

(Meyer, 2000, p. 1) states, "In the recent decades, the worth of an organization has been driven increasingly by the value of its intangible, as opposed to tangible assets". Whereas at the beginning of the last century "hard" assets such as machinery and raw materials may have provided the company's primary value, many highly successful companies at the outset of the 21st century have only a miniscule holding of such assets in comparison with their overall value", and further more, "For these companies, their worth is driven by a different type of capital asset: intellectual property" and "Intellectual capital takes many forms, including such amorphous elements as organizational culture and philosophy". A primary component of intellectual capital comes from the energies of the organizations personal". (Meyer, 2000, p. 1).

Legal Basis:

(Meyer, 2000, p. 1) explains, "In the United States, certain aspects of innovative energies are provided legal protection as a type of property-intellectual property. Various forms of (IP) are legally protected in the United States and abroad, and some are considered so basic to have a constitutional basis, and,

"Article 1, Section 8 of the United States constitution states in Clause 8 that Congress shall have power "To promote the Progress of Science and useful Arts, by securing for Limited to Authors and Inventors the exclusive Right to their respective Writings and Discoveries", and further,

"Based on this authority, the federal statues establishing federal patent and copyright laws developed. Under the general power granted to Congress in the constitution to regulate Commerce, federal trademark statues developed. In addition, the laws of the various states of the United

States have developed, both through common law based on judicial decisions and on laws enacted by state legislatures, to protect trade secrets".

(Meyer, 2000, p. 2) continues to explain (IP) is to "be considered as a mechanism used to balance competing rights and issues. For example, the United States historically has disfavored monopolies. Some (IP) rights implicate tension with other basic rights; the copyright law, for instance, directly impacts the freedom of speech guaranteed in the Bill of Rights".

"Patent law provides a clear example of this balancing act" emphasizes (Meyer, 2000). Continuing, Meyer states, " A basic tenet of patent law relates to the quid pro quo between inventors and society: There must be a tradeoff in the benefit of society that comes from a patent grant in exchange for the benefit to the inventor that comes from the grant", and "Patent documents themselves graphically evidence this tradeoff in that they include not only a section detailing the legal claims by which the inventor obtains legal rights, but a detailed specification of what the invention is that serves as a roadmap for future innovators and allows society the full benefit of the invention once the patent monopoly expires".

Essential Characteristics of Patents

(Meyer, 2000, p. 3) states, "Federal patent law protects inventions that are novel, useful, and unobvious. To be novel, a patent application must be the first person to invent the subject matter of a patent. An invention generally will be assumed to be useful unless there is some reason to believe that it will not work. Examples of patentable subject matter include processes, machines, and composition of matter. Patentable inventions need not be pioneering breakthroughs. Patent applicants can obtain a patent on modest improvements in existing technology as long as the improvements are not obvious to ordinary practitioners of the art".

(Meyer, 2000, p. 3) continues that "a patent grants its owner the right to exclude others from making, using, selling, or offering to sell the claimed invention into the United States without a license. A patent does not necessarily grant the owner the right to practice the invention, since this might require the use of technology patented by someone else. Patents are considered the strongest form of intellectual property since original creation is not a defense to a patent infringement claim. Patents also are time consuming and expensive to obtain, leading many companies to only seek patent protection for critically important innovations”.

(Meyer, 2000, p. 3) explains “patent protection generally lasts up to 20 years from when the application is filed. One may transfer patent rights to others, and such transfers are recorded in the U.S. Patent and Trademark Office (Patent Office or PTO for short). To obtain foreign patent protection, one must file a patent application in each country where protection is desired. If a patent is infringed, a court may order the infringer to cease the infringement and pay damages to the patent owner”.

Considerations In Forming An Intellectual Strategy

(Gortych, 2000, p. 155) states "a challenge facing today's high-tech companies is generating, managing and leveraging intellectual property (IP) in a manner that optimizes its value. This endeavor requires a well-defined IP strategy. While there are numerous possible IP strategies a company can adopt, there are a relatively small number of fundamental considerations and devices that go into formulating and executing a particular IP strategy. An understanding of these considerations and devices allow scientists, technicians, engineers, managers and executives at high-tech companies to begin the process of forming an IP strategy that suits their own company's needs".

Fundamental Considerations: Relation To Business Plan

(Gortych, 2000, p. 157) states "a company cannot have a coherent IP strategy without having a coherent business plan. A company's IP strategy and its business plan must align to obtain value-optimized IP. In many companies, the IP strategy and the business plan tend to be misaligned, and in some cases are at odds with each other. In certain companies that emphasize IP in its business, the business strategy and IP strategy can bootstrap off one another. For example, where a company makes an important discovery and obtains valuable patents based on discovery, the business plan can change the emphasis from selling the products to licensing the patents covering the discovery. Further, the IP strategy may change to emphasize developing and patenting applications surrounding its recent discovery, and then aggressively enforcing its IP rights".

Patents: The Ultimate Intellectual Property Strategy:

(Gortych, 2000, p. 155) emphasizes, "patents are a key device, and most preferable in protecting specific novel inventions for high-tech companies. A patent provides the right to exclude others from practicing the invention as defined in the claims of the patent. A significant issue that the high-tech company's face is what to patent and how to go about obtaining patents so that the investment made in developing the technology and in obtaining patent protection provides the greatest return".

(Gortych, 2000, p. 155) continues, "for strategic purposes, it is preferable to think about patents in terms of portfolios that cover particular technologies, rather than as isolated patents. The idea behind creating a patent portfolio is to build a wall around the technology so that another would need to traverse to use the technology. The patents are the bricks in the wall. A wall with just a few bricks makes for a barrier that is easily traversed. The patent portfolio wall can also be used in combination with IP devices".

(Gortych, 2000, p. 160) states, "it is often the case that a fundamental invention in a technology will spawn other inventions that a company should patent. It is therefore an important part of an IP strategy to plan to continue patenting in a technology to stay ahead of competitors and to maintain a strong portfolio. A patent portfolio is a living thing that needs to be cared for and maintained. Patents expire, and some patents some patents become less valuable with time while other patents become more valuable. Further, the technology can evolve along several different lines; competitors can obtain patents related to the technology, and so on".

(Gortych, 2000, p. 160) continues, "a problem with having only a few patents in a technology is that sophisticated companies may readily design around them. It is a rare patent that, by itself, completely excludes another from a technology. Even if a patent is a "core" patent in a technology, a sophisticated competitor may have its own strategy of obtaining a host of improvement patents that the owner or users of the core patent would need a license". Gortych states, "Also, pure numbers of patents can matter.

Many small companies would find it simply overwhelming and/or unaffordable to properly analyze a portfolio of 50 patents to determine their legal position with respect to avoiding infringement. It is usually a good deal more difficult and expensive to properly construe and design around a large number of claims of related patents than do so for a single claim of a single patent".

Researcher's Conclusion Of Intellectual Property Strategy Practice

Therefore in conclusion, the researcher believes and practices in its own business organization in creating minimally a single or better yet, a portfolio of patents to protect a particular high-tech novel innovation; which is believed to be the preferred aspect of an IP strategy, vs. to relying on other lesser forms of protections, i.e., trade secrets, or no protection at all.

Due to these beliefs and findings of Intellectual Property facts described herein, the author/researcher of this dissertation and CEO of its' own business organization, has followed the advise written herein, and has invented/co-invented; and has received (six) granted/ issued United States Patent & Trademark Office patents, in addition to having had submitted many other patent pending applications within the USPTO, EPO, and PCT.

Overview

A review was performed on thirty (30) separate pieces of published literature in the area of lenticular optical lens designs, lenticular printable material and its manufacturing processes, lenticular based computer autostereography (pre-press) imaging methods, lenticular printing manufacturing processes, and closely but unrelated literature describing commercial attempts to duplicate lenticular printing optical effects of animation and depth. The information gained through this search was used to support the methodology to be used in this study. The format of this chapter is to discuss the literature in a mostly chronological order in the Literature Review section.

Past Research And Its Impact On The Study

The researcher's substantial study of past research performed on the lenticular subject preliminarily conclude that at no time previous to the issuing of the Jacobsen patents did technology exist of similar nature. This inherent fact has substantial impact on the study for the reason that it helps prove the novel ness and uniqueness of the study.

Review Of Related Literature Materials

Bravenec et al. US Patent # 5,967,032, (1999):

"Printing Process Using A Thin Sheet Lenticular Lens Material".

In this patent, the inventor attempts to claim the novel invention of lenticular printing process using a thin sheet lenticular lens material. Inventor Bravenec et al's, invention comes after over three years since Jacobsen's first to invent lenticular web printing patents. Bravenec et al. describes a process for printing an image on clear lenticular lens material with a printing press using separate film negatives for black, cyan, yellow and magenta. The black negative is selected and each other three negatives, and the lens material, is registered with the selected black negative. Each of the negatives is adjusted to the selected black negative and the lens material is in registry with each other. After this process, separate printing plates are prepared for each of the negatives. The plates are placed on to the press cylinders at the proper print units and the lens material is run through the press with each of the plates being used to print on the lens material. The plates are adjusted by the press operator as required to align the plates and register between each ink color. After final register adjustments are completed, the lens material runs through the press resulting with the lenticular printed image in proper desired display.

The researcher questions the legal validity of the Bravenec, et al., US Patent # 5,967,032 for the reasons that the printing system described within the patent appears to have been used previously (prior art) and continues to be practiced within the printing industry and is similarly used to print standard printing jobs long before the issuance of the said patent.

Bravenec et al. US Patent # 5,974,967, (1999):

"Registration System For Lenticular Printing".

In reviewing this patent, the inventor claims to have invented a lenticular printing registration system, which maintains color registration of colors printed on a lenticular lens material during printing on a printing press to form a desired image. The inventor presents that a predetermined pattern is printed on the lens material in addition to the special effect image. A video camera seeks an image of each printed pattern as the lenticular material moves from the start of the press all the way to the end of the press. During this one press pass, a strobe light and magnifier are used to “freeze” the image for viewing through the monitor to insure that the lenticular image is in correct color register between all the print units. A base line pattern is printed as bars for each color. By viewing the relative position of the bars to the baseline pattern, the register alignment of each color is determined, and if necessary, proper adjustments are made within the print units to align the color and register to present the lenticular image in proper form.

It is of the researcher’s belief that the said patent could be proven to be invalid for the reason that the described registration print system has been used (prior art) within printing industry long before the issuance of the patent, and continues to be practiced today. In addition, the said patent issued over three years is after the first Jacobsen patent issued relating to lenticular printing on roll fed web presses.

Brosh et al. US Patent # 5,924,870, (1999):

"Lenticular Image And Method".

In reviewing this patent, the researcher discovers an unrelated invention to lenticular printing. Brosh et al., claims the novel invention of computer generated lenticular images (pre-press) involving the computer manipulation of minimally one image and of a second image. The images can be sequential in time of the same image or sequential in spatial perspective, or completely unrelated. Images are scanned into a computers memory and then digitally interlaced (sliced). The output of the images can be made to any desired resolution. The output-interlaced image can then be printed upon a lenticular lens material to the proper geometry of the lenticules pitch. The final product will be viewed by seeing the first image from a starting perspective, and the second image from a second and ending viewing perspective.

The researcher believes the Brosh patent to be a valid aid to the lenticular printing industry, particularly since the invention relies on computer digitally converting (prepress) lenticular images compared to the industries prior use of 35MM still film negative cameras. This invention helps promote quality on press while printing lenticular images either by sheet-fed or via roll fed web printing.

Eastman Kodak Company. PT Cruiser Ad Research Results, (2000):

A study by The PreTesting Company, Inc., an independent research company that test advertising, analyzed two versions of an advertisement run in the year 2000 by Daimler-Chrysler for its new PT Cruiser vehicle. Two versions of a four-page tip-in ad for the PT Cruiser were created for testing: one with a dynamic image on the cover page of the ad and one without. The test incorporated a 3 ½ x 2 ½" dynamic lenticular image of the PT Cruiser affixed to the first page of the ad. The dynamic lenticular image showed the PT Cruiser exterior turning on an axis, then zooming in on the trunk, which opened to demonstrate different seat configurations inside the car. The control ad also incorporated a traditional 2D flat art photo of the cars exterior.

The research was based on mall-intercept interviews in ten (10) U.S. cities. Subjects were ages 25-50 with a minimum household income of $40,000.00. There were an equal number of men and women, and people with and without a college degree. The analysis by the PreTesting Company measured and quantified the results of time spent looking at the cover page, time spent looking at the rest of the ad and total time spent looking at the entire ad. Subjects were measured across two exposures to the advertisement.

The results of the study were convincing. The analysis showed, amongst other things, that the test subjects spent on average over four times more looking at the page with the dynamic lenticular image and almost twice as much time viewing the rest of the ad, even though there was no difference in those pages. The study also proved that a second exposure to an ad incorporating a lenticular image can continue to increase reader involvement.

<u>The results as published were:</u>

1) Increased Stopping Power: Readers spent five times as long viewing the cover page with the lenticular image as the one without.

2) Increased Involvement: The test group showed an 85% increase in the time spent viewing the other pages of the ad, pages that were identical in the test and control groups.

3) Continued Performance In Repeat Exposures: In the second exposure, viewers spent twice as long looking at the ad with the lenticular image than the ad without.

4) Gave Consistent Performance: Increased viewing time for the ad with the lenticular image was observed regardless of gender, age or education.

5) Generated Higher Product Perceptions and Ranking: Viewers of the lenticular image ad rated the product as being better and ranked it higher than did the control group.

6) Extended Use: More viewers in the test group said they would use the lenticular image after viewing the ad than did the control group.

The researcher's own business experience producing lenticular advertisements for customers through its business organization has also obtained similar quantifiable and measurable marketing results as cited by its own customer base.

Franko, Sr. U.S. Patent # 6,624,946 (2003):

"In-Line Lenticular Film Manufacturing Having A Selected Web Orientation".

In this patent, the inventor attempts to claim the novel invention of a lenticular in-line printing process using a press made and formed lenticular lens material. Inventor Franko, Sr. (2003), invention comes seven years after, since Jacobsen's first to invent lenticular in-line web printing patents. Franko, Sr. (2003) describes a process for in-line lenticular film manufacturing having a selected web orientation to include providing an optically clear material web to an in-line converting and or printing press. The optically clear material web is advanced into the in-line converting and or printing press in a machine direction of the press. The press includes a lenticule forming means for forming lenticules in the optically clear material web. The lenticules are formed in a selected orientation relative to the machine direction of the press.

Franko, Sr. (2003) discloses Jacobsen U.S. Patents # 5,560,799 (1996), and # 5,753,244 (1998); as well as the Quadracci U.S. Patent # 5,266,995 as references cited of prior art (U.S. Patent documents) to the U.S. Patent Office while attempting to patent Franko, Sr. (2003) U.S. Patent # 6,624,946.

Franko, Sr. (2003) attempts to manufacture a web of lenticular labels created in-line with individual labels that are oriented perpendicular, rather than parallel, to the machine direction. The prior art creates so-called “wipe-on” lenticular adhesive based labels for application by affixing machines that will then apply the lenticular web and its labels directly from the machine direction in a “parallel-sideways” orientation relative to the containers. It is the intention of the Franko, Sr. (2003) invention to create lenticular lens material and printing thereon in an orientation that is perpendicular to the machine direction.

<u>Franko, Sr. (2003) summary of invention includes:</u>

1) Provide an in-line process that creates lenticular lens material in an orientation that is perpendicular to the machine direction

2) Provide an in-line process that creates lenticular lens material in any selected orientation relative to the machine direction

3) Create a lenticular lens material that is constructed during an in-line converting and printing process simultaneously.

It is of the researcher's opinion that Franko, Sr. successfully patents the recently awarded U.S. Patent # 6,624,946 (2003) by re-packaging the patent application and combining certain prior art techniques disclosed by both Jacobsen (1996 & 1998) and Quadracci (1993). It is of the researcher's further opinion that by attempting to create the lenticular lens on the press; while also printing onto the lens simultaneously, the quality control between the two processes will be quite a challenge due to this next reason. Registration from "center-of-lenticules" to the print alignment to individual print register within the 4-12 print stations will be a constant demand of the press operators and of the entire manufacturing process; and it is predicted to fail to produce a quality lenticular printed product, in addition to not being capable of delivering a consistent lenticular product (good or bad).

Goggins. U.S. Patent # 5,896,230 (1999):

"Lenticular Lens With Multidimensional Display Having

Special Effect Layer".

In this invention relating to lenticular (pre-press), the inventor creates a method of producing a multidimensional lenticular image having a special effect, e.g., glow in the dark, reflective qualities, fluorescent imaging, responsiveness to ultraviolet light, etc. A lenticular printable lens is provided having a plurality of equal spaced, parallel lines and smooth planar back surface. A plurality of planar images are created, ordered and interlaced into a pre-chosen sequence. The interlaced images are printed and arranged into a desired manner in relation to the lenticular lens. Last, a special effect coating is then applied to a desired portion of the interlaced images to illustrate a desired visual effect. It is the researchers belief the Goggin invention that comes over three years after the issuance of the first Jacobsen patent is useful in expanding the special imaging effects available to lenticular printing; however, Goggins patent has no direct relation to, nor does it not attempt to improve the present in-line lenticular web printing technology the Jacobsen brings to the industry.

Goggins. US Patent # 6,424,467 B1, (2002):

"High Definition Lenticular Lens".

Inventor Goggins discloses in this invention a method to produce a high definition lenticular lens, which also is capable of providing a viewable high definition lenticular image. The high definition lenticular lens includes a front surface having a plurality of lenticules and a substantially smooth flat surface opposite the front side. Each lenticule is claimed to have characteristic parameters that include a focal length, an arc angle, and a width. The arc angle is greater than 90 degrees and the width is less than about 0.0067 inches. The lens has a gauge thickness that is equal to or substantially equal to the focal length. The high definition lenticular image includes a precursor image joined to the high definition lenticular lens.

It appears to the researcher that inventor Goggins attempts to improve the imaging quality while printing to the high definition lenticular lens where by decreasing the lenticule pitch width of 0.006667 inches or less, while at the same time decreasing the overall thickness of the lenticular lens to 0.01000 inches or less. By reducing the lenticular lens overall thickness, it makes it possible to print the invention on rotary web fed printing presses. Since the Jacobsen patents # 5,560,799 (1996) and # 5,753,344 (1998) relies on roll fed web print production processes, Goggins invention could possibly bring added value to the future advancement of the lenticular printing industry.

Gulick, Jr. US Patent # 6,237,264 B1, (2001):

"Device And Method For Producing Lenticular Images With Motion".

The invention created by Gulick relates to the field of lenticular devices for 3D viewing of images and more particularly to a device associated with the method for forming the device such that a portion of the field of view of the device provides the viewer with motion images. The invention claims to successfully provide a lenticular device that displays motion, by that the views of each individual scene be fully extinguished so that the effect of ghosting between adjacent views is minimized as the lenticular device is rotated at such a slight angle as to change individual views.

The researcher believes that advantages of the invention could help the lenticular printing industry by providing a lenticular device wherein a combination of non-moving (still) and a motion image are viewable – within a band of viewing angles, so that a viewer may optically view a detailed enhanced image of the still lenticular images and the motion of a image without having the blurriness generally associated with moving motion images.

Jacobsen et al. US Patent # 5,181,745, (1993):

"Printed Image Creating The Perception Of Depth".

Prior to the later dated enhanced inventions of Jacobsen US Patents # 5,560,799 (1996) and 5,753,344 (1998), which relates to the advanced in-line lenticular print production of actual 3D and animated lenticular print imaged products on to lenticular substrate, inventor Jacobsen attempted to create an "illusion of depth" in the perception of the viewer by printing 2D flat images on to multiple individual layered clear substrates. By printing and combining the individual multiple layers, the final construction appeared to give the illusion of flat depth, which is described in the current analysis of US Patent # 5,181,745 (1993).

Inventor Jacobsen teaches in US Patent # 5,181,745 (1993) a printed image, suitable for creating an illusion of depth in the perception of a viewer of the image, which comprises a multilayer transparent laminate structure having a back surface and a viewing front surface. A number of the layers in the laminate structure each have a portion of the perceived image printed upon at least one surface of the front and back surfaces. That portion of the image perceived to be the most distant from the viewer is located upon a printed layer which is furthest from the viewing front surface of the laminate structure, and that portion of the image perceived to be most proximate to the viewer is located upon a printed layer closest to the viewing front surface. The portions of the image perceived to be at varying distances there between are located upon intermediate printed layers in a sequence, which corresponds to the perceived varying distances of the intermediate image portions. At least a majority of the image portions are dissimilar parts of the perceived image. Generally, the laminate structure contains a plurality of layers each having a portion of the perceived image printed upon the layer front surface, but a layer may have a part of the image on its front surface and another part on its back surface.

Depth perception may be furthered enhanced by the insertion of transparent unprinted panels between the printed layers, thus creating additional spacing of the sandwiched multiple printed layers.

Inventor Jacobsen later discovered the invention to become to costly to produce an affordable printed advertisement for simulated flat 3D printed images. The invention also seemed to lack substantial three-dimensional depths, which would be later demanded by the advertising industry.

Due to the described facts, inventor Jacobsen abandoned further development of the flat 3D multi-layered print product and sought to create an approved and lower cost technology to illustrate virtual three dimensional depths. With this thought in mind, Jacobsen came to invent an advanced novel invention described in this next review of related literature of Jacobsen, US Patent # 5,560,799, (1996).

<u>Jacobsen. US Patent # 5,560,799, (1996):</u>

"In-Line Printing Production Of Three-Dimensional Image Products Incorporating Lenticular Transparent Material".

Within this particular important and relevant review of related literature, inventor Jacobsen (1996) first discovers an entirely new novel approach to an invention to include various methods for printing massive volumes of images that produce realistic virtual 3D images, in addition to the option of adding or combining animated printed images onto “one-ply of lenticular substrate”, utilizing novel roll fed printing production processes.

Exhaustive research performed during this dissertation will determine the importance the described, “first of its kind invention”, brings to the lenticular printing industry; while also supporting the main thesis stated within the title page and abstract section of this dissertation, “First Novel Invention Of In-Line Web Fed Roll Print Manufacturing Production Of Animated / Three Dimensional Imaged Print Products Incorporating Advanced Transparent Substrate... It’s Advantages And The Comparison/ Contrast Order Analysis To Prior U.S.P.T.O. Patented Art”.

In US Patent # 5,560,799, inventor Jacobsen (1996) brings to the printing industry an entirely new advanced modern method of lenticular print production manufacturing never seen before. The creation, and first to invent concept and its’ process begins as early as 1989 during the inventor’s exploration and hobby use of 3D stereographic photography used with 3D stereographic viewers, and later with 3D photographic lenticular film prints. The present Jacobsen invention was officially documented within the USPTO by filing a patent application on December 22, 1993, later to become an official granted patent on October 01, 1996. Jacobsen later develops advancements to the patent discussed, and receives an additional Patent # 5,753,344 (1998), which will be later explored within this papers review of literature section.

Jacobsen's (1996) invention relates to the in-line web offset, flexographic, or rotogravure roll fed printing press production of lenticular printed products, which provide the illusion of depth and distance, in addition to animation of still images. The high speed web fed production process is continual, and completed in just one printed machine press pass without interruption, compared to the previous industry standard method of sheet fed printing, which is produced one piece at a time, and which also requires additional off-line multiple sub-steps of finishing. The 3D and animated images are printed directly upon the smooth side of the transparent lenticular lens array material, which activates the virtual depth and animation.

Prior to the Jacobsen (1996) invention, several processes and products have previously been developed to fabricate printed pieces that display an illustrative image which appears to be three dimensional (3D) when viewed, giving the illusion of depth to the image. In one example, non-lenticular based 3D images described in US Patent # 5,181,745, were developed by Jacobsen (1993) in earlier attempts to create three dimension by a printing process having different segments of an image printed by an in-line web fed printing method on sequential transparent multiple layers of transparent smooth polished substrate material. One segment of the image, such as the background, would be printed upon opaque paper stock, which forms the bottom layer of the finished product. The final image produces an appearance of simulated depth since the various segments of the image are actually placed at a varied distances from each other.

Additionally, virtual three-dimensional printed images have been formed using a combination of lenticular transparent sheet material through a line formed image, printed on paper, when viewed. This photographic technique is used to produce a line formed image of the subject matter to be displayed, and the array of line formed images printed are perceived as a single image when viewed through the lenticular transparent when the lenses of the transparent and the printed line formed image are in proper alignment. US Patent # 5,028,950 and earlier patents refer and disclose methods for forming such line formed images by a “single sheet, one at a time, photographic printing process”.

Specifically, US Patent # 5,028,950 discloses a photography based system for forming a latent line formed image on extruded transparent APET or PETG plastic lenticular engraved material, using photography-based continuous print film from a set of frames of negative images. The printer, similar to the machines used in photo labs to develop camera negative film, has an edit station at which images from negative images from a number of frames of negative images are generated and visually displayed, and selected data signals for the images are processed to produce key subject identifier signals indicative of the content and location of area. These signals are compared with signals from other frames. A photographic print station separately projects the image of each frame onto print film. The image formed beneath the lenticular transparent surface is a line formed image, and is aligned or registered under the array of lenticular lenses. Light passes through the lenses, and the focal length of the lenses focuses lines of light behind the lens array. The spatial frequency of the line formed image is matched to the foci of the lenses formed in the lenticular film. Each image is an independent line behind the lens, and each lens is divided into eight segments. The light passing through the lens is broken into eight segments. The reflected light from the image emerges in eight zones, and the right and left eyes of the viewer observe the reflected light in parallax. The eyes only see a pair of images at one time, but as the eye scans, different pairs of images are viewed, providing on one printed piece the appearance of depth in the 3 images, or a three-dimensional depth image. Alternatively, or in combination thereof, by placing different images on different lines, the image can be made to change in the eyes of the viewer, where the viewed picture image becomes “animated” and changes as the angle from which the image is altered by tilted the lens either left to right, or top to bottom.

The photographic printer taught in US Patent # 5,028,950 does not provide a single, and continuous one web fed machine press pass as described in US Patent # 5,560,799 as compared herein.

Due to the partial exemplar findings illustrated within this literature review, the inventor Jacobsen determined that there was a need for a lower cost, high speed, and high volume printing production system to supply virtual three dimensional and animated lenticular printed products to the printing and advertising industries.

Accordingly, US Patent # 5,560,799, Jacobsen (1996) teaches a particular highly efficient rotary web fed printing process for rapidly producing high volumes of lenticular printed products which create an illusion of depth and animation in the perception of the viewer of the image, at affordable costs to the buyers of such desired products.

A summary of the invention will be presented in technical form describing the many embodiments of the lenticular printing process and the lenticular printed products it produces below. Upon completion of the summary, the nineteen method claims within the actual published patent will be presented.

Jacobsen (1996) describes that the present invention, US Patent # 5,560,799 provides a method of rapidly producing a high volume of printed screened or stochastic image products suitable for creating an illusion of depth in the perception of the viewer.

In one embodiment, Jacobsen (1996) describes a method of US Patent # 5,560,799, as an opaque web and a transparent web having a lenticular surface and a flat undersurface, which is provided to a rotary web fed in-line finishing printing system. The lenticular surface comprises lenticular “lenticules”, best described as corrugations, or ridged parallel grooves that are either molded, extruded, embossed or otherwise formed into the surface. These lenticules form a multiplicity of linearly arrayed lens elements in the lenticular surface. One of the two roll fed webs is transported and fed into the in feed input of the first series of four color print web offset, flexographic, screen or rotogravure printing units prior to entering the in-line finishing system. The first web enters the rotary web fed press at a preselected speed monitored as certain feet per minute for printing an image on the selected web substrate, being a line formed image which is viewed as an almost continuous tone image when viewed through a compatible lenticular surface. When the web being fed is the lenticular material, the line formed image is applied to the flat underside of the lenticular web material. The printed image on the web is cured to the lenticular material by passing through either ultraviolet ink curing lamps, or by low temperatures within an appropriate heat-setting unit, which also permanently cures and sets the inks. The second other roll fed web of material is transported to and fed into the second in feed input set of four color printing units, using either web offset, flexographic, screen or rotogravure printing units prior to entering the in-line finishing system. This second set of print units, in certain embodiments, may be a printer assembly, but not equipped with printing plates, since only one of the two webs is provided with a viewable image thereon in these certain embodiments. The second set of print units advances the other web in parallel and at the same speed as the first web. The two webs are then advanced together simultaneously and in register through an optional ribbon deck which then slits and positions the web into predetermined web widths prior to entering the two webs to a adhesive or glue lamination unit at the preselected speed, and the webs are laminated together with the opaque web located beneath and in register to the transparent web. The adhesive or glue laminated two web sheets are then advanced at the preselected speed into a sheeter, rotary cutter or trimmer, which cuts the laminated webs into, predetermined size sheets or individual unit sizes. The option also exists to deliver the two web laminated substrates into a rewound roll form for later processing.

Jacobsen (1996) continues to teach the line formed image, printed as described above and appearing on either the opaque paper web or the transparent lenticular web, or both, creates the illusion of 3D depth, animation or combinations of both lenticular enhanced image techniques when viewed through the lenticular surface. It is desirable that the line formed image is printed in the form of round, elliptical dots, or stochastic screening at a screen value wherein the image appears almost as a continuous tone image, similar to the high quality of an actual photographic continual tone image. The image is printed in four color process inks using four color separations printing dots/spots of yellow, cyan, magenta, and black, which are the four color process color inks or spots, to form a multicolor almost continuous tone image by techniques known in the printing art.

Jacobsen (1996) continues to teach in one preferred method, the line form image is printed on the flat smooth underside of the transparent lenticular web opposite the lenticular surface containing the lenticules. The surface of the transparent web opposite the lenticular surface, upon glue laminating the web to the opaque web, will be the underside of the transparent web, which is in contact, and is glue laminated to the opaque web. The line form image may also be printed on the opaque web. The image printed on the opaque web will be facing and ultimately will be laminated to the transparent web.

Jacobsen (1996) also believes it may be desirable to print an additional image on the one web which was not previously printed as described above. In this optional embodiment, if the first line formed image is printed on the flat underside of the transparent web, and then the additional image can be printed on the opaque web. On the contrary, if the line form image was printed on the opaque web, then the additional image can be printed on the transparent web. In either case, after the first and second images have been printed by advancing the two laminated webs through the print units at the preselected speed, the printed line form images are set by advancing the webs through the same ultraviolet curing lamps or heat setting curing units at the preselected speed. Upon glue laminating the webs together by advancing the webs through a glue laminating station at the preselected speed, the image printed on the laminating sheet or roll creates the illusion of 3D depth or animation or combinations thereof when viewed through the top side of the lenticular surface which contains the lenticules.

Jacobsen (1996) describes yet another optional embodiment of the invention, in which the method may include the in-line finishing production of a multi-page signature having a die cut cover layer overlying a lenticular 3D or animated printed image. The method of the present invention may also include, in the laminating step, advancing the opaque web at the preselected speed to a glue laminating station, applying adhesive to create pressure sensitive type adhesive, permanent adhesive, or other suitable adhesives to the webs, and then pressing the webs together in nip rollers.

The method of the invention, in the steps of printing an image on at least one of the opaque web and transparent web, includes the step of printing a line formed image on the one web which comprises segments of the printed image in linear side by side relationship to form a single, unified image when viewed through the lenticular surface of the transparent web. The line formed image is dimensionalized or animated to be compatible with the lenticular lens array formed in the transparent web.

In a further embodiment of the invention, Jacobsen (1996) teaches the method of producing by using two roll fed web printing via offset, flexographic, screen, or rotogravure in-line production process simulating a moving animated image that changes based upon the angle at which the image is viewed. In this aspect of the invention, the method includes the steps of providing an opaque web, and a transparent web having a lenticular surface, and transmitting one of the webs to a first set of print units at a preselected speed for printing on the one web a line formed dual image in linear side by side relationship to form two separately distinguishable images when viewed through the coordinated lenticular surface of the transparent web at varying angles. The method includes setting the image on the one web in a heat curing unit while advancing the one web through the curing unit at the preselected speed, then advancing both webs through a glue laminating unit at the preselected speed and glue laminating the webs together with opaque web located beneath the transparent web, and advancing the laminated webs at the preselected speed into a rotary cutting unit which cuts the laminated webs into finished ready product, or to a substrate sheeter to deliver maximum sized sheets as only limited by the maximum size of the printing press itself.

Jacobsen (1996) also teaches another embodiment of the invention in where a screened or spot printed image has been applied to the flat underside of the lenticular transparent material, and the web has passed through an ink setting -curing unit, sufficient additional opaque ink is applied to cover the full area of the flat underside of the lenticular lens material. The inked surface reflects light overhead when the image is viewed, and in this reflective print embodiment, the need for separate opaque paper substrate backing is eliminated.

In yet another example embodiment of the invention, Jacobsen (1996) describes a further step possible to the preceding paragraph, in which additional text or images are printed on top of the previously imprinted opaque flat underside of the lenticular lens material. For example, the image viewed through the lenticular lenses may be a sports action image, with appropriate explanation, identification and or statistics printed on the reverse side of the final finished product. In addition, Jacobsen (1996) stresses an additional benefit by which a individual or multiple ribbon(s) from the opaque paper substrate web may be one hundred percent or segmented pattern glue laminated to the previously fully printed underside of the transparent lenticular lens substrate web, since the underside is now opaque and the laminating glue will not be visible through the lenticular surface and will not distort the three dimensional or animated printed image.

In order to accomplish the previously described example embodiments of the invention, Jacobsen (1996) recommends a preferred printing system to include ten or more perfecting printing units, in addition to having two substrate webs in feed reel stands. Perfecting printing units are capable of printing images on two sides of a printable web substrate simultaneously. One example of manufacturing product mentioned previously would require the use of a first set series of four perfecting printing units to apply a four color process line formed image on the opaque paper substrate material web. A second set series of perfecting printing units with an additional five or six printing unit's capable of printing four color process, five or six colors would then apply a four color line formed image on the underside of the transparent lenticular lens material substrate. A fifth print unit of the second set series of print units would then apply an opaque print coat to the underside of the transparent lenticular lens material substrate web, over the previously printed four color line formed image. Further more, a sixth print unit from the second set series of print units may be used to apply a second opaque coat over the first opaque coat to create a coating with more density. The sixth print unit, or an additional print unit may apply printed text or other material to the opaque printed surface created by the fifth and sixth printing units described above. In one further example embodiment of the invention, Jacobsen (1996) explains the in-line printing processes mentioned above can be utilized to produce high volumes of printed displays adapted for back-lit lighting. This is accomplished by printing the line formed image on the flat underside of the transparent lenticular lens material substrate without applying a white opaque ink, or by only applying a very light white transparent ink to the remaining undersurface. Light would then be allowed to come through the portion of the material not covered by the image to be viewed, therefore accenting the image.

In addition to the nineteen method claims to follow in the next paragraph, Jacobsen's (1996) selected teachings mentioned herein within this brief review of the literature only cover basic selected partial embodiments. Since the scope of the invention could encompass virtually unlimited possibilities of end product and manufacturing options, it would be impractical to attempt to explain all the various scenarios.

Jacobsen (1996) states the following nineteen method invention claims within US Patent # 5,560,799:

1) Claim one through nineteen states: "A method of producing in single in-line process a printed image suitable for creating an illusion of depth in the perception of a viewer of the image, comprising the steps of: providing an opaque web to an in-line printing process; providing a transparent web to the in-line printing process, said transparent web having a lenticular surface on one side and a flat surface on an opposing underside; transporting said transparent web to a first printer unit of said in-line printing process at a pre-selected speed; printing an image on said flat surface of said transparent web, said image being compatible for viewing when viewed through said lenticular surface of said transparent web; applying an opaque material to cover the entire flat underside surface of said transparent web upon which said image is printed subsequent to the step of printing the image on said flat underside surface of said transparent web; setting said image on said flat surface of said transparent web in a heat setting means of said in-line

printing process, said transparent web advancing through said heat setting means at said pre-selected speed; advancing said webs through a laminating means of said in-line printing process at said pre-selected speed and laminating said webs together, with said opaque web located beneath said transparent web and forming a final image which is visible when viewed through the lenticular surface; advancing said laminated webs through a plow tower means for folding said opaque web into portions with said transparent web sandwiched there between; advancing said laminated webs at said pre-selected speed into a cutting means of said in-line process, which cutting means cuts said laminated webs into sheets; conveying said laminated sheets to a stacking means of said in-line printing process for stacking of said laminated sheets; and said final image printed on said flat surface of said transparent web creating the illusion of depth in said final image when viewed through the lenticular surface".

2) The method of claim one further including the steps of providing an additional web of material, laminating said

additional material as a cover layer upon said laminated sheets, and die cutting and removing a portion of said cover layer overlaying a portion of said laminated sheets, said image being observable through said die cut portion of said cover.

3) The method of claim one wherein said laminating step includes advancing said opaque web and said transparent web at said pre-selected speed to gluing means of said in-line printing process, selectively applying glue to said dual webs, and pressing said webs together.

4) The method of claim three wherein said laminating step includes passing said webs through a laminating nip roll station after passing said webs through said gluing means.

5) The method of claim one wherein the step of printing an image on said transparent web includes the step of printing a line form single image on said web, which line formed single image comprises segments of said printed image in linear side by side relationship which forms a single, unified

image when viewed through said lenticular surface of said transparent web.

6) The method of claim one wherein the step of applying opaque material to the flat surface of the transparent web includes the substeps of applying a plurality of coats of opaque material to said flat surface.

7) The method of claim one including further steps of affixing additional printed material to said opaque material in a direction facing away from said flat surface of said transparent web.

8) The method of claim one including the further step of applying additional printed material to a surface of the opaque web facing away from the flat surface of the transparent web.

9) A method of producing in a single in-line printing process a printed image suitable for creating an illusion of depth in the perception of a viewer of the image, comprising the steps of: providing a transparent web to an in-line printing process, the transparent web having a lenticular surface on

one side and a flat surface on an opposing underside; transporting the transparent web to a first printer unit of said in-line printing process at a pre-selected speed; printing an image on the flat surface of the web, the image being compatible for viewing when viewed through the lenticular surface; applying an opaque coating to the flat surface of the web subsequent to the step of printing an image on the flat surface of the web; applying an opaque web material to the flat surface of the transparent web subsequent to the step of applying an opaque coating to the flat surface of the transparent web; setting the image in a heat setting means of said in-line printing process, the transparent web advancing through the heat setting means at said pre-selected speed; advancing web at the pre-selected speed into a cutting means of said in-line printing process which cuts the web into individual units; conveying said individual units to a stacking means for stacking said individual units; and the printed image on the flat surface of the web creating an illusion of depth when viewed through the lenticular surface of the web.

10) The method of claim nine wherein the step of printing an image on the flat surface of the web includes the step of printing a line formed single image on said web, which line formed single image comprises segments of said printed image in linear side by side relationship which forms a single, unified image when viewed through said lenticular surface.

11) The method of claim nine wherein the step of printing an image on the flat surface of the web includes the step of printing line formed dual images on said web, which line formed dual images comprise segments of said dual images printed on said web in linear side by side relationship to form two separately distinguishable images when viewed through said lenticular surface of said transparent web at varying angles.

12) The method of claim nine wherein the step of applying an opaque coating to the flat surface of the web includes the substeps of applying a first coat of printing ink over the entire flat surface of the web and drying the first coat following the substep of applying the first coat.

13) The method of claim twelve including the additional substeps of applying a second coat of printing ink over the entire flat surface of the web subsequent to the substep of drying the first coat of printing ink, and drying the second coat of printing ink subsequent to the step of applying the second coat of printing ink.

14) The method of claim thirteen including the additional substeps of applying a third coat of printing ink over the entire flat surface of the web subsequent to the substep of drying the second coat of printing ink, and drying the third coat of printing ink subsequent to the step of applying the third coat of printing ink.

15) The method of claim nine wherein the opaque web material is applied to the flat surface of the transparent web by laminating the opaque web to the flat surface of the transparent web.

16) The method of claim nine comprising the further of applying additional printed material to the opaque coating previously applied to the flat surface of the web.

17) The method of claim nine wherein the opaque coating is applied to the flat surface of the web prior to the time the image printed on the flat surface has dried or cured.

18) The method of claim seventeen including the additional step of transporting said web at said pre-selected speed to a drying apparatus, and drying the printed image and opaque material subsequent to the step of applying said opaque material.

19) And finally, the method of claim eighteen is including the step of cutting the web material into individual sheets subsequent to the step of drying the printed image and opaque material.

<u>Jacobsen U.S. Patent # 5,753,344, (1998):</u>

"In-Line Printing Production Of Three Dimensional Image Products Incorporating Lenticular Transparent Material".

In review of the referenced literature, Jacobsen (1998) expanded the later patent by adding two additional apparatus claims of the said invention by teaching further novel developments over the preceding US Patent # 5,560,799 of October 1, 1996, which had referenced nineteen method claims.

<u>In addition to the example embodiments discussed in previous literature review of US Patent # 5,560,799, inventor Jacobsen now adds two additional novel claims to expand the invention:</u>

1) Claim one states: "A three-dimensional image printed product for use in advertising and mass printing industries including a printed image suitable for creating an illusion of depth in perception of a viewer of the image, said printed product comprising: a transparent web having a lenticular surface on one side and a flat surface on an opposing surface; a first portion of a line formed image printed on said flat surface of said transparent web; an opaque coat printed over the first portion of the line formed image on

said flat surface of said transparent web; an opaque web laminated to said flat surface of said transparent web and over the first portion of the line formed image; a second portion of the line formed image printed on a surface of said opaque web facing said flat surface of said transparent web said first and second portions of said line form image being in register to create a single line formed image having the appearance of depth when viewed through said lenticular surface of said transparent web; and additional printed material affixed to the said of said opaque web opposite the surface of said opaque web facing said flat surface of said transparent web".

2) Claim two states: " A three-dimensional image printed product for use in advertising and mass printing industries including a printed image suitable for creating an illusion of depth in the perception of a viewer of the image, said printed product comprising: a transparent web having a lenticular surface on one side and a flat surface on an opposing side; a line formed image printed on said flat surface of said transparent web; an opaque coat printed

over said line formed image on said flat surface of said transparent web; said opaque coat including a plurality of printed coats applied to said flat surface of said transparent web; and additional printed material affixed to said opaque coat in a direction facing away from said flat surface of said transparent web".

Jacobsen. US Patent # 6,153,039, (2000):

"Card And Method Of Making Same".

Concurrently and during the pre-granting of US Patent # 6,153, 039 (2000) in the early 1990's, Jacobsen attempts to animate and three-dimensionalize a print product beyond "standard ink on paper commercial printing", by developing advanced lenticular imaging principles, which are discussed within this research paper. Working in between the inventions mentioned above, Jacobsen additionally introduced a novel printing process and product involving "interactive moving paper and plastic slides within carriers", to mimic a form of animation. Accordingly, this non-lenticular, two-dimensional print product break through, commercially named, "The Sliding Lamigram Magic Changing Window" was born. The "Sliding Lamigram Magic Changing Window" (SLMCW) was one more attempt by Jacobsen to revolutionize the printing industry with "print action devices" that would bring standard commercial printing “alive”. Although the invention to be described is novel, it is considered by the inventor Jacobsen to be too expensive as a final printed product, and not as grand; as in comparison to the lenticular inventions Jacobsen introduces to the printing and advertising industries.

In US Patent 6,153,039 (2000), Jacobsen teaches and states the invention to include: A method of forming a novelty card using an in-line web offset printing and production process, including the steps of providing a web of printable material and a web of a transparent material of a pre-determined width to a printing apparatus. A strip of the printable material is formed having at least a front panel, a rear panel and an insert panel. At least one image is printed on the rear panel, and at least one image is printed on the transparent material. A window is formed in the front panel through which the printed image on the rear panel can be viewed. A panel is then formed from the portion of the transparent material bearing the printed image. The panel is secured to the front panel so that it spans the window. The insert is separated from the strip of printable material and positioned onto the front panel to separate the images. The rear panel is folded onto the front panel so that the image on the second side of the rear panel is aligned with the interior of the window and viewable there through. The rear panel is then secured to the front panel to form a pocket or envelope with at least one opening which slid ably accepts and retains the insert. The end product works by simply switching out one (A) image to another (B) image, or by adding more detail features to one image such as including color to a black drawn image outline. The changes occur by sliding the inner center movable slide up and down which then alternately changes the before and after images. The end product is very limited to the animated effects it offers as compared to the lenticular inventions discussed herein.

Johnson, et al. US Patent Application Publication # US 2003/0002160 A1, January 02, 2003:

"Lenticular Lens Array And Tool For Making A Lenticular Lens Array", and including,

Johnson, et al. International Application Published Under The Patent Cooperation Treaty (PCT) # WO 02/101424 A2, December 19, 2002:

"Lenticular Lens Array And Tool For Making A Lenticular Lens Array".

In a most recent attempt to improve the optical quality of the industry's standard printable transparent cylindrical lenticular lens material, co-inventor, Gary A. Jacobsen of United States Patent Application Publication # US 2003/0002160 A1 (2003) and of it's sister patent application, International Application Published Under The Patent Cooperation Treaty (PCT) # WO 02/101424 A2 (2002), retains a leading optical scientist and prior Chair and Professor of the Optical Department of University of Alabama/Huntsville, Professor R. Barry Johnson. Johnson, also past president and noted Fellow, within the respected worldwide optical engineering organization, “Society of Optical Engineers”, is greatly instrumental in advancing the said patent contents of the application publication claims and helps implement the futuristic novel invention concepts along with Jacobsen, whom is a printing industry expert with over 30 years experience in mechanical print engineering, non-lenticular and lenticular printing and imaging processes, that also includes web handling and in-line finishing systems. Jacobsen and Johnson’s team approach determines after much research study and laboratory analyses of the prior lenticular art, including both the current and previous optical lenticular lens design and lenticular materials, that an advanced optical lenticular lens design and lenticular material is desired, and by developing the said inventions will enhance the final viewed printed lenticular image quality. Additionally, the new lens design and its material would help advance the use of Jacobsen’s currently granted lenticular print process and product patents discussed and compared within this research paper. Accordingly, Jacobsen seeks to improve the entire optical lenticular lens array material and lenticular printing and imaging systems.

Last, due to the strong belief in the patent process system and protection it offers engineers, inventors, and companies, Jacobsen seeks and applies for (US and EPO/PCT) global patent protection of the new patent pending inventions, which will be discussed in the next paragraphs.

Before stating the descriptions and pending claims of US Patent Application Publication # US 2003/0002160 A1 (2003), and of the sister International Application Published Under The Patent Cooperation Treaty (PCT) # WO 02/101424 A2 (2002), the researcher will summarily describe the reasoning, features and optical benefits of the new optical lenticular lens design, commercially trade named, “LentiClear Lenticular Lens 2004”.

Co-inventor Jacobsen (2002/2003) researches methods to develop the most advanced, optically correct and clear printable thin-gauge lenticular lens array materials to produce higher quality lenticular viewable printed products. After careful optical laboratory analysis, Jacobsen determined that the industry’s standard various lenticular “cylindrical or spherical” lenses have limited optical performance properties and are similar variations of older prior art lens designs. Due to these findings, Jacobsen (2002/2003) co-invents and co-develops a new "aspheric/elliptical" optical lens array design. The new optical lenticular lens array design would not simply copy or reverse engineer the current cylindrical/spherical lenticular lens designs and materials.

Creating the most advanced "aspheric/elliptical" lenticular lens array designs and lenticular printable material would also require a superior diamond tool, which would then record the "aspheric/elliptical" lens design profile into the extruded lenticular lens array shape material itself. The diamond tool tip surface would require a limit of "tool waviness", or (surface smoothness), from a low of less than 1 micron, up to 3 microns. The surface tip of the diamond tool would comprise of a plurality of intersecting points of the facets; between two, three or more facets creating a pseudo-ellipse, or optionally and most preferred, a single plane true elliptical shape. The superior ultra-smooth diamond tool would bring the following benefits:

1) A new scientifically novel and improved elliptically enhanced outer physical shape of the lenticular lenticule;

2) Improved internal optical functions to promote cleaner and clearer printed images to the viewer;

3) Less visible projected image aberrations;

4) Enhanced printed image resolution due to lower aberrations and distortion;

5) Higher image contrast as compared to the standard spherical lenticular lens materials.

Due to the above mentioned benefits of using the ultra-smooth diamond tool, and by adding the advanced optical elliptical lens design to the tool described, the following combined benefits of use would exist in the lenticular lens array material:

1) New enhanced optical designs exist for both extruded , molded and cast/embossed style lenticular lens materials;

2) Overall material thickness of lens designs can be created to produce lens array material from 0.004 mil and beyond;

3) Ability to print images clearer, smaller serif type and point sizes, e.g., flipping from black to color copy, language changes;

4) Thinner lens structures are flexible enough to affix to containers, jars, bottles, cups, cartons, and flexible packaging without de-laminating due to memory of heavier

and thicker lens array gauges, while maintaining great optical print characteristics;

5) Thinner optically correct lenticular lens array materials using said invention reduces the thickness and weight per square inch of the lenticular material, thus reducing the cost of use;

6) Invention has comparable lenticular performance of thicker lens array designs, but at a much lower material thickness;

7) Invention offers increased lenticule viewing width area for broader animated imaging techniques and performance at lower material thicknesses in addition to higher and finer lens pitch;

8) Invention designed to help decrease material press make-ready start up and press running waste as compared to standard spherical lenticular array materials, thus reducing costs of usage;

9) Invention engineered to increase quality of print images by as much as 35%, as compared to current standard cylindrical/spherical lens array designs;

10) Invention design produces proper ray tracing and existing of light (printed image) to viewer for unequaled viewing performance;

11) Optical lens designs in able use of thinner lenticular material lens designs that are dimensionally stable in both sheet and roll form for either press application;

12) Higher lens uniformity;

13) Increased higher ink receptivity;

14) Enables using multiple printing processes, including offset, flexographic, gravure, letterpress, and digit imaging/print processes;

15) Provides less cross talk, (image ghosting).

Description of US Patent Application Publication # US 2003/0002160 A1, January 2, 2003; and of Johnson, et al., International Application Published Under The Patent Cooperation Treaty (PCT) # WO 02/101424 A2, December 19, 2002:

Johnson and Jacobsen (2002/2003) describe a lenticular lens array for creating a visual effect for an image viewed through the lenticular lens array comprises a plurality of lenticules disposed adjacent to each other. Each lenticule comprises a lenticular lens element on one side and a substantially flat surface on an opposite side. Each lenticular lens element has a vertex and a cross section comprising a portion of an elliptical shape. Alternatively, the cross section can compromise an approximated portion of an elliptical shape. The elliptical shape comprises a major axis disposed substantially perpendicular to the substantially flat surface of each respective lenticular lens element. The vertex of each respective lenticular lens element lies substantially along the major axis of the elliptical shape. Accordingly, the present inventions one specific major advantage over the prior art is that it can reduce spherical aberration associated with conventional lenticular lens array by providing a lenticular lens array having an elliptical cross-section shape. The elliptical cross-section shape can provide sharp focusing of on-axis light and can increase the clarity of off-axis light. The characteristic shape of the elliptical cross section can be determined based on a particular application. Many parameters can influence the elliptical shape. For example, the parameters include a refractive index (N) of the array material, a thickness (t) from the vertex of each lens element to a rear surface of the array, a lens junction depth (d) where adjacent lenses join, and other parameters. A pseudo elliptical lens element also can provide a lenticular lens array having reduced spherical aberration.

Patent Claims of Johnson, et al., US Patent Application Publication # US 2003/0002160 A1, January 2, 2003; and of Johnson, et al., International Application Published Under The Patent Cooperation Treaty (PCT) # WO 02/101424 A2, December 19, 2002:

Jacobsen and Johnson (2002/2003) make 28 specific claims which follow and describe the invention claims:

1) A lenticular lens array for creating a visual effect for an image viewed through said lenticular lens array, comprising: a plurality of lenticules disposed adjacent to each other to form the lenticular lens array, each lenticule comprising a lenticular lens element on one side and a

substantially flat surface on an opposite side, wherein each lenticular lens element has a vertex and a cross section comprising a portion of an elliptical shape, the elliptical shape comprising a major axis disposed substantially perpendicular to the substantially flat surface of each respective lenticular lens element, and wherein the vertex of each respective lenticular lens element lies substantially along the major axis of the elliptical shape.

2) The lenticular lens array according to claim 1, further comprising an interlaced image printed on the flat surface of at least one of said plurality of lenticules, wherein viewable portions of said interlaced image change as a viewing angle of said lenticular lens array changes.

3) The lenticular lens array according to claim 1, further comprising an interlaced image printed on the flat surface of at least one of said plurality of lenticules, wherein viewable portions of said interlaced image produce a three-dimensional visual effect when viewed through said lenticular lens array.

4) The lenticular lens array according to claim 1, further comprising an opaque substrate, having an interlaced image printed thereon, coupled to the substantially flat surface of said plurality of lenticules, where the interlaced image printed on said opaque substrate faces the substantially flat surface of at least one of said plurality of lenticules, and wherein viewable portions of the interlaced image change as a viewing angle of said lenticular lens array changes.

5) The lenticular lens array according to claim 1, further comprising a substrate coupled to the substantially flat surface of said plurality of lenticules.

6) The lenticular lens array according to claim 5, wherein said pluralities of lenticules are cast onto said substrate.

7) The lenticular lens array according to claim 6, wherein a discontinuity exists between two adjacent lenticules.

8) The lenticular lens array according to claim 1, further comprising a plurality of substrates coupled to the substantially flat surface of said plurality of lenticules.

9) The lenticular lens array according to claim 8, wherein one of said plurality of substrates comprises an adhesive layer.

10) A lenticular lens array for creating a visual effect for an image viewed through said lenticular lens array, comprising: a plurality of lenticules disposed adjacent to each other to form the lenticular lens array, each lenticule comprising a lenticular lens element on one side and a substantially flat surface on an opposite side, wherein each lenticular lens element has a vertex and has a cross section comprising an approximated portion of an elliptical shape, the elliptical shape comprising a major axis disposed substantially perpendicular to the substantially flat surface of each respective lenticular lens element, and wherein the vertex of each respective lenticular lens element lies substantially along the major axis of the elliptical shape.

11) The lenticular lens array according to claim 10, wherein the approximated portion of the elliptical shape comprises: a circular-shaped portion that approximates a circular-shaped portion of the elliptical shape; and a plurality of substantially

straight portions, each substantially straight portion approximating a portion of the elliptical shape.

12) The lenticular lens array according to claim 10, wherein the approximated portion of the elliptical shape comprises: a circular-shaped portion that approximates a circular-shaped portion of the elliptical shape; a first pair of corresponding substantially straight portions separately disposed adjacent to opposite ends of the circular-shaped portion and approximating a first portion of the elliptical shape; and a second pair of corresponding substantially straight portions separately disposed adjacent to a respective one of the first pair of substantially straight portions and approximating a second portion of the elliptical shape.

13) The lenticular lens array according to claim 10, wherein the approximated portion of the elliptical shape comprises: a circular-shaped portion that approximates a circular-shaped portion of the elliptical shape; and a first substantially straight portion disposed adjacent to the circular-shaped portion and approximating a first portion of the elliptical shape.

14) The lenticular lens array according to claim 13, wherein the approximated portion of the elliptical shape further comprises a second substantially straight portion disposed adjacent to the first substantially straight portion and approximating a second portion of the elliptical shape.

15) The lenticular lens array according to claim 10, further comprising a substrate coupled to the substantially flat surface of said plurality of lenticules.

16) The lenticular lens array according to claim 10, wherein the approximated portion of the elliptical shape comprises a plurality of facets each approximating a portion of the elliptical shape.

17) The lenticular lens array according to claim 16, wherein the plurality of facets comprises a plurality of corresponding pairs of facets.

18) The lenticular lens array according to claim 16, wherein the plurality of facets comprises: a vertex facet disposed at the vertex of respective lenticular lens elements and positioned substantially orthogonal to the major axis of the elliptical

shape; and a plurality of corresponding pairs of facets disposed outside of said vertex facet.

19) A method for producing a tool, the tool for creating a mandrel for forming elliptically-shaped lens elements of a lenticular lens array, comprising the steps of: providing a base member having a radius “b” corresponding to a minor axis of an elliptical shape, the elliptical shape corresponding to a desired elliptical shape for each lens element of the lenticular lens array; and cutting the base member along a plane that forms an angle “k” with the minor axis of the desired elliptical shape, wherein the elliptical shape comprises a major axis perpendicular to the minor axis, wherein a vertex of the desired elliptical shape lies at a point “a” along the major axis, and wherein the angle “k” is given by the formula cosine (k) = b/a.

20) The method according to claim 19, wherein the base member comprises a cylindrical shape.

21) The method according to claim 19, wherein the base member comprises diamond.

22) The method according to claim 19, wherein the radius “b” and the point “a” are adjusted from the desired elliptical shape to compensate for a protective surface that will be placed on the mandrel after being created by the tool.

23) The method according to claim 19, wherein the base member comprises a cone shape.

24) A tool for creating a mandrel for forming pseudo elliptically-shaped lens element of a lenticular lens array, comprising: a circular-shaped portion that approximates a circular portion of an elliptical shape, the elliptical shape corresponding to a desired shape elliptical shape for each lens element of the lenticular lens array; and a plurality of facets disposed adjacent to said circular-shaped portion, each facet approximating a portion of the elliptical shape.

25) The tool according to claim 24, wherein said plurality of facets comprises a first pair of corresponding facets separately disposed on opposite ends of said circular-shaped portion.

26) The tool according to claim 25, wherein said plurality of facets further comprises a second pair of corresponding facets separately disposed adjacent to a respective one of the first pair of corresponding facets.

27) The tool according to claim 24, wherein said circular-shaped portion and said plurality of facets comprise diamond.

28) The tool according to claim 24, wherein the elliptical shape is larger than the desired elliptical shape to compensate for a protective surface that will be placed on the mandrel after being created by said tool.

Due to the numerous benefits discussed previously in the review of the pending published patent applications, a combined summary will be presented at this point describing the overall advantages of its use, as compared to the current industry's use of non-elliptical lenticular material. The context of this summary is based on the present invention utilizing either pseudo elliptical lenticular material, or true elliptical lenticular lens array material; both lenticular materials being manufactured from the tool, and the tool being created from the tool methods described herein.

Combined Summary: Benefits Of Use Practicing The Jacobsen Inventions:

The present and preceding lenticular tool and lenticular material inventions discussed provide extreme benefits of use when coupled to the previously discussed lenticular printing processes of, Jacobsen, U.S. Patent # 5,560,799 (1996), and Jacobsen U.S. Patent # 5,753,344 (1998).

Accordingly, in this context of analysis, the researcher determines the following observations, and summarily describes:

Optically speaking first, the present Johnson, et al., U.S. 2003/0002160 A1, January 2, 2003 invention, titled, "Lenticular Lens array And Tool For Making A Lenticular Lens Array", provides the following major class benefits:

1) Provides a lenticular lens array that can optimize printed display quality of animated and three-dimensional images for mass production.

2) The lenticular lens array can mitigate the spherical aberration typically produced by a conventional array. For example, the present invention can provide a lenticular

lens array that can produce a substantially focused axial image and can improve the off-axis image.

3) The mitigation of the spherical aberration afforded by the inclusion of the elliptically shaped lens, when compared to conventional lenses, allows the utilization of thinner gauge lenticular lenses to achieve the same or better performance of same or heavier gauge materials.

4) Additionally, the current invention can provide a lenticular lens array having a reduced lens junction depth, which can mitigate off-axis light blocking by adjacent lenses.

5) Sheets of thinner lenticular lenses offer significant advantages when affixed to cylindrical objects vs. thicker lenses.

6) Use of thinner lenticular gauge material reduces costs of use up to 50% percent less as compared to conventional heavier lenticular gauge materials used today.

Utilizing and combining the present issued Jacobsen lenticular printing patents, U.S. Patent # 5,560,799, (1996) and US Patent # 5,753,344, (1998) titled, “In-Line Printing Production Of Three-Dimensional Image Products Incorporating Lenticular Transparent Material” to the previous discussed Johnson, et al. US Patent Application Publication, US 2003/002160 A1, January 02, 2003, titled, “Lenticular Lens Array And Tool For Making A Lenticular Lens Array”, provides the following combined major class benefits:

1) Allows printing upon a lenticular lens array that can substantially optimize printed display quality of animated and three-dimensional images used for mass production of lenticular printed products

2) Allows quality based printing upon thinner gauge lenticular materials using “continuous” web fed roll print production technology vs. “one at a time”, single sheet fed print production

3) “Continuous” web fed roll print production is much more cost efficient than “one at a time”, single sheet fed print production

4) Combining the aforementioned mentioned technologies can create new, never-seen-before printed lenticular formats and structures including: entire outer lenticular packaging enhancements (box over wraps); segmented applied lenticular label coverage to outer packaging; pressure sensitive, non-pressure sensitive, self adhesive, and non-self-adhesive lenticular label products; multi-ply, multi-substrate peel open pressure sensitive and non-pressure sensitive lenticular labels; lenticular laminated to paper board products; packaging in-packs and on-packs; beverage cups having decorative partial or full lenticular cup wraps; video, dvd, or cd disc cover lenticular treatments; direct mail; magazine inserts; newspaper inserts; or contest and game sweepstakes components that comprise use of partial or full lenticular enhancements.

Kumagai et al. US Patent # 5,724,188, (1998)

"Lenticular Lens Sheet".

The invention created by Kumagai (1998) relates to a lenticular lens sheet, which could not be utilized, or would not add any benefit to the lenticular printing industry, which the researcher explains in great detail within this research paper. This particular field of invention relates to a lenticular lens sheet for use in transmission type screen of a rear projection type television, and more particularly to a lenticular sheet to be used in the rear projection type television which is provided with lenticular lenses of fine pitch and which uses a liquid crystal display panel. Kumagai (1998) invention includes a double-faced lenticular lens sheet comprising incident side lenses formed on one of the main faces and emergent side lenses formed on the other main face, such that light rays are incident on the incident side lenses in parallel with the optical axis pass through the lenticular lens sheet and are emitted from the emergent side lenses.

Due to the above facts, the researcher determines that the Kumagai (1998) invention is of little value to the advancement of the lenticular printing industry, nor adds any improvement over the discussed Jacobsen published literature.

Koltzenburg, Teresa. (2000, January). Paper Film Foil Converter Magazine, Narrow Web Feature, "Bringing A New Dimension To 3-D Imaged Packaging".

During Koltzenburg's company assigned research to investigate new novel approaches to advances in printed packaging advertising and novel manufacturing methodology, Senior Editor Koltzenburg discovered published patent material within the United States Patent and Trade Mark Office (USPTO) relating to the Jacobsen lenticular printing patents reviewed within this paper. Upon learning of Jacobsen's lenticular printing technology, Paper Film Foil Converter Magazine requested to visit and interview Jacobsen's company headquarters' in Itasca, IL, USA, doing business as, Web Communications Group, Inc. / Animated Printing & Packaging (WCG/APAP). After Koltzenburg interviewed Jacobsen and toured the WCG/APAP facility, a major industrial based article was written and published titled, "Bringing a New Dimension To 3-D Imaged Packaging", which included the following opening descriptive narrative subtitle, "Web Communications Group's recently secured patents are set to provide packaging buyers and manufacturers with an exciting new way to make their products (jump off) the shelves". Since a copy of the current article under literature review will be placed within this papers appendix for reference and later reading, the entire article and its contents will not be repeated herein; however, the researcher will present the main focus of the article, which includes the following divisional subtitles from the article:

1) "<u>3-D: Now and Then"</u>, which describes a comparison of three-dimensional printing used in the 1950's in contrast to modern printing techniques utilized by inventor Jacobsen today;

2) "<u>Less Steps, Less Cost, More Products"</u>, which "Less Steps" describes comparison order analysis to prior sheet-fed print manufacturing to Jacobsen's' modern roll web-fed high speed and one step complete manufacturing lenticular printing processes; secondly, "Less Cost" describes the cost savings in manufacturing by utilizing the Jacobsen patents as compared to the prior slow, one at a time, sheet-fed print process; thirdly, "More Products" describes the vast array of new packaging products possible due to the Jacobsen patents, which include the few product samplings: video jackets, compact disc insert cases, beverage cup graphic wraps, direct mail tip-ons, FDA approved food in-packs, magazine inserts, and much more.

3) "It's All in the Lens (and the Printing): which explains the technical advantages of both the lenticular lens and lenticular printing processes.

4) "The Man Behind the Patents": describes the research method utilized by Jacobsen during the conception of the lenticular printing invention idea, past career history, current academic studies, and current role Jacobsen and WCG/APAP play in the continuing lenticular packaging product development and manufacturing sectors.

The researcher determines and concludes by reviewing the published article written by Koltzenburg, that Paper Film Foil Converter magazine finds novel ness and sound advantage by utilizing the Jacobsen (1996 & 1998) lenticular patents and the lenticular products it creates.

<u>Kuo et al. OE Magazine, The Monthly Publication of SPIE – The International Society for Optical Engineering, (July, 2001 issue), Titled: Total Immersion:</u>

Within the current literature article under review, subtitled: "Streaming 3-D video, audio, and a sense of touch will surround people with a virtual environment over their high-speed internet connections", the authors describes an unrelated, but intriguing futuristic emerging technology under research, as compared to the currently described lenticular lens array materials and animated and three dimensional printing technologies.

The authors Kuo, et al. whom are with Integrated Media Systems Center at the University of Southern California describe a total-immersion technology called "Immersipresence". This developing technology includes the use of streaming 3-D video, audio, and a sense of touch in a virtual environment, which is connected over high-speed internet connections. The emerging technology adds a new optical component to the system, namely three-dimensional, real time visual display that puts the user in the middle of a scene being transmitted from some other location. The authors go on to explain that the total-immersion technology will dramatically change the world of computers, TV, and film into virtual three-dimensional environments, right into consumers living rooms, or practically anywhere else. With the expansion of satellite transmission, this technology may be accessible in all parts of the world. By transmitting live scenes over the internet in 3-D, the technology will augment the real environment. In essence, the real environment for example, within 10 years could have people shopping from their living rooms via an internet home-shopping channel that will allow them to see and talk to lifelike, full bodied human representations of store clerks. Within 15 years it is predicted the system may be able to provide a realistic sense of touching and feeling the products. Three-dimensional audio will make it sound like people are in the shopping mall. These immersive environments could be a living room, factory floor, office or classroom.

Comparing this intriguing futuristic total-immersion technology to the current lenticular technology discussed within this research paper - both have only one similar characteristic, each technology does not use the aid of unnoticed screens or special colored filter glasses. In closing, the researcher believes the current lenticular printing technology discussed herein will not ever have the capability of ever progressing to the point discussed within this particular review of literature. Additionally, the total-immersion technology most likely will not bring any usefulness to the lenticular printing industry.

Luttenberger. Packaging Technology & Engineering, Professional Journal of Packaging (1999):

Within this review of literature, the editor, David Luttenberger of Packaging Technology & Engineering sends a congratulatory letter and notice to Gary A. Jacobsen, Chief Engineer and President/CEO of Web Communications Group, Inc. (WCG) dated September 09, 1999. Luttenberger announces that WCG's entry has been judged as the winner of the "Emerging Technology Award", in Packaging Technology & Engineering's 1999 Technology of the Year Awards Competition. WCG is invited to attend and receive 1st place winning plaque for this "Emerging Technology" category at the Award Reception to be held September 28, 1999 during and in conjunction with the WestPack Packaging Industry Convention, Anaheim, California.

WCG's proprietary entry, which was titled, "3D Lenticular Packaging/Printing (Entire Full Wrap)" was acknowledged as novel and useful to the packaging industry by the judging committee for its combination use of both 3D and flip animation imagery and for its' unique presentation of decorative lenticular packaging style. Under the direction of Jacobsen, WCG's print engineering staff created and submitted a lenticular imaged mock-up proof of a (consumer packaged goods sample) to

Packaging Technology & Engineering. The pre-press production mock-up comprised of (A) 0.10" point thick underlying SBS Carrier Board and also included (B) WCG's future patent pending, 0.0102 Mil, 142 LPI thin-gauge lenticular lens material which was then laminated and attached to the entire outer SBS Board surface. The completed and submitted lenticular mock-up entry sample resembled Colgate-Palmolive's, "Total Dental Crème" outer packaging carton with art graphics that appeared both as three-dimension and 2 phase flip animation. The lenticular mock up samples were placed on display for public viewing during the entire shows length.

<u>Morton. US Patent # 6,163,406, (2000): Lenticular Image Bearing Member With Variable Line Spacing To Improve Image Quality.</u>

Inventor Morton (2000) teaches and describes an invention that relates in general to lenticular imaging. Morton (2000) specifically teaches a lenticular image bearing member and a manufacturing of method of manufacturing a lenticular bearing member having a variable line spacing to improve image quality. Conventional lenticular imaging techniques have utilized an image receiving member having a plurality of groups of image scan lines corresponding to different views. A constant scan line spacing is used between the image scan lines within a group, thereby resulting in at least one scan line that is on-axis with a lens utilizing to image the scan lines and a number of scan lines that are off-axis with the lens. While the quality of the images when viewed on axis to the lens can be very good, the image quality degrades substantially for off-axis lines due to the inherent imitations of the lens. Therefore, Morton (2000) desires to provide a lenticular image in which the image quality is maintained viewing all scan lines. The researcher determines while reviewing this literature that there appears to be novel ness in the patent invention, however it is unclear if it brings any value added to the lenticular printing industry within the context of what this research paper explores.

Morton. US Patent # 6,211,896 B1, Method For Producing Lenticular Images (2001):

In the review of this literature, inventor Morton (2001) continues to attempt to advance the quality of lenticular images by teaching images are written with a writing spot which is scanned over a recording material. The shape of the writing spot and at least one component of the recording material influence the image quality of the recorded image. The improvement within this invention is said to comprise to shape the writing spot or at least one of the contributing components of the recording material to obtain an overall response which is accordingly substantially trapezoidal. The summation of the overall responses is free from ripples and thereby improves quality. Morton (2000) believes the invention will help prevent an image from being indistinct from one another, with an example being the show of moiré patterns or other flickering effects. The researcher believes that while this invention also appears novel, it does not address the technical issues explored or required to advance the commercial lenticular printing industry in using in-line web fed printing equipment, and the requirement of thin gauge lenticular material.

Neefe. US Patent # 4,406,189, (1983):

Method Of Making Lenses With A Lenticular Cut:

While researching lenticular based prior art through the United States Patent & Trademark Office, the researcher determines after reading this review of literature material that the invention relates to a method of rapidly making lenticular contact lenses having a flange thinner than the optical section of the lens and of uniform thickness regardless of refractive power. It is determined that this invention has no value to this papers research due to the fact the end use purpose of this invention relates to optical eye contact lenses for the eye care industry.

Quadracci. US Patent # 5,108,531, (1992):

"Method And Apparatus For Stereographic Printing With Preshrinking:

During the near exhaustive search and review of prior U.S. patented art, the researcher determines that Quadracci (1992) is possibly the first inventor and possible first U.S. industry printer who attempts to print lenticular images using a rotary web fed single roll (semi-continuous, multiple step) printing process, rather than using a single, one at a time, non-continuous sheet fed printing process which is currently the industry preferred method; with the only exception being the Jacobsen's dual web roll fed continuous (one step) in-line finished lenticular printing patents discussed herein previously. It is interesting to note now that Quadracci will introduce three more future lenticular print continuation-in-part patents, which will be discussed now, and later within this paper, which attempts to manufacture lenticular roll fed printing in a more cost effective manner than discussed within this particular review. In order to understand the unique nuances of the other "less effective manufacturing methods" to be taught and compared to each other in this paper, specifically, in comparison to the previously discussed "highly productive and effective Jacobsen lenticular printing patents", it will be necessary to explain each manufacturing process thoroughly in detail in order to grasp the pro/con differences of each process by a comparison/contrast order analysis. An overall description of manufacturing method and process will be explained in each review of literature when applicable through out this paper. The researcher will present a detailed summary and conclusion of the various discussed lenticular print manufacturing processes in Chapter V: Summary, Conclusions, & Recommendations section later in this dissertation.

Quadracci (1992) introduces to the printing industry the first printing process to print lenticular images on a heat set web offset press. Although this particular manufacturing process is interesting in concept, and is theoretical to be more cost effective and have higher productivity than “one at a time lenticular sheet fed printing”, it really is not. The Quadracci patent requires “three complete separate manufacturing steps” in order to produce a completed and finished lenticular printed product. The Jacobsen lenticular print manufacturing patents reviewed previously only require “one step” to produce a completed and finished lenticular printed product. This important fact needs to be reflected upon and remembered during the reading of this paper when comparing the lenticular print manufacturing methods within the review of literatures chapter.

Quadracci (1992) describes a method of highly accurate printing using a web offset press, particularly for the purpose of stereographic printing. Consistent reproductions of a composite image are produced on a “paper web”, and registry between the image and an embossed lenticular screen is maintained, by preshrinking (e.g., reducing the moisture content of) the “paper” prior to printing the composite image on the “paper web”. Quadracci (1992) further explains preshrinking the paper prevents the subsequent ink drying operation from causing shrinkage of the paper and concomitant variations in the image, permitting in-line formation of a screen in accurate registry with the image. It should be noted that this (three step manufacturing process) consists of:

1) Web offset printing the interlaced images directly to plain opaque white paper substrate from roll to rewound roll;

2) Placing the pre-printed paper roll into a secondary roll unwind stand within the embossing laminator unit; and then the lenticular embossing unit creates the lenticular embossed lenticular lenticule pattern onto a second roll of polished/polished APET clear substrate; and later the two roll substrates are press/nipped and adhesive laminated together in attempt of proper registration, creating a 2 ply paper/lenticular substrate that is rewound into a semi-finished state;

3) Whereas the 2 ply roll substrates are then brought to the separate down stream multi-step processing of sheeting, die cutting, trimming, counting, packing, shipping, etc.

<u>Quadracci et al. US Patent # 5,266,995, (1993):</u>

"Method For Forming A Graphic Web Image".

Quadracci, et al. (1993) expands the scope of original US Patent # 5,108,531 (1992) discussed in the previous review of literature by obtaining the current patent in review. The present invention now is to expand the previous claims by means of a continuation-in-part patent stating a method for forming a graphic image web to include a precursor image web combined with a congruent lenticular lens web to produce the illusion of (3D) - three dimensionality in a visually perceptible image on the graphic image web. To produce this illusion of three dimensionality, an image field including an object is defined. The object is imagewise and exposed onto a photographically sensitive element over a plurality of spatially disparate views through a lenticular lens having a prescribed optical geometry. Upon developing the latent image on said element, it is printed to form the precursor image web. The congruent lenticular lens web is then optically combined with the precursor image web to create the graphic image web having graphic information of photographically acceptable quality imparted with the illusion of three - dimensionality. Although new claims are added herein to include the ability to create three-dimensional images, the researcher discovers the base requirement of three-step manufacturing is still inherent and is not improved any further as to reduce the multiple manufacturing step processes.

Quadracci et al. US Patent # 5,285,238, (1994):

"Method Of Forming A Graphic Image Web".

Quadracci et al. (1994) expands claims yet again by means of continuation-in-part patent application within the patent in review to a further method of forming a graphic image having the image of three-dimensionality by joining a precursor image with a superimposed lenticular film through which said precursor image is to be viewed, the improvement comprising the added step of applying a lenticular coating having a plurality of lenticules to a precursor image web having a plurality of image elements to produce a graphic image web in which the perceptible image possesses photographically acceptable quality, wherein said image elements of said precursor image web are "printed at an angle" which corresponds to the pitch of said lenticules in said UV resin applied lenticular lenticule coating.

Although new additional claims are added herein to US Patent # 5,285,238 to include the ability to create three dimensional images that are “printed at an angle”, which corresponds to the pitch of said lenticules in said lenticular coating, the researcher once more discovers the base requirement of three-step manufacturing is still inherent and is not improved any further as to reduce the multiple manufacturing step processes.

Quadracci et al. US Patent # 5,457,515, (1995):

“Method Of Forming A Graphic Web”.

Quadracci et al. (1995) expands claims by means of continuation-in-part patent application once more within the patent in review to a further method of forming a graphic image having the appearance of three-dimensionality, the method comprising the steps of: providing a pre-formed lenticular film material having a flat smooth side and having a side with lenticules opposite the flat side; and printing an image direct onto the flat smooth side of the lenticular film using a “single web fed direct to lens printing process” to produce a graphic image web in which perceptible image possesses photographically acceptable quality, wherein the image elements are printed on the lenticular film at an “angle” which corresponds to the pitch of the lenticules of the lenticular film.

It is at this point and time that Quadracci et al. (1995), now attempts to reduce the various multiple steps of lenticular print manufacturing by printing directly onto one web of transparent lenticular substrate vs. printing interlaced images to one web of opaque paper substrate and later in down stream processing then adhesive laminate to a second web of transparent cast embossed lenticular material. The researcher determines after review, although the Quadracci et al. (1995) last improvement to the invention discussed reduces the manufacturing process by only one step in the printing production process. It must be noted that there still are several more additional manufacturing steps that must now occur in the post printing converting and finishing area to complete the lenticular printing to finished useable consumer product. It is determined by the researcher that the last improvement introduced to the patent in review as a result of means of continuation-in-part patent application by Quadracci, et al. (1995) does not reduce the previous Quadracci lenticular manufacturing process. The implied improvement of the invention simply shifts the printing to the lenticular plastic substrate and away from the opaque paper substrate.

In conclusion, it appears that Quadracci, et al. (1995) final patent improvement continues and remains to require (three manufacturing steps or more) to produce the lenticular printing and finishing to a final consumer usable ready advertising product, as compared to the Jacobsen (1996 &

1998) lenticular patents that require only (one step) manufacturing to final consumer ready usable advertising product.

Rosenthal. US Patent # 6,084,713, (2000):

"Lenticular Optical System".

In reviewing this literature of review patent, the researcher discovers an additional but unrelated invention to lenticular printing. Inventor Rosenthal teaches a lenticular optical system in which a composite image is viewable through a lens sheet from a first angle and an object or image placed at a preselected distance beneath the composite image is viewable from a second angle. Optical designs and alignment processes are disclosed which make possible the economical production of thin lenticular materials, which facilitate the manufacturing, and utilization of the optical system in packaging. The researcher determines that Rosenthal (2000) invention does not take in consideration the special requirements of in-line rotary web fed print production. It is unclear if the invention would bring any value to the present lenticular manufacturing environment.

Sandor et al. US Patent # 5,519,794, (1996):

"Computer-Generated Autostereography Method And Apparatus".

Inventors Sandor & Meyers (1996) introduce an important aspect within lenticular print production not discussed yet within this present dissertation. Within this review of literature, the inventors elucidate a method and apparatus for making autostereographic images (interlacing conventional 2D images and converting to animation or 3D images when viewed through lenticular lens array) wherein a "computer" vs. "camera" is provided with a number of planar images in digital form, in a two-dimensional conventional array of columns and rows of digital data. The columns are interleaved (interlaced) and rotated image so that the interleaved columns of the rotated image are substantially unaligned with the rows and columns of the digital representation of this image. The digital representation of the image is rotated using an algorithm that is independent of resolution and number of input images. The resulting image is then output on a high resolution-imaging device so that the columns of interleaving are substantially unaligned with both the direction of printing and the normal to direction of printing. The output from the high resolution imaging device is then placed in a registered relationship with a means for viewing selected ones of the input images, preferably to a lenticular lens array material or barrier screen.

In previous known recorded inventions relating to the pre-press area of lenticular print production, film based cameras were used to create interleaving by shooting the same image at various angles by moving the camera on a moving track and recording multiple camera exposures. Another method used to create interleaving of an image was to record an image through a camera having two, three or four lens that recorded the one image to the same film frame. In both examples, the interleaved final film based images were then placed behind a lenticular lens array or barrier grid for viewing. The present invention brings forth an important advancement to lenticular pre-press lenticular processes whereby the computer acts as a camera but within a digital working environment. The researcher discovers much flexibility is introduced by Sandor, et al. (1996) into lenticular imaging and brings great value added to the lenticular pre-press and print production processes required to manufacture lenticular images.

<u>Label & Narrow Web Industry – Rodman Publications, (1999):</u>

"Features Section" indicates on page 67-68 – "A fascinating process moves from sheet fed to roll fed". The articles title begins as: <u>3D Lenticular Printing Moves From Sheet Fed To Roll Fed.</u>

The Label & Narrow Web Industry (LNWI) publication dated March 1999, pp. 67-68 writes: "The printing of 3D images on plastic lenticular lenses has until now been captive in the sheet fed offset segment of the industry. Today, a newly patented process gives roll fed web printers the opportunity to explore this new field". LNWI continues and writes "The printing of three-dimensional images on lenticular plastic has moved from the sheet fed to the roll fed arena with the development of a new printing technology by Web Communications Group, Inc. (WCG), of Itasca, IL. Web Communications Group, Inc. has secured two U.S. patents with (other U.S. and foreign PCT patents pending) associated with printing quality 3D lenticular images on web offset lithography presses, as well as, and not limited to, rotary web fed, gravure, and letterpress processes". LNWI continues to report; "The breakthrough came after nine years of research, development, and plenty of live on-press testing, and much patience by Gary Jacobsen, president of WCG. Jacobsen is a second generation printer and practitioner of the graphic arts industry for 25 years, and is also working toward obtaining a custom advanced degree in printing technology and imaging sciences through a major university." It is determined by LNWI that the Jacobsen patents (1996 & 1998) brings great value to the lenticular printing industry by offering extreme cost effective mass manufacturing methods in addition to contributing new lenticular consumable advertising printed products not made possible before with the necessary multiple step post printing off-line finishing required. One advantage of the Jacobsen (1996 & 1998) patents described within the article explains one of the benefits being its' rapid manufacturing speed. Traditional sheet fed lenticular printing has production speed cycles of fewer than 5,000 sheet impressions per hour, versus the web fed production cycle speeds of over 20,000 or more roll type impressions per hour. A second major advantage of the Jacobsen (1996 & 1998) lenticular printing patents is the ability to include all finishing steps required of the final consumable advertising product, which is performed completely in-line on press, all at the same time and simultaneously as the printing is occurring. A third key advantage of the Jacobsen (1996 & 1998) patents is the ability to print on ultra-thin, e.g., 0.004 mil lenticular lens array substrates versus thicker lenticular substrates required for sheet fed printing. The thinner lenticular substrate saves substantial money on the materials portion of the production costs. In conclusion, LNWI determines that the Jacobsen (1996 & 1998) patents are an extreme benefit to the advancement of the lenticular printing industry.

Watanabe et al. US Patent # 6,157,491, (2000):

"Lenticular Lens Sheet".

In reviewing this literature of review patent, the researcher discovers a supplementary but unrelated invention to lenticular printing. Inventor Wantanabe et al. teaches a lenticular lens array sheet for use as a rear-projection screen, which comprises a body sheet; back lenses having a substantially elliptical cross section and formed in a back surface of the body sheet; front lenses formed in a front surface of the body sheet at the focal points of the back lenses or in the vicinity thereof; and a light absorbing layer formed on sections of the front surface at the non-focal points of the back lenses. Wantanabe et al. continues to describe pitches p of the back and front lenses, and the thickness t of the lenticular lens sheet equal to distance between a plane in contact with the back lenses and a plane in contact with the front lenses meet in inequality: $1.1<t/p<1.4$, and conic coefficient k of a conic section defining the cross section of the back lenses is in the range of -0.5 to 0.4. The researcher determines that the present invention only relates to a lenticular lens sheet designed for use as a rear-projection screen for a projection television system in which light rays from a projected image source are projected on a projection display screen on an enlarged scale by a optical lens system; and is particularly for the purpose of projecting an image by a single picture source, such as an LCD (liquid crystal display) or a DMD (digital micromirror device) is projected for observation. The reviewed invention appears to have no benefit to, nor does it advance the lenticular printing technology taught by Jacobsen (1996 & 1998) patents.

Yoshimura et al. US Patent # 5,687,024, (1997):

"Lenticular Lens Sheet".

In review of this literature patent, the researcher discovers yet another additional but unrelated invention to lenticular printing. Inventor Yoshimura et al. describes and teaches a lenticular lens sheet comprising lengthwise long lenticular lenses formed on the light incident-side surface and light emergent-side surface thereof, the lenticular lenses being constituted of cylindrical lenses each having a long dimension in the top and bottom direction of a screen when used, and satisfying a predetermined equation in which parallel light rays are made incident on the surface of its incident-side lens at horizontal incident angle of 0 degrees, - 11 degrees and + 11 degrees and the emergent luminance's of the respective light rays are standardized by evaluating the emergent luminance at an emergent-side horizontal visual angle of 0 degrees to be 1, and the emergent luminance's of the respective light rays at a horizontal visual angle 0 degrees H degree are respectively represented as an additional predetermined equation. This makes it possible to obtain a lenticular lens sheet that may cause fewer changes with changes in the horizontal visual angles and has been improved in color uniformity.

It is determined that the novel ness of this invention lies with the main purpose of helping to improve the quality of projection TV images, therefore having no direct advancement or impact to the lenticular printing industry.

Yoshimura et al. US Patent # 6,101,031, (2000):

"Lenticular Lens Sheet Capable Of Reducing Color Shift And Improving Overall Light Team Transmittance".

In examination of this last piece of literature in review, inventor Yoshimura et al. describes and teaches yet another invention relating to a lenticular lens sheet capable of reducing the color shift and improving the overall light beam transmittance.

The lenticular lens sheet has an incident side lenticular lens on its light beam incident side surface and further has an emergent side lenticular lens on its emergent side surface, with peak portions of the emergent side lenticular lens being formed at substantially convergent positions of the incident side lenticular lens. When an inter-lens distance at the sheet central portion is taken to be t degrees and an inter-lens distance of an end portion of a viewable area of a rear-projection screen composed of this lenticular lens sheet is taken at t-1, the rate of the inter-lens distances t degree and t-1 is determined to satisfy $0.98<t-1<1.10$.

The present invention was developed with a view to eliminate color shifting, and advances the lenticular lens array to provide a double-sided lenticular lens sheet capable of reducing the color shift with respect to a single-sided lenticular lens sheet, and further has the capability of enhancing the overall light beam transmittance of the sheet and further of improving the light use efficiency by preventing the light ellipse by the light-absorbing layer formed on the sheet emergent side surface.

The researcher determines that the novel ness of this invention lies within the main purpose again of helping to improve the quality of projection TV images, therefore having no direct advancement to, or impact to the lenticular imaged printing industry.

Chapter 3

Method

Overview

Chapter 3 will overview the methods used during the research of this study, including: the research approach, the method used for data gathering data; the database selected for analysis; and the means of determining the validity, uniqueness, limitations and summary of the data.

Approach

<u>There are two kinds of research:</u>

1) Pure research

2) Applied research

This study will be performed in the pure approach. Earlier research will not be extended; however, it will be compared and contrasted. The literature discussed in chapter 2 will be applied to the study.

There are five types of research methods that could be used:

1) Historical / Case Study Method

2) Descriptive Survey Method

3) Analytical Survey Method

4) Experimental Method

5) Comparison / Contrast Order Analysis

The research method to be used in this study will be presented in the scientific / technical expository written nature in the pure applied form, utilizing the comparison / contrast order analysis research method. Further more; the dissertation is to be written in the American Psychological Association (APA) style format.

Data Gathering Method

The researcher will review, analyze and focus on thirty (30) U.S. Patents, in order of: related, closest related, and finally unrelated literature (patents) from the United States Patent & Trademark Office (USPTO), thus being the *"prior art"*, i.e., granted utility and product patents pertaining to (3D) three-dimensional or animated (stereographic) processes, including but not limited to the following areas: *lenticular prepress, lenticular printing*, *lenticular lens array material manufacturing, and the printed end use products of lenticular technology*. In addition, six (6) various published literatures were reviewed and analyzed, obtained from major industrial printing publications, and other published articles written within the promotional, label and plastics industries. Many of the published articles referenced, acknowledge and promote the use of the Jacobsen lenticular patents due to the extreme novel advantages in manufacturing, resulting in lower product costs. A continuing theme exists in such published writings: the Jacobsen patents brings cost effective, novel enhanced lenticular printed consumable lenticular advertising, promotional and packaging product advancements to the mass distributed consumables industries.

Database of Study

The database consisted of thirty (30) related, closest related, and somewhat related literatures of (patents) from the United States Patent & Trademark Office, thus being the *"prior art"*, i.e., granted utility and product patents pertaining to (3D) three-dimensional or animated (stereographic) processes, including but not limited to the following areas: *lenticular prepress, lenticular printing*, *lenticular lens design and lenticular lens array material manufacturing, and finally the printed end use products of lenticular technology*. In addition, six (6) various published literatures were obtained from major industrial printing publications, and other published articles written within the promotional, label and plastics industries.

Validity of Data

The validity of data presented within this study is assumed to be entirely correct, full and accurate, in respect to the published thirty (30) granted (United States Patent & Trademark Office) patents presented within the literature of review section of this paper. As to the validity of data presented within the six (6) various published literatures obtained from various major industrial printing, promotional, label and plastic industries sectors, the articles written on the subject matter is also assumed to be legitimate and accurate, minimally from the standpoint that the views of the editors writings are fact based, fully non-biased, and solely professional in nature.

Originality & Limitation of Data

The researcher did not uncover any similar studies relating to this papers title, thesis and abstract: "First Novel Invention Of In-Line Web Fed Roll Print Manufacturing Production Of Animated / Three-Dimensional Imaged Print Products Incorporating Advanced Lenticular Transparent Substrate...Its Advantages And The Comparison / Contrast Order Analysis To Prior U.S.P.T.O. Patented Art". Therefore, the study has an inherent uniqueness and originality in its approach to the topic. This is not to say the review of literature did not reveal issues relating to other persons or corporations attempting to explore, reverse engineer or advance the said topics technology, however, when found to exist, it appears to have occurred **"after"** the public made disclosure by the (USPTO) of the original Jacobsen (1996 & 1998) US Patents. This fact supports the papers claim of "first to invent" and further more supports the papers novel ness of the invention.

The limitation of data is restricted by the present amount of literature material reviewed within this paper (36 reviews). The current data itself is large, comprehensive, and involves a great number of variables and is, in itself, a limitation due to lack of all available viewpoints on the subject matter. The data is limited and cannot be all encompassing, and many of the conclusions drawn are based on the researcher's own conclusions drawn upon the authors own interpretations of the literature (data), and upon the authors own reference points and knowledge of the subject matter.

Summary of Chapter 3

The researcher reiterates again that there were no similar studies or inventions found within the data relating to this papers title, thesis and abstract: "First Novel Invention Of In-Line Web Fed Roll Print Manufacturing Production Of Animated / Three-Dimensional Imaged Print Products Incorporating Lenticular Transparent Substrate...Its Advantages And The Comparison / Contrast Order Analysis To Prior U.S.P.T.O. Patented Art".

Therefore, the study and its research method utilized have an inherent uniqueness and originality in its approach to the topic. This is not to say the review of literature did not reveal issues relating to other persons or corporations attempting to explore, reverse engineer or advance the said topics technology.

The research method utilized the study of published USPTO patents and major industrial publication writing materials. The comparison/contrast order analysis research method provides a useful framework and approach to a thorough study of the topic, which was thoroughly discussed within Chapter 2 - (review of literature).

C h a p t e r   I V

Data Analysis

Overview

Within the previous chapter 3, it described the research methods used in this dissertation as well as a description of the data gathering methods, data validation/analysis techniques, and potential limitations of the study. This chapter will provide the actual results of the data analysis and will provide the basis of rational for the summary, conclusions and recommendations to be presented in chapter 5.

Description of Findings in Chapter 3

As stated previously, the researcher did not uncover any similar studies relating to this papers title, thesis and abstract: “First Novel Invention Of In-Line Web Fed Roll Print Manufacturing Production Of Animated / Three-Dimensional Imaged Print Products Incorporating Advanced Lenticular Transparent Substrate...Its Advantages And The Comparison / Contrast Order Analysis To Prior U.S.P.T.O. Patented Art”.

Introduction

As discussed previously within the abstract section, the "problem" presented for study will be re-introduced once again to help support the data analysis review to occur within this chapter 4.

Prior to the lenticular printing industries first of its' kind invention of Jacobsen Patents # 5,560,799, (1996) and # 5,753,344, (1998) granted within the United States Patent and Trademark Office (USPTO), there were only seven other (USPTO) categories of unrelated or closely related prior art data records indicating:

1) Lenticular interlacing prepatory (prepress),

2) Inefficient multi-step lenticular (printing processes),

3) Related consumer products that have been developed to fabricate (photographically) created lenticular images,

4) Sequentially stepped non-lenticular (printed layers of transparent material) to simulate dimension and distance of printed images,

5) (Multiple step process) single roll lenticular web fed offset printing requiring separate multiple off-line post production finishing procedures,

6) (Sheet fed lenticular printed products) manufactured at one sheet at a time that display a virtual illustrative printed image, which appears to be three dimensional (3-D) or animated (moving sequential images) when viewed by the naked human eye.

7) Lenticular optical lens design and lenticular lens array material manufacturing methods.

In a brief comparison of the Quadracci patent to Jacobsen U.S. Patents # 5,560,799, (1996) and # 5,753,344, (1998), discussed previously, it accurately demonstrated the inefficiency of the prior art by requiring minimally three or more separate manufacturing steps before product completion, as compared to Jacobsen's "continuous in-line lenticular print manufacturing method utilizing a one pass rotary web fed printing process", which creates an illusion of three dimensional depth, or animation in the perception of the viewer.

Therefore, the first problem existed for a solution to a lower cost, higher speed, and efficient high volume printing production system which supplies large quantities of virtual three-dimensional and animated image printed products utilizing techniques and materials which incorporate lenticular transparent and *line formed printed screened, i.e.: dotted or spotted, images printed* in proper register beneath the array of lenses found in the lenticular transparent material.

Secondly, the problem existed and continued with a need to create an efficient, new and novel, *lower cost*, *high speed*, <u>*continuous in-line*</u> <u>lenticular print manufacturing method utilizing a one pass rotary web fed printing process</u> which would create an illusion of depth, or animation in the perception of the viewer of the image as compared to any other prior art recorded within the United States Patent & Trademark Office.

Thirdly, the problem existed and continued for a need to provide a <u>*continuous in-line roll fed printing process incorporating roll fed lenticular transparent, preferably made of transparent plastic, and roll fed opaque paper stock substrate, wherein line formed images are printed on the lenticular stock, on the paper stock, or both simultaneously in one embodiment*</u>*.* The lamination and combination of two printed substrates together created within one press pass would create a finished three-dimensional or animated printed product ready for consumer viewing. This manufacturing technique would save precious time from creative development and design to market and would be available to advertisers at a lower cost due to highly efficient manufacturing procedures.

Very last, the fourth problem existed for a printing process that must also be rapid enough to meet the quick delivery deadline requirements of advertisers, and be required to also be capable of manufacturing a new unseen before range of three dimensional and animated lenticular print products that could be used by the packaging, advertising and promotional industries.

Therefore to help solve this problem, it was the objective of this study to explore the use of specialized inventions, engineering and lenticular print manufacturing production, utilizing double web rolls simultaneously for either: offset lithography, flexographic, gravure and letterpress, resulting in the construction formation of paper/plastic combined printed products, using advanced in-line printing and finishing processes to produce unique, low cost, all machine manufactured paper printed products. The research study presented the facts necessary to support the implied stated thesis within the abstract of this dissertation, describe the problems, establish the researchers claim of “first in industry to invent” status and demonstrate the solutions to the problems indicated in the conclusion findings. Also within this dissertation study, the researcher thoroughly performed a forensic audit approach by dissecting and analyzing the remaining prior art by the comparison/contrast order analyses of the referenced U.S. Patents (prior art). The conclusive findings will be presented in chapter 5 with a summary, conclusions and recommendations to the referenced materials.

Factors That Could Limit Data

The database consisted of thirty (30) related, closest related, and somewhat related literatures of (patents) from the United States Patent & Trademark Office, thus being the *"prior art"*, i.e., granted utility and product patents pertaining to (3D) three-dimensional or animated (stereographic) processes, including but not limited to the following areas: *lenticular prepress, lenticular printing*, *lenticular lens array material manufacturing, and the printed end use products of lenticular technology*. In addition, six (6) various published literatures were obtained from major industrial printing publications, and other published articles written within the promotional, label and plastics industries. Because the information presented in this study is from one perspective of the researcher, it becomes difficult to analyze the information and remain objective, which is critical.

Additionally, factors that could limit data is possible by presenting only the select amount of literature material reviewed within this paper (36 literature reviews). The current data itself is specific, comprehensive, and involves a great number of variables and is, in itself, a limitation due to lack of other outside unavailable viewpoints on the subject matter. The data is limited and cannot be all encompassing, and many of the conclusions drawn are based on the researchers own conclusions drawn upon the authors' own interpretations of the literature (data), and upon the authors own reference points and knowledge of the subject matter.

Possible Omissions/Errors of Data

It is likely possible omissions and error of data could occur because the data is presented in the comparison/contrast order analysis method. Since the researcher approaches the subject matter and presents the data information in the researchers own perspective, the specific scope and end purpose of the inventions being analyzed may not be presented in the most reliable manner in every instance. However, under the current circumstances, which involved the researcher studying over 36 articles of specialized scientific literature relating to lenticular technology's, it remains the most suitable method of research.

Reliability of Data

The reliability of data presented within this study is assumed to be entirely correct, full and accurate, in respect to the published thirty (30) granted (United States Patent & Trademark Office) patents presented within the literature of review section of this paper. As to the reliability of data presented within the six (6) various published literatures obtained from various major industrial printing, promotional, label and plastic industries sectors, the articles written on the subject matter is also assumed to be legitimate and accurate, minimally from the standpoint that the views of the editors writings are fact based, fully non-biased, and solely professional in nature.

Significant Findings of Data

One major objective of this study was to explore the advantages of using specialized in-line print manufacturing method type inventions as compared to the prior art. These novel inventions utilized custom developed/ engineered lenticular based web handling and lenticular print manufacturing production systems, requiring double web rolls of various printable substrates, manufactured simultaneously using either: offset lithography, flexographic, gravure and or letterpress print processes, resulting in the construction formation of paper/plastic combined printed products. The aforementioned system using advanced in-line web printing and finishing processes were designed to produce unique, low cost, high quality and all machine made manufactured paper printed products in one production pass.

The significant finding of data to follow will help sustain the facts necessary to support the implied stated thesis within the abstract of this dissertation.

Bravenec et al. U.S. Patent # 5,967,032, (1999) "Printing Process Using A Thin Sheet Lenticular Lens Material".

In this patent, the inventor attempts to claim the novel invention of lenticular printing process using a thin sheet lenticular lens material. Inventor Bravenec et al's., invention comes after over three years since Jacobsen's first to invent lenticular web printing patents.

Bravenec et al. U.S. Patent # 5,974,967, (1999) "Registration System For Lenticular Printing"

In reviewing this patent, the inventor claims to have invented a lenticular printing registration system, which maintains color registration of colors printed on a lenticular lens material during printing on a printing press to form a desired image.

Brosh et al. U.S. Patent # 5,924,870, (1999) "Lenticular Image And Method".

In reviewing this patent, the researcher discovers an unrelated invention to lenticular printing. Brosh et al., claims the novel invention of computer generated lenticular images (pre-press) involving the computer manipulation of minimally one image and of a second image

Eastman Kodak Company. PT Cruiser Ad Research Results, (2000)

A study by The PreTesting Company, Inc., an independent research company that test advertising, analyzed two versions of an advertisement run in the year 2000 by Daimler-Chrysler for its new PT Cruiser vehicle. Two versions of a four-page tip-in ad for the PT Cruiser were created for testing: one with a dynamic image on the cover page of the ad and one without. The test incorporated a 3 ½ x 2 ½" dynamic lenticular image of the PT Cruiser affixed to the first page of the ad. The dynamic lenticular image showed the PT Cruiser exterior turning on an axis, and then zooming in on the trunk, which opened to demonstrate different seat configurations inside the car. The control ad also incorporated a traditional 2D flat art photo of the cars exterior.

Franko, Sr. U.S. Patent # 6,624,946, (2003) **"**In-Line Lenticular Film Manufacturing Having A Selected Web Orientation".

In this patent, the inventor attempts to claim the novel invention combining of a lenticular in-line printing process using a press made and formed lenticular lens material. Inventor Franko, Sr. (2003), invention comes after seven years since Jacobsen's first to invent lenticular in-line web printing patents.

Goggins. U.S. Patent # 5,896,230, (1999) "Lenticular Lens With Multidimensional Display Having Special Effect Layer".

In this invention relating to lenticular (pre-press), the inventor creates a method of producing a multidimensional lenticular image having a special effect, e.g., glow in the dark, reflective qualities, fluorescent imaging, responsiveness to ultraviolet light, etc.

Goggins. U.S. Patent # 6,424,467 B1, (2002) “High Definition Lenticular Lens”.

Inventor Goggins discloses in this invention a method to produce a high definition lenticular lens, which also is capable of providing a viewable high definition lenticular image.

Gulick, Jr. U.S. Patent # 6,237,264 B1, (2001) “Device And Method For Producing Lenticular Images With Motion”.

The invention created by Gulick relates to the field of lenticular devices for 3D viewing of images and more particularly to a device associated with the method for forming the device such that a portion of the field of view of the device provides the viewer with motion images.

Jacobsen et al. U.S. Patent # 5,181,745, (1993) **“**Printed Image Creating The Perception Of Depth”.

Prior to the later dated enhanced inventions of Jacobsen US Patents # 5,560,799 (1996) and 5,753,344 (1998), which relates to the advanced in-line lenticular print production of actual 3D and animated lenticular print imaged products on to lenticular substrate, inventor Jacobsen attempted to create an “illusion of depth” in the perception of the viewer by printing 2D flat images on to multiple individual layered clear substrates. By printing and combining the individual multiple layers, the final construction appeared to give the illusion of flat depth

Jacobsen. U.S. Patent # 5,560,799, (1996) **"**In-Line Printing Production Of Three-Dimensional Image Products Incorporating Lenticular Transparent Material".

Within this particular important and relevant review of related literature, inventor Jacobsen (1996) first discovers an entirely new novel approach to an invention to include various methods for printing massive volumes of images that produce realistic virtual 3D images, in addition to the option of adding or combining animated printed images onto "one-ply of lenticular substrate", utilizing novel roll fed printing production processes.

Exhaustive research performed during this dissertation will determine the importance the described, "first of its kind invention", brings to the lenticular printing industry; while also supporting the main thesis stated within the title page and abstract section of this dissertation, "First Novel Invention Of In-Line Web Fed Roll Print Manufacturing Production Of Animated / Three Dimensional Imaged Print Products Incorporating Advanced Transparent Substrate... It's Advantages And The Comparison/ Contrast Order Analysis To Prior U.S.P.T.O. Patented Art".

Jacobsen. U.S. Patent # 5,753,344, (1998) **"**In-Line Printing Production Of Three Dimensional Image Products Incorporating Lenticular Transparent Material".

In review of the referenced literature, Jacobsen (1998) expanded the later patent by adding two additional apparatus claims of the said invention by teaching further novel developments over the preceding US Patent # 5,560,799 of October 1, 1996, which had referenced nineteen method claims.

Jacobsen. U.S. Patent # 6,153,039, (2000) **"**Card And Method Of Making Same".

Concurrently and during the pre-granting of US Patent # 6,153, 039 (2000) in the early 1990's, Jacobsen attempts to animate and three-dimensionalize a print product beyond "standard ink on paper commercial printing", by developing advanced lenticular imaging principles, which are discussed previously within this research paper. Working in between the inventions mentioned above, Jacobsen additionally introduced a novel printing process and product involving "interactive moving paper and plastic slides within carriers", to mimic a form of animation. Accordingly, this non-lenticular, two-dimensional print product break through, commercially named, "The Sliding Lamigram Magic Changing Window" was born. The

"Sliding Lamigram Magic Changing Window" (SLMCW) was one more attempt by Jacobsen to revolutionize the printing industry with "print action devices" that would bring standard commercial printing "alive". Although the invention to be described is novel, it is considered by the inventor Jacobsen to be too expensive as a final printed product, and not as grand; as in comparison to the in-line web fed roll print manufacturing lenticular inventions Jacobsen introduces to the printing and advertising industries.

Johnson, et al. U.S. Patent Application Publication # U.S. 2003/0002160 A1, January 02, 2003: "Lenticular Lens Array And Tool For Making A Lenticular Lens Array"

Jacobsen and Johnson's (2003) team approach determines after much research study and laboratory analyses of the prior lenticular art, including both the current and previous optical lenticular lens design and lenticular lens materials, that an advanced optical lenticular lens design and lenticular lens material is desired, and by developing the said inventions will enhance the final viewed printed lenticular image quality. Additionally, the new lens design and its material would help advance the use of Jacobsen's current granted lenticular print process and product patents discussed and compared within this research paper. Accordingly, Jacobsen seeks to improve the entire optical lenticular lens array material and lenticular printing and imaging systems

Johnson, et al. International Application Published Under The Patent Cooperation Treaty (PCT) # WO 02/101424 A2, December 19, 2002 "Lenticular Lens Array And Tool For Making A Lenticular Lens Array"

Jacobsen and Johnson's (2002) team approach determines after much research study and laboratory analyses of the prior lenticular art, including both the current and previous optical lenticular lens design and lenticular materials, that an advanced optical lenticular lens design and lenticular material is desired, and by developing the said inventions will enhance the final viewed printed lenticular image quality. Additionally, the new lens design and its material would help advance the use of Jacobsen's current granted lenticular print process and product patents discussed and compared within this research paper. Accordingly, Jacobsen seeks to improve the entire optical lenticular material and lenticular printing and imaging systems

Kumagai et al. U.S. Patent # 5,724,188, (1998) **"**Lenticular Lens Sheet".

The invention created by Kumagai (1998) relates to a lenticular lens sheet, which could not be utilized, or would not add any benefit to the lenticular printing industry, which the researcher explains in great detail within this research paper. This particular field of invention relates to a lenticular lens sheet for use in transmission type screen of a rear projection type television, and more particularly to a lenticular sheet to be used in the rear projection type television which is provided with lenticular lenses of fine pitch and which uses a liquid crystal display panel. Kumagai's (1998) invention includes a double-faced lenticular lens sheet comprising incident side lenses formed on one of the main faces and emergent side lenses formed on the other main face, such that light rays are incident on the incident side lenses in parallel with the optical axis pass through the lenticular lens sheet and are emitted from the emergent side lenses.

<u>Koltzenburg. Paper Film Foil Converter Magazine, Bringing a New Dimension To 3-D Imaged Packaging, (Jan, 2000)</u>

During Koltzenburg's company assigned research to investigate new novel approaches to advances in printed packaging advertising and novel manufacturing methodology, Senior Editor Koltenburg discovered published patent material within the United States Patent and Trade Mark Office (USPTO) relating to the Jacobsen lenticular printing patents reviewed within this paper. Upon learning of Jacobsen's lenticular printing technology, Paper Film Foil Converter Magazine requested to visit and interview

Jacobsen's company headquarters' in Itasca, IL, USA, doing business as, Web Communications Group, Inc. / Animated Printing & Packaging Company (WCG/APAP).

Kuo et al. OE Magazine, Total Immersion, (July, 2000)

Within this literature article under review, subtitled: "Streaming 3-D video, audio, and a sense of touch will surround people with a virtual environment over their high-speed internet connections", the authors describes an completely unrelated, but intriguing futuristic emerging technology under research, as compared to the currently described lenticular lens array materials and animated and three dimensional printing technologies.

Luttenberger. Packaging Technology & Engineering – Professional Journal of Packaging, (1999)

Within this review of literature, the editor, David Luttenberger of Packaging Technology & Engineering sends a congratulatatory letter and notice to Gary A. Jacobsen, Chief Engineer and President/CEO of Web Communications Group, Inc. (WCG) dated September 09, 1999. Luttenberger announces that WCG's entry has been judged as the winner of the "Emerging Technology Award", in Packaging Technology &

Engineering's 1999 Technology of the Year Awards Competition. WCG is invited to attend and receive 1st place winning plaque for this "Emerging Technology" category at the Award Reception to be held September 28, 1999 during and in conjunction with the WestPack Packaging Industry Convention, Anaheim, California.

Morton. U.S. Patent # 6,163,406, (2000) Lenticular Image Bearing Member With Variable Line Spacing To Improve Image Quality:

Inventor Morton (2000) teaches and describes an invention that relates in general to lenticular imaging. Morton (2000) specifically teaches a lenticular image bearing member and a manufacturing of method of manufacturing a lenticular bearing member having a variable line spacing to improve image quality.

Morton. U.S. Patent # 6,211,896 B1, (2001) Method For Producing Lenticular Images (2001):

In the review of this literature, inventor Morton (2001) continues to attempt to advance the quality of lenticular images by teaching images are written with a writing spot which is scanned over a recording material. The shape of the writing spot and at least one component of the recording material influence the image quality of the recorded image.

Neefe. U.S. Patent # 4,406,189, (1983) Method Of Making Lenses With A Lenticular Cut:

While researching lenticular based prior art through the United States Patent & Trademark Office, the researcher determines after reading this review of literature material that the invention relates to a method of rapidly making lenticular contact lenses having a flange thinner than the optical section of the lens and of uniform thickness regardless of refractive power.

Quadracci. U.S. Patent # 5,108,531, (1992) **"**Method And Apparatus For Stereographic Printing With Preshrinking:

During the near exhaustive search and review of prior U.S. patented art, the researcher determines that Quadracci (1992) is possibly the first inventor and possible first U.S. industry printer who attempts to print lenticular images using a rotary web fed single roll (semi-continuous, multiple step) printing process, rather than using a single, one at a time, non-continuous sheet fed printing process which is currently the industry preferred method; with the only exception being the Jacobsen's dual web roll fed continuous (one step) in-line finished lenticular printing patents discussed herein previously.

Quadracci et al. U.S. Patent # 5,266,995, (1993) **"**Method For Forming A Graphic Web Image".

Quadracci et al. (1993) expands the scope of original US Patent # 5,108,531 (1992) discussed in the previous review of literature by obtaining the current patent in review. The present invention now is to expand the previous claims by means of a continuation-in-part patent stating a method for forming a graphic image web to include a precursor image web combined with a congruent lenticular lens web to produce the illusion of (3D) - three dimensionality in a visually perceptible image on the graphic image web.

Quadracci et al. U.S. Patent # 5,285,238, (1994) **"**Method Of Forming A Graphic Image Web".

Quadracci et al. (1994) expands claims yet again by means of continuation-in-part patent application within the patent in review to a further method of forming a graphic image having the image of three-dimensionality by joining a precursor image with a superimposed lenticular film through which said precursor image is to be viewed, the improvement comprising the added step of applying a lenticular coating having a plurality of lenticules to a precursor image web having a plurality of image elements to produce a graphic image web in which the perceptible image possesses photographically acceptable quality, wherein said image elements of said precursor image web are "printed at an angle" which corresponds to the pitch of said lenticules in said UV resin applied lenticular lenticule coating.

Quadracci et al. U.S. Patent # 5,457,515, (1995) **"**Method Of Forming A Graphic Web".

Quadracci et al. (1995) expands claims by means of continuation-in-part patent application once more within the patent in review to a further method of forming a graphic image having the appearance of three-dimensionality, the method comprising the steps of: providing a pre-formed lenticular film material having a flat smooth side and having a side with lenticules opposite the flat side; and printing an image direct onto the flat smooth side of the lenticular film using a "single web fed direct to lens printing process" to produce a graphic image web in which perceptible image possesses photographically acceptable quality, wherein the image elements are printed on the lenticular film at an "angle" which corresponds to the pitch of the lenticules of the lenticular film.

Rosenthal. U.S. Patent # 6,084,713, (2000) **"**Lenticular Optical System".

In reviewing this literature of review patent, the researcher discovers an additional but unrelated invention to lenticular printing. Inventor Rosenthal teaches a lenticular optical system in which a composite image is viewable through a lens sheet from a first angle and an object or image placed at a preselected distance beneath the composite image is viewable from a second angle. Optical designs and alignment processes are disclosed which make possible the economical production of thin lenticular materials, which facilitate the manufacturing, and utilization of the optical system in packaging.

Sandor et al. U.S. Patent # 5,519,794, (1996) **"**Computer-Generated Autostereography Method And Apparatus".

Inventors Sandor & Meyers (1996) introduce an important aspect within lenticular print production not discussed yet within this present dissertation. Within this review of literature, the inventors elucidate a method and apparatus for making autostereographic images (interlacing conventional 2D images and converting to animation or 3D images when viewed through lenticular lens array) wherein a "computer" vs. "camera" is provided with a number of planar images in digital form, in a two-dimensional conventional array of columns and rows of digital data. The columns are interleaved (interlaced) and rotated image so that the interleaved columns of the rotated image are substantially unaligned with the rows and columns of the digital representation of this image. The digital representation of the image is rotated using an algorithm that is independent of resolution and number of input images. The resulting image is then output on a high resolution-imaging device so that the columns of interleaving are substantially unaligned with both the direction of printing and the normal to direction of printing. The output from the high resolution imaging device is then placed in a registered relationship with a means for viewing selected ones of the input images, preferably to a lenticular lens array material or barrier screen.

Label & Narrow Web Industry - Rodman Publications, "3D Lenticular Printing moves from Sheetfed to Rollfed", (March, 1999)

"Features Section" indicates on page 67-68 – "A fascinating process moves from sheet fed to roll fed". The articles title begins as: 3D Lenticular Printing Moves From Sheet Fed To Roll Fed.

The Label & Narrow Web Industry (LNWI) publication dated March, 1999, pp. 67-68 writes: "The printing of 3D images on plastic lenticular lenses has until now been captive in the sheet fed offset segment of the industry. Today, a newly patented process gives roll fed web printers the opportunity to explore this new field". LNWI continues and writes "The printing of three-dimensional images on lenticular plastic has moved from the sheet fed to the roll fed arena with the development of a new printing technology by Web Communications Group, Inc. (WCG), of Itasca, IL. Web Communications Group, Inc. has secured two U.S. patents with (other U.S. and foreign PCT patents pending) associated with printing quality 3D lenticular images on web offset lithography presses, as well as, and not limited to, rotary web fed, gravure, and letterpress processes".

Watanabe et al. U.S. Patent # 6,157,491, (2000) "Lenticular Lens Sheet".

In reviewing this literature of review patent, the researcher discovers a supplementary but unrelated invention to lenticular printing. Inventor Watanabe et al. teaches a lenticular lens array sheet for use as a rear-projection screen, which comprises a body sheet; back lenses having a substantially elliptical cross section and formed in a back surface of the body sheet; front lenses formed in a front surface of the body sheet at the focal points of the back lenses or in the vicinity thereof; and a light absorbing layer formed on sections of the front surface at the non-focal points of the back lenses.

Yoshimura et al. U.S. Patent # 5,687,024, (1997) "Lenticular Lens Sheet".

In review of this literature patent, the researcher discovers yet another additional but unrelated invention to lenticular printing. Inventor Yoshimura et al. describes and teaches a lenticular lens sheet comprising lengthwise long lenticular lenses formed on the light incident-side surface and light emergent-side surface thereof, the lenticular lenses being constituted of cylindrical lenses each having a long dimension in the top and bottom direction of a screen when used.

Yoshimura et al. U.S. Patent # 6,101,031, (2000) "Lenticular Lens Sheet Capable Of Reducing Color Shift And Improving Overall Light Team Transmittance".

In examination of this last piece of literature in review, inventor Yoshimura et al. describes and teaches yet another invention relating to a lenticular lens sheet capable of reducing the color shift and improving the overall light beam transmittance.

Chapter V

Summary, Conclusions & Recommendations

<u>Introduction</u>

The summary of the study to follow will include the accumulation of sub-answers and resolution into an overall formed answer to the hypothesis as presented in Chapter 1.

The thesis in Chapter 1 was to explore and study the first novel invention of in-line web fed roll print manufacturing production of three-dimensional imaged print products incorporating lenticular transparent substrate, demonstrate its advantages and perform a comparison/contrast order analysis to the prior art within the United States Patent & Trade Mark Office, including the analysis of other major industrial literature reviews relating to any or all past and current lenticular technologies.

The summary is the culmination of the discussion and recommendations gathered from the study of the literature of review and data analysis thereof. This section will also contain the results of the study.

This study was designed primarily to examine the extent to which similar and dissimilar lenticular print manufacturing methods and processes (if any) existed <u>**prior**</u> to and if any improvements were attempted <u>**after**</u> the invention of the Jacobsen US Patents # 5,560,799 (1996) and # 5,753,344 (1998). In addition, the study was intended to scrutinize and illustrate the "advantages" of using and combining the Jacobsen (1996, 1998, 2002, 2003) patents, processes/products, and compare/contrast those findings against any of the known prior art available for comparison.

<u>**Summary & Conclusion**</u>

As discussed previously within this dissertation, the "problem" presented for study will be summarized to support the data analysis reviewed within the previous chapters.

<u>The researcher has found:</u>

<u>Prior</u> to the lenticular printing industries first of its' kind invention of <u>Jacobsen Patents # 5,560,799</u>, (1996) and <u># 5,753,344</u>, (1998) granted within the United States Patent and Trademark Office (USPTO), there were only seven other (USPTO) categories that the researcher found and studied related to prior art data records indicating:

1) Lenticular interlacing prepatory (prepress),

2) Inefficient multi-step lenticular (printing processes),

3) Related consumer products that have been developed to fabricate (photographically) created lenticular images,

4) Sequentially stepped non-lenticular (printed layers of transparent material) to simulate dimension and distance of printed images,

5) (Multiple step process) single roll lenticular web fed offset printing requiring separate multiple off-line post production finishing procedures,

6) (Sheet fed lenticular printed products) manufactured at one sheet at a time that display a virtual illustrative printed image, which appears to be three dimensional (3-D) or animated (moving sequential images) when viewed by the naked human eye.

7) Lenticular optical lens design and lenticular lens array manufacturing methods

In a first major comparison/contrast of the Quadracci patent to the Jacobsen U.S. Patents # 5,560,799, (1996) and # 5,753,344, (1998), discussed previously in Chapter 2, the conclusion of the comparison clearly and accurately demonstrates the inefficiency of the closest known prior art developed (near or before) the time of the Jacobsen (1996 & 1998) inventions by requiring minimally three or more separate manufacturing steps before product completion, as compared to Jacobsen's "continuous in-line lenticular print manufacturing method utilizing a one pass rotary web fed printing process", which creates an illusion of three dimensional depth, or animation in the perception of the viewer.

In a second major comparison/contrast of the Franko, Sr. U.S. Patent # 6,624,946 (2003) titled: "In-Line Lenticular Film Manufacturing Having A Selected Web Orientation", as compared to the Jacobsen U.S. Patents # 5,560,799, (1996) and # 5,753,344, (1998), discussed previously in Chapter 2, the conclusion of the comparison clearly and accurately demonstrates the attempted improvement by Franko, Sr. to advance in-line web lenticular technology past the technology of the Jacobsen patents. Franko, Sr. now today has the closest known and newest prior art developed (**after**) the disclosure of the Jacobsen (1996 & 1998) inventions

In the Franko, Sr. U.S. Patent # 6,624,946 (2003) titled: "In-Line Lenticular Film Manufacturing Having A Selected Web Orientation", the inventor attempts to claim the novel invention of a lenticular in-line printing process using a press made and formed lenticular lens material vs. using a off-line pre-formed lenticular material. Inventor Franko, Sr. (2003), invention comes seven years after the introduction of Jacobsen's "first to invent" lenticular in-line web printing patents. Franko, Sr. (2003) describes a process for in-line lenticular film manufacturing having a selected web orientation to include providing an optically clear material web to an in-line converting and or printing press. The optically clear material web is advanced into the in-line converting and or printing press in a machine direction of the press. The press includes an in-line lenticule forming means for forming lenticules in the optically clear material web. The lenticules are formed in a selected orientation relative to the machine direction of the press.

Franko, Sr. (2003) discloses Jacobsen U.S. Patents # 5,560,799 (1996), and # 5,753,244 (1998); as well as the Quadracci U.S. Patent # 5,266,995 as references cited of prior art (U.S. Patent documents) to the U.S. Patent Office while attempting to patent Franko, Sr. (2003) U.S. Patent # 6,624,946.

Franko, Sr. (2003) attempts to manufacture a web of lenticular labels created in-line with individual labels that are oriented perpendicular, rather than parallel, to the machine direction. The prior art creates so-called “wipe-on” lenticular adhesive based labels for application by affixing machines that will then apply the lenticular web and its’ labels directly from the machine direction in a “parallel-sideways” orientation relative to the containers. It is the intention of the Franko, Sr. (2003) invention to create lenticular lens material and printing thereon in an orientation that is perpendicular to the machine direction.

Franko, Sr. (2003) summary of invention includes:

1) Provide an in-line process that creates lenticular lens material in an orientation that is perpendicular to the machine direction

2) Provide an in-line process that creates lenticular lens material in any selected orientation relative to the machine direction

3) Create a lenticular lens material that is constructed during an in-line converting and printing process simultaneously.

It is the researcher’s summary and concluding opinion that Franko, Sr. successfully patents the recently awarded U.S. Patent # 6,624,946

(2003) by re-packaging the patent application and combining certain prior art techniques disclosed by both Jacobsen (1996 & 1998) and Quadracci (1993). It is of the researchers' further opinion that by attempting to create the lenticular lens in-line on the press; while also in-line printing onto the lens simultaneously, the ability to maintain quality between the two processes will be quite a challenge due to this next reason. Registration from the "center-of-lenticules" to the print alignment to individual print register within the 4-12 print stations will be a constant demand of the press operators and of the entire manufacturing process itself. The researcher predicts the Franko, Sr. patented invention will fail to produce a quality lenticular printed product; in addition to not being capable of delivering a consistent lenticular product (good or bad).

Summary & Conclusion of Jacobsen Patent's: (First To Invent, Documented Originality & Dominant Leading Industry Position)

Prior to the researcher's decision to apply for U.S. Patent applications for the currently granted Jacobsen U.S. Patent # 5,560,799 (1996) and U.S. Patent # 5,753,344 (1998), it was discussed previously in this paper that a thorough formal prior art search was conducted by WCG's previous patent counsel (Welsh & Katz) of Chicago, IL; in conjunction with the prior art search services offered through the United States Patent & Trade Mark Office. It was discovered after the initial search phase was completed; it appeared there were <u>no other inventions granted previously to the type of lenticular technology that Jacobsen sought to patent.</u>

<u>This fact will serve to compliment the researchers' claim and conclusion of the *"first to invent", and "documented originality".*</u>

In the year 2001, a second analysis was requested by WCG to WCG's current patent counsel, (King & Spalding) of Atlanta, GA, to compare and contrast the Jacobsen (1996 & 1998) lenticular printing patents to the Quadracci (1992, 1993,1994,1995) lenticular printing patents, both of which was discussed within the review of related literature section of this paper. Since the opinion of counsel is privileged attorney work product, and is a privileged client/attorney communication, and quite confidential, the actual work and conclusions cannot be sighted herein. However, the researcher will again repeat and highlight some basic inherent facts between the two patents. This will help support the present summary and conclusion within this research paper of the claims of the researcher: <u>*"first to invent", "documented originality"* and finally, *"dominant leading industry position"*</u> in respect to the Jacobsen inventions and claims within the actual patents reviewed.

Summary & Conclusion of Jacobsen Patents Manufacturing Highlights Include (Partial Only) See Actual Patents For Complete Claims:

1) Single roll web printing upon lenticular material rewound back to roll, or delivering to individual unit, or variable sized sheeted products.

2) Double web roll printing to both lenticular and opaque substrate simultaneously while laminating two-roll substrates together in-line on press.

3) Printing either by wet trap or dry trap methods with one process, or via hybrid combinations of offset, flexo, gravure or letterpress methods.

4) Printing by dry trap method with one or more plurality of dry trap printing images and plurality of dry trap opaque white barriers. Option to print additional plurality of conventional images on top of dry trapped opaque white barrier.

5) Printing to either lenticular, or to opaque substrate separately or to both substrates simultaneously.

6) In-line finishing processes is performed consecutively after printing one or two webs including: plow folding or slitting the dual webs into multiple ribbons or combinations thereof to create the proper format construction; laminating said dual webs together to create a sandwiched two ply web construction; die cutting away areas of the web, contour die cutting special shapes, applying backbone glue, wet flap glue, remoistable glue, pressure sensitive glue, repositionable glue for stickers, bead strip gluing, glue tacking, applying scratch off inks, ink jet imaging, cutting web into individual units, stacking weighing and packing to cartons/skids, or optionally delivering to ¼, ½, ¾, or full press impression sheets.

7) Optionally off-line finishing the webs at a post-production printing in-line finishing system.

The descriptions of methods and products presented are merely a condensed version of the said patents. Complete descriptions and actual claims within said patents represent the actual manufacturing processes and end products possible when utilizing the Jacobsen patents, and should be relied upon exclusively when evaluating the intellectual properties presented.

<u>Summary & Conclusion: Advantages From Using Jacobsen's Two Web In-Line Lenticular Print Manufacturing vs. the Prior Art, i.e., Single Roll Web, and Sheet-Fed Print Processes</u>

Until the introduction of Jacobsen patents, U.S. Patents # 5,560,799 (1996), and 5,753,344 (1998), it was discussed previously in this paper that the mass production of large eye-catching 3D and animated printed advertising products for major consumer promotions has been too expensive and too time-consuming. Advertisers had to use a combination of traditional sheet fed printing and slow, multiple off-line finishing manufacturing steps to produce various 3D and animated print advertising products.

Jacobsen's (1996 & 1998) 3D and animated web fed printing processes which include complete in-line finishing processes that are performed concurrently and simultaneously with the print process solve this problem. The new dual web fed printing technologies give advertisers far greater flexibility to create more interesting and complex 3D and animated advertising, promotional, direct mail, packaging, or pressure sensitive label products, in addition with the advantage of substantial cost savings and the ability to deliver product with much tighter timelines.

To summarize and conclude how the Jacobsen (1996 & 1998) patents accomplish the aforementioned advantageous claims, a (sample theoretical print project) will be presented in layman terms, moving away temporarily from the highly technical terminology that has been used up to this moment.

The (Sample Theoretical Print Project) Will Be Illustrated In Two Ways:

1) Manufacturing by using traditional sheet fed manufacturing steps, which could also include printing via single roll web fed print process (prior arts)

2) Compare/contrast the traditional sheet fed and single roll web fed print process methods to the Jacobsen patented dual roll web fed printing and in-line finishing processes.

Summary & Conclusion Sample Theoretical Project:

An advertiser needs a special catalog for a large quantity direct mail program. The catalog must be unique and make a strong, memorable impact with the advertisers target prospects. The flat finished size needs to be 5" wide x 11" tall in order to qualify for the lowest USPS automated bulk mail rate. The elements would include: a stunning 3D lenticular printed image (as large as possible) as well as a 14 page, 4 color brochure with multiple perforated coupons. The catalog also needs to be a completely self-contained mailer with an outside cover die-cut window to reveal part of the catalogs interior, to which the 3D lenticular image is attached, to lure the readers inside the direct mail catalog. The advertiser seeks to print a quantity of 5,000,000 units and mail through out the United States.

Option 1: Traditional Prior Art Sheet Fed Or Single Roll Web Fed Printing With Off-Line Finishing:

Manufacturing (7) steps to include:

1) Print: The 4 color 3D/Animated image onto the lenticular plastic substrate, "one sheet at a time" using sheet fed printing, or print via single roll web fed and deliver to full single press sheets

2) Off-line: Trim and cut out the 3D lenticular unit to proper size from the pre-printed lenticular press sheets

3) Off-line: Print separately the 4 color, 14 page paper brochure / mailable carrier by single sheet fed or single roll web fed print processes

4) Off line: Die-cut a window opening into the paper carrier

5) Off-line: Perforate all paper based coupons within the 14 internal body pages

6) Off-line: Cut, fold and saddle stitch the 4 color, 14 page brochure/carrier

7) Off-line: Tip-in and permanently affix the 3D lenticular plastic unit into the paper brochure/carrier so that the 3D image shows through the die cut window opening, refold the catalog, and wafer seal the catalog closed, ready to mail to consumer.

Option 2: Summary & Conclusion: Preferred Method Using Jacobsen Patents:

Manufacturing (1) step to include:

1) Utilize all in-line rotary web fed continuous production: Web print simultaneously onto dual rolls A) the 4 color image onto the lenticular plastic, B) web print the 4 color paper brochure, then laminate the 3D lenticular unit into brochure, plow fold, spine glue the 11” backbone, die cut cover window opening, rotary trim and seal the carrier, ready to mail.

Summary Conclusion:

The entire combined four color printed 3D lenticular and paper direct mail catalog is produced all in (one) continual machine press pass vs. the (seven) manufacturing steps required to produce the same sample theoretical printed catalog product, using traditional (prior art) single sheet fed or single roll web fed printing methods with multiple off-line finishing processes.

Final Collimated Summary & Conclusion

The researcher has concluded and determined that the Jacobsen patents (1996 & 1998) solves the first problem that existed for a solution to a lower cost, higher speed, and efficient high volume printing production system which supplies large quantities of virtual three-dimensional and animated image printed products utilizing techniques and materials which incorporate lenticular transparent and *line formed printed screened, i.e.: dotted or spotted, images printed* in proper register beneath the array of lenses found in the lenticular transparent material.

Secondly, it has been determined that the Jacobsen patents (1996 & 1998) solves the second problem that existed and continued for a need to create an efficient, new and novel, *lower cost, high speed, continuous in-line* lenticular print manufacturing method utilizing a one pass rotary web fed printing process which would create an illusion of depth, or animation in the perception of the viewer of the image as compared to any other prior art recorded within the United States Patent & Trademark Office.

Thirdly, it has been determined that the Jacobsen patents (1996 & 1998) solves the third problem that existed for a need to provide a *continuous in-line roll fed printing process incorporating roll fed lenticular* *transparent, preferably made of transparent plastic, and roll fed opaque paper stock substrate, wherein line formed images are printed on the lenticular stock, on the paper stock, or both simultaneously in one embodiment.* The lamination and combination of two printed substrates together created within one press pass creates a finished three-dimensional or animated printed product ready for consumer viewing. This manufacturing technique saves precious time from creative development and design time to market and is available to advertisers at a lower cost due to highly efficient manufacturing procedures.

Very last, it has been determined that the Jacobsen patents (1996 & 1998) solves the fourth problem that existed for a printing process that must also be rapid enough to meet the quick delivery deadline requirements of advertisers, and be required to also be capable of manufacturing a new unseen before range of three dimensional and animated lenticular print products that could be used by the packaging, advertising and promotional industries.

Therefore it is of the researcher's final summary and conclusion that the Jacobsen patents (1996 & 1998) solves the aforementioned problems.

Discussion: Final Summary & Conclusion Questions

The researcher concludes that the study does support and does not reject the hypothesis due to the facts presented within this paper.

The researcher also agrees that the study supports and does contradict previous research due to the novel ness of the subject matter.

The author believes the study is not conclusive and that further research is needed outside the scope of research that was performed from the records found within the United States Patent & Trade Mark Office. Since prior art could possibly be found outside the United States, further research and study could be applied and extended, since the data is limited and not conclusive.

The researcher determines the following implications of this research to the discipline: Now, for the first time ever, compelling new animated & 3D printed lenticular formats can be mass-produced for major advertising campaigns and promotions. The Jacobsen (1996 & 1998) patented, advanced all in-line rotary web, flexographic, gravure, letter press and digital imaging print methods and in-line finishing systems cut the costs, and time that is associated with traditional sheet fed printing that requires additional post off-line, multi-step converting. The result is: faster job turnaround, on-time delivery, more-competitive pricing and lastly, the ability to create new-never-seen-before sophisticated lenticular finished advertising, promotional or packaging based products.

The researcher concludes that relative practices should be redefined if possible to extend the current lenticular technology to an advanced state if at all possible. The author believes this may not be possible due to the industries mature state of current manufacturing technology, and due to the fact of the industry's current usage of the Jacobsen patents (1996 & 1998).

Due to the forgoing facts, the author concludes the findings fully support the hypothesis of the paper.

Significant Findings of Study

The researcher did not uncover any similar studies or inventions relating to this papers title, thesis and abstract: "First Novel Invention Of In-Line Web Fed Roll Print Manufacturing Production Of Animated / Three-Dimensional Imaged Print Products Incorporating Lenticular Transparent Substrate...Its Advantages And The Comparison / Contrast Order Analysis To Prior U.S.P.T.O. Patented Art". Therefore, the study has an inherent uniqueness and originality in its approach to the topic. This is not to say the review of literature did not reveal issues relating to other persons or corporations attempting to explore, reverse engineer or advance the said topics technology, however, when found to exist, it appears to have occurred "**after**" the public made disclosure by the (USPTO) of the original Jacobsen (1996 & 1998) U.S. Patents. This fact alone supports the papers claim of "first to invent" and further more supports the papers novel ness of the invention.

Conclusions Drawn of Study

The researcher's conclusions drawn from the study include the following major points referenced within the study previously:

Jacobsen Patent's: (First To Invent, Documented Originality & Dominant Leading Industry Position)

Prior to the researcher's decision to apply for U.S. Patent applications for the currently granted Jacobsen U.S. Patent # 5,560,799 (1996) and U.S. Patent # 5,753,344 (1998), a thorough formal prior art search was conducted by WCG's previous patent counsel (Welsh & Katz) of Chicago, IL, in conjunction with the prior art search services offered through the United States Patent & Trade Mark Office. It was discovered after the initial search phase was completed; it appeared there were no other inventions granted previously to the type of lenticular technology that

Jacobsen sought to patent. This fact will serve to compliment the researcher's claim of *"<u>first to invent", and "documented originality</u>".*

<u>Advantages of Using Jacobsen's Two Web In-Line Lenticular Print Manufacturing vs. the Prior Art, i.e., Single Roll Web, and Sheet-Fed Print Processes:</u>

Until the introduction of Jacobsen patents, U.S. Patents # 5,560,799 (1996), and 5,753,344 (1998), the mass production of large eye-catching 3D and animated printed advertising products for major consumer promotions has been too expensive and too time-consuming. Advertisers had to on a combination of traditional sheet fed printing and slow; multiple off-line finishing manufacturing steps to produce various 3D and animated print advertising products.

Jacobsen's 3D and animated web fed printing processes which include complete in-line finishing processes that are performed concurrently and simultaneously with the print process solve this problem. The new dual web fed printing technologies give advertisers far greater flexibility to create more interesting and complex 3D and animated advertising, promotional, direct mail, packaging, or pressure sensitive label products, in addition with the advantage of substantial cost savings and the ability to deliver product with much tighter timelines.

<u>Combined Summary & Conclusion: Benefits Of Use Practicing The Jacobsen Inventions:</u>

The present and preceding lenticular tool and lenticular material inventions discussed: Johnson, et al., U.S. 2003/0002160 A1, January 2, 2003 invention, titled, “Lenticular Lens array And Tool For Making A Lenticular Lens Array, <u>provide extreme benefits of use when coupled</u> to the previously discussed lenticular printing processes of, Jacobsen, U.S. Patent # 5,560,799 (1996), and Jacobsen U.S. Patent # 5,753,344 (1998).

Accordingly, in this context of analysis, the researcher determines the following observations, and summarily describes and concludes:

Optically speaking first, the present Johnson, et al., U.S. 2003/0002160 A1, January 2, 2003 invention, titled, “Lenticular Lens array And Tool For Making A Lenticular Lens Array”, <u>provides the following major class benefits:</u>

1) Provides a lenticular lens array that can optimize printed display quality of animated and three-dimensional images for mass production.

2) The lenticular lens array can mitigate the spherical aberration typically produced by a conventional array. For example, the present invention can provide a lenticular lens array that can produce a substantially focused axial image and can improve the off-axis image.

3) The mitigation of the spherical aberration afforded by the inclusion of the elliptically shaped lens, when compared to conventional lenses, allows the utilization of thinner gauge lenticular lenses to achieve the same or better performance of same or heavier gauge materials.

4) Additionally, the current invention can provide a lenticular lens array having a reduced lens junction depth, which can mitigate off-axis light blocking by adjacent lenses.

5) Sheets of thinner lenticular lenses offer significant advantages when affixed to cylindrical objects vs. thicker lenses.

6) Use of thinner lenticular gauge material reduces costs of use up to 50% percent less as compared to conventional heavier lenticular gauge materials used today.

Utilizing and combining the present issued Jacobsen lenticular printing patents, U.S. Patent # 5,560,799, (1996) and US Patent # 5,753,344, (1998) titled, “In-Line Printing Production Of Three-Dimensional Image Products Incorporating Lenticular Transparent Material” to the previous discussed Johnson, et al. US Patent Application Publication, US 2003/002160 A1, January 02, 2003, titled, “Lenticular Lens Array And Tool For Making A Lenticular Lens Array”, provides the following combined major class benefits:

1) Allows printing upon a lenticular lens array that can substantially optimize printed display quality of animated and three-dimensional images used for mass production of lenticular printed products

2) Allows quality based printing upon thinner gauge lenticular materials using “continuous” web fed roll print production technology vs. “one at a time”, single sheet fed print production

3) “Continuous” web fed roll print production is much more cost efficient than “one at a time”, single sheet fed print production

4) Combining the aforementioned mentioned technologies can create new, never-seen-before printed lenticular formats and

structures including: entire outer lenticular packaging enhancements (box over wraps); segmented applied lenticular label coverage to outer packaging; pressure sensitive, non-pressure sensitive, self adhesive, and non-self-adhesive lenticular label products; multi-ply, multi-substrate peel open pressure sensitive and non-pressure sensitive lenticular labels; lenticular laminated to paper board products; packaging in-packs and on-packs; beverage cups having decorative partial or full lenticular cup wraps; video, dvd, or cd disc cover lenticular treatments; direct mail; magazine inserts; newspaper inserts; or contest and game sweepstakes components that comprise use of partial or full lenticular enhancements.

<u>New Proposed Lenticular Enhanced Print Products Include:</u>

The Jacobsen (1996 & 1998) patented inventions provide a (one step) continual roll web fed lenticular printing method via (web offset lithography, flexographic, rotogravure, and letterpress) processes that are produced by either screened or stochastic values replicating 3D or animated lenticular imaging. The single lenticular roll or dual web -

lenticular/opaque paper rolls either deliver as single roll to roll; single roll to flat product; or as double web rolls to final sheeted product, or preferably to in-line finished lenticular printed product ready for consumable advertising usages. Examples immediately follow:

Concluding Products & Lenticular Applications Include:

Corporate Brand Identity Packaging:

• Brand Product Identification

• Entire Outer Packaging Enhancements (Box Overwraps)

• Segmented Applied Lenticular Coverage To Outer Packaging

• Pressure-Sensitive & Self-Adhesive Lenticular Products

• Multi-Ply, Multi-Substrate Peel Open Pressure Sensitive Labels

• Lenticular Laminated To Paperboard Products

In-Packs & On-Packs (FDA direct food contact approved)

Beverage Cups: Decorative Partial Or Full Wraps

Video, DVD, CD Disc Cover Lenticular Treatments.

Concluding Promotional Products and Applications Include:

- Pressure Sensitive Adhesive Labels
- Magazine Inserts and FSI's
- Mini-Catalogs and Mini-Comic Books
- Brochures
- Direct Mail
- Postcards
- Structural Pop-Ups
- Huge Back-Lit and Reflective Posters
- Kid's Premiums and Trading Cards
- Spinning Wheels and Slide Charts
- Security Game Pieces and Punch Out Puzzles
- Scratch-Offs, Fragrance Scents, Special Inks
- Ink Jet Variable Imaging of Data

Depending upon the desired format, it is possible to add-on many other special effect options in-line on press, including: rotary die-cutting and removing web material, die cutting contour shapes, perforating for coupons and tear-offs, remoistenable glue for bounce backs, reply envelopes, T-shirt iron-on color printed transfers, pop-out puzzles, structural paper rising pop-ups, unusual fold sequences and format constructions, latex scratch rub-offs, ink jet imaging variable data or consecutive numbering for contests, plus special coatings, inks, papers and plastic substrates—many of which can be applied or created in just one press pass.

Recommendations for Further Research

The researcher recommends further research, study and development for the uses of newer and more cost efficient lenticular material resins that creates the lenticular lens arrays. Currently APET, PETG, and RIGID PVC plastic resins are commonly used today. Since the Jacobsen (1996 & 1998) web fed roll printing process patents can utilize very ultra-thin gauge lenticular materials, less expensive resins that result in a thinner gauge but more stable lens arrays would be desired.

In addition, further research, study and development would be desired to continue in the area of two or more lenticular roll in feed systems that are fed into the rotary web fed in-line printing and finishing systems discussed herein. Most notably, it would be further desired to obtain industry advancements in the art of the web handling areas of lenticular transparent substrates as well as improvements with the press registration systems in order to achieve, advance and extend the current technology of today.

Advancements in the aforementioned areas would result in more consistent and superior quality lenticular print manufacturing, as well as offer newer extended consumer based lenticular end print products to the advertising, promotion and packaging industries.

REFERENCES

Bravenec, Daniel W. & Marsh, Gary C. (1999). Printing process using a thin lenticular lens material. United States Patent # 5,967,032, 1-10.

Bravenec, Daniel W. & Marsh, Gary C. (1999). Registration system for lenticular printing. United States Patent # 5,974, 967, 1-7.

Brosh, Scott & Gottfried, Phil. (1999). Lenticular image and method. United States Patent # 5,924,870, 1-11.

Eastman Kodak Company. (2000). <u>PT Cruiser Ad Research Results.</u> New York: Author.

Goggins, Timothy P. (1999). Lenticular lens with multi-dimensional display having special effect layer. United States Patent # 5,896,230, 1-8.

Goggins, Timothy P. (2002). High definition lenticular lens. United States Patent # 6,424,467 B1, 1-12.

Gortych, Joseph E. (2000). <u>Intellectual Property Issues Facing High-Tech Industries</u>. Boston, Mass, 155-160.

Gulick, Stephen, Jr. (2001). Device and method for producing lenticular images with motion. United States Patent # 6,237,264 B1, 1-11.

Jacobsen, Gary A. (1993). Printed image creating the perception of depth. United States Patent # 5,181,745, 1-12.

Jacobsen, Gary A. (1996). In-line printing production of three dimensional image productions incorporating lenticular transparent material. United States Patent # 5,560,799, 1-12.

Jacobsen, Gary A. (1998). In-line printing production of three dimensional image productions incorporating lenticular transparent material. United States Patent # 5,753,344, 1-12.

Jacobsen, Gary A. (2000). Card and method of making same. United States Patent # 6,153,039, 1-13.

Johnson ET AL. (2003). Lenticular lens array and tool for making a lenticular lens array. United States Patent Application Publication # US2003/0002160 A1.

Johnson ET AL. (2002). Lenticular lens array and tool for making a lenticular lens array. International Application Published Under The Patent Cooperation Treaty (PCT) # WO 02/101424 A2.

Koltzenburg, Teresa (2000, January). Bringing a New Dimension to 3-D Imaged Packaging. Paper Film Foil Converter Magazine. NW6-NW8.

Kumagai, Yoshihiro, & Matsuzaki, Ichiro. (1998). Lenticular lens sheet. United States Patent # 5,724,188, 1-7.

Kuo, C.C, (Jay), Neumann, Ulrich, Chrysostomos, Nikias, M. McLeod, Dennis, Sawchuck, Alexander (2001, July 11). Total Immersion-Streaming 3-D Video, Audio, and a Sense of Touch Will Surround People with a Virtual Environment Over Their High-Speed Internet Connections, 1-5. Retrieved July 11, 2001 from the World Wideweb: http://oemagazine.com/fromthemagazine/jul01/totalimmersion.html.

Luttenberger, David (1999, September). ("3D Lenticular Packaging/Printing Entire Full Wrap") -Award Winning Notification Letter from Editor for "Emerging Technology." Packaging Technology & Engineering Magazine.

Morton, Roger, R.A. (2000). Lenticular image bearing member with variable line spacing to improve image quality. United States Patent # 6,163,406, 1-7.

Morton, Roger A. (2001). Method for producing lenticular images. United States Patent # 6,211,896 B1, 1-31.

Neefe, Charles W. (1983). Method of making lenses with a lenticular cut. United States Patent # 4,406,189, 1-4.

Quadracci, Thomas A. (1992). Method and apparatus for stereographic printing with preshrinking. United States Patent # 5,108,531, 1-5.

Quadracci, Thomas A. & Wickert, Thomas R. (1993). Method for forming a graphic web image. United States Patent # 5,266,995, 1-13.

Quadracci, Thomas A. & Wickert, Thomas R. (1994). Method for forming a graphic image web. United States Patent # 5,285,238, 1-14.

Quadracci, Thomas A. & Wickert, Thomas R. (1995). Method for forming a graphic image web. United States Patent # 5, 457, 515, 1-14.

Rosenthal, Bruce A. (2000). Lenticular optical system. United States Patent # 6,084, 713, 1-25.

Sandor, Ellen R. & Meyers, Stephan B. (1996). Computer-generated autostereography method and apparatus. United States Patent # 5,519,794, 1-20.

Three-Dimensional Lenticular Printing moves from Sheetfed to Rollfed. (1999, March). <u>Label & Narrow Web Industry</u>, p. 67-68.

Watanabe, Hitomu & Oda, Kunpei. (2000). Lenticular lens sheet. United States Patent # 6,157,491, 1-14.

Yoshimura, Osamu & Matsuzaki, Ichiro. (1997). Lenticular lens sheet. United States Patent # 5,687,024, 1-16.

Yoshimura, Osamu & Tango, Hidehiro & Matsuzaki, Ichiro. (2000). Lenticular lens sheet capable of reducing color shift and improving overall light team transmittance. United States Patent # 6,101,031, 1-12.

Appendix

Glossary: Definition Of Terms and Acronyms

(Section 1) is the most basic commonly used (terms and acronyms) that will be read throughout this dissertation. Do to the overall length of the (advanced terminology of terms and acronyms), those will be placed within further sections inside the Appendix, located in sections 2 and 3.

BASIC COMMON PAPER TERMS AND ACRONYMS (Section 1):

1) **Advertising**: Paid form of non-personal message communicated through the various media by industry, business firms, nonprofit organizations, or individuals.

2) **Autostereo**: 3D (three-dimensional image) viewed without wearing glasses.

3) **Cutoff**: A printed sheet which length is equal to the circumference of the plate cylinder used in a roll web fed printing press.

4) **Printing Cylinder**: Cylindrical devices on a printing press, including plate cylinders, the impression, blanket cylinders, and impression cylinders.

5) **Die cut**: Piece of paper or other substrate that has been cut into a special shape or design using a sharp steel die which removes excess waste areas.

6) **Flexography**: A relief letterpress, lower quality printing process which uses wraparound rubber plates and fast drying inks.

7) **Gravure**: Printing process, also called intaglio, where the matter to be duplicated is etched into the printing surface rather than raised from the surface as in letterpress printing.

8) **Hologram**: A three dimensional image formed by interference between a coherent laser beam and the light scattered by the object being imaged, and recorded on a high-resolution photographic plate; viewable when illuminated with the same light that formed the image.

9) **Image**: Visual counterpart or likeness of an object, a person, or scene produced by an optical device such as a camera, digital process, or illustrated art work.

10) **In-line**: A method of producing a finished printed product all in one printing machine pass.

11) **Laminate**: Bond a plastic film/substrate to a printed sheet by means of applying a permanent adhesive to one ply while pressure is applied to both substrates creating a two ply laminated unit.

12) **Lenticular**: A clear plastic material molded, embossed or extruded on one side of the material with a series of vertical cylindrical lenses that focus eye sight on different parts of underlying printed images. Commonly used for the purpose of specialty printing to create: 3D, animated, morphing, flipping or combination thereof visual images, or to encode multiple images that are singularly viewed by modestly rotating the printed image.

13) **Lenticular Lens**: Vertical cylindrical lenticules embossed or extruded into clear base plastic.

14) **Letterpress**: A relief printing method.

15) **Lithography**: A high quality, and cost efficient offset printing process in which the printing surface is neither raised nor etched into the print transfer plate, but which the printing and nonprinting areas exist on the same plane, and printing is effected by means of a chemical process that allows ink to adhere to only the parts of the surface to be reproduced.

16) **Printing Press**: Manual or automatic machine that uses an inked surface to print words and images on paper or any other comparable surface. Printing processes include lithography, flexography, gravure, letterpress, and digital.

17) **Web Press Rotary**: Press that prints on a continuous roll of paper or other substrate material called a web, rather than on individual sheets of cut paper.

ADVANCED PRINTING & OPTICAL TERMINOLGY (Section 2)

A

Aberration - The failure of an optical lens to produce an exact point-to-point correspondence between the object and its resulting image. Various types are chromatic, spherical, coma, astigmatism and distortion.

Absorption - The loss of light of certain wavelengths as it passes through a material and is converted to heat or other forms of energy.

Accuracy - The extent to which a machine vision system can correctly measure or obtain a true value of a feature. The closeness of the average value of the measurements to the actual dimension.

Active Illumination - Lighting a scene with a light source coordinated with the acquisition of an image. Strobed flash tubes, pulsed lasers and scanned LIDAR beams are examples.

Algorithm - A set of well-defined rules or procedures for solving a problem or providing an output from a specific set of inputs.

Ambient light - Light which is present in the environment of the imaging front end of a vision system and generated from outside sources. This light, unless used for actual scene illumination, will be treated as background noise by the vision system.

Analog - A smooth, continuous voltage or current signal or function whose magnitude (value) is the information. From the word "analogous," meaning "similar to."

Analog-to-Digital Converter (A/D) - A device which converts an analog voltage or current signal to a discrete series of digitally encoded numbers (signal) for computer processing. Architecture - For a vision system, the hardware organization designed for high speed image analysis.

Area - Portion or area of the image to be analyzed. Area analysis measures the number of pixels which fall in a specified range of gray levels for the feature of interest.

Area Array Camera - A solid state imaging device with both rows and columns of pixels, forming an array which produces a 2-D image.

Array Processor - A specially designed vision engine peripheral which attaches to the host to speed up arithmetical calculations by using parallel processing techniques. The host manages image data access and analysis results.

Artifact - An artificially created structure (by accident or on purpose), form or shape, usually part of the background, used to assist in measurement or object location.

Artificial Intelligence - The capability of a computer to perform functions normally attributed to human intelligence, such as learning, adapting, recognizing, classifying, reasoning, self- correction and improvement. Rarely found connected to vision systems.

ASIC - An acronym for Application Specific Integrated Circuit. All vision system elements including firmware can be integrated onto one ASIC.

Aspect ratio - The ratio of the width to the height of a frame of a video image. The U.S. television standard is 4:3 or 1.333

Astigmatism - A defect in a lens which causes blur or imperfect image results, since the rays from a given point fail to meet at the focal point.

Asynchronous - A camera characteristic which allows the return to top-of-frame to occur on demand, rather than synchronously following the 60 hz power line scanning frequency.

Attribute List - List of distinguishing features which are selected for IP calculation.

Autofocus - The ability of an imaging system to control the focus of the lens to obtain the sharpest image on the detector. Edge crispness is a typical control variable.

B

Background - The part of a scene behind the object to be imaged.

Backlighting - Placement of a light source behind an object so that a silhouette of that object is formed. It is used where outline information of the object and its features is important rather than surface features.

Backpropagation - A training technique which adjusts the weights of the hidden and input layers of a neural net to force the correct decision for a given feature vector data input set.

Baffle - A type of shield that prohibits light from entering an optical system.

Bandpass Filter - An absorbing filter which allows a known range of wavelengths to pass, blocking those of lower or higher frequency.

Bar Code - An identification system that employs a series of machine-readable lines of varying widths of black and white. Usually read with a laser scanner.

Bar Code (2-D) - An arrangement of rectangles and spaces that contains far more information than a traditional bar code.

Barrel Distortion - An optical imperfection which causes an image to bulge convexly on all sides similar to a barrel.

Beamsplitter - An optical device which divides one beam into two or more separate beams. A simple coated piece of glass in the optical path might reflect 60% of the light down onto the object, while allowing the other 40% to pass.

Beta Risk (-risk) - The risk of accepting bad or defective product.

Binary - An image with pixel values either one or zero.

Binary image - A black and white image represented as a single bit containing either zeros and ones, in which objects appear as silhouettes. The result of backlighting or thresholding.

Bit - An acronym for a Binary digit. It is the smallest unit of information which can be represented. A bit may be in one of two states, on or off, represented by a zero or a one.

Bit Map - A representation of graphics or characters by individual pixels arranged in rows and columns. Black and white require one bit, while fancy high definition color up to 32.

Blanking - The time during a raster scan retrace when the video signal is suppressed.

Blob - A single, connected region in a binary or grayscale image.

Blob Analysis - Identification of segmented objects in an image based on their geometric features (i.e. area, length, number of holes). (SRI)

Borescope - A device for internal inspection of difficult access locations such as pipes, engines, rifle barrels and pipes. Its long narrow tube contains a telescope system with a number of relay lenses. Light is provided via the optical path or fiber bundles. A 45 degree mirror at the end allows inspection of tube walls.

Boundary - The line formed by the joining of two image regions, each having a different light intensity. The edge of a region or object.

Bounding Box - The four coordinates which define a box around the object parallel to the major and minor axis. (SRI feature)

Brewster's Angle - The angle at which incident light, by reflecting at a boundary between two mediums of different refractive indices (i.e.

air/glass or air/water), becomes plane polarized. For air/glass it is about 67.4 degrees.

Brightness - The total amount of light or incident illumination on a scene or object per unit area. Also called intensity.

Bus - A local area network inside a computer which electrically connects all cards. They all hear the same information.

Byte - Eight bits of digital information. A byte has values from 0 to 255, and is the unit most common to represent the gray scale value of one pixel.

C

C-mount - A threaded means of mounting a lens to a camera.

Calibration - The act of relating X and Y pixel spacing to a known or predetermined pixels per unit length (i.e. inch, mm) factor. Often involves adjusting the imager position in setup.

CCD - Charge Coupled Device. A photo-sensitive image sensor implemented with large scale integration technology.

CCD - Frame Transfer CCD. The entire image is transferred from the sensing area to a storage area on chip. Data (charge) is read out from the storage area in a full frame mode. This workhorse of the industry is also capable of non-RS-170 operation.

CCD - Interline Transfer CCD. Data (charge) is transferred simultaneously out by odd and even lines or fields directly from the image sensors to their corresponding sensor registers. The output from the camera is always one field (frame) behind the image being captured.

Centroid - The center of mass of an object having a constant density, or of an object having varying density, weighted by the gray scale value.

Character - A single letter, digit or punctuation symbol requiring one byte storage.

Character Recognition (OCR) - Imaging and recognizing individual characters in a scene. Also called Optical Character Recognition.

Character Verification (OCV) - Imaging and verifying the correctness, quality and legibility of known characters in an image. Also Optical Character Verification.

Child - An object wholly contained within another object called the parent (SRI). A washer, including the hole, is the parent, and the hole is the child.

Chroma - The quality of a color including both the hue and saturation. Not present in gray.

CID - Charge Injection Device - A photo-sensitive image sensor implemented with large scale integration technology. Based on charge injection technology, a CID can be randomly addressed, non-destructively read, can be subscanned in a small region and is less susceptible to charge overflow from bright pixels to neighbors. The pixel structure is contiguous with maximum surface to capture incident light which is useful for sub-pixel measurement.

CIE - An acronym for a chromaticity coordinate system developed by the Commission Internationale de l'Eclairage, the international commission on illumination. In the CIE system, a plot of ratios (x, y and z) of the three standard primary colors (tristimulus values) to their sum. The most common diagram is the 2 dimensional CIE (x,y).

Classification - Assignment of image objects to one of two or more possible groups. Decisions are made by evaluating features either 1) structurally based on relationships or 2) statistically. For example, 1) a penny is round, a certain diameter (a tolerance) and has a histogram of a mean value; or 2) statistically, the object is measured a number of times, then the average and standard deviation are recorded. After training the features are weighted based on significance in object identification. For multiple features, absolute values are used.

Closing - A dilation followed by an erosion. A morphological operator useful to close holes and boundaries.

Coaxial Illumination - Front lighting with the illumination path running along the imaging optical axis and usually introduced with a 45 degree angle beam splitter.

Coherent Fiber Optics - A bundle of optical fibers with the input and output spatial x-y relationship maintained, resulting in near spatially correct image transmission.

Collimate - To produce light with parallel rays.

Collimated Lighting - Radiation from a given point with every light ray considered parallel. In actuality, even light from a very distant point source (i.e. a star) diverges somewhat. Note that all collimators have some aberrations.

Color - A visual object attribute which may be described by a "coordinate system" such as hue, saturation and intensity (HSI), CIE or LAB. Wavelengths in the visible part of the electromagnetic spectrum to which retinal rods respond.

Color Space - A two or three dimensional space used to represent an absolute color coordinate. RGB, HSI, LAB and CIE are all representations of color spaces.

Color Temperature - A colorimetric concept related to the apparent visual color of a source, but not its actual temperature.

Colorimetry - Techniques used to measure color of an object or region and to define the results in a comparison or coordinate system.

Composite Video - A television signal which is produced by combining both a video or picture signal with horizontal and vertical synch and blanking signals.

Condenser Lens - Used to collect and redirect light for the purpose of illumination. Often used to collect light from a small source and project even light onto an object.

Connectivity Analysis - An SRI routine used to determine which pixels are interconnected and part of the same object or region. The results are used for blob analysis.

Contrast - The difference of light intensity between two adjacent regions in the image of an object. Often expressed as the difference between the lightest and darkest portion of an image. Contrast between a flaw or feature and its background is the goal of illumination.

Contrast Enhancement - Stretching of the gray level values between dark and light portions of an image to improve both visibility and feature detection.

Convolution - Superimposing a m x n operator (usually a 3x3 or 5x5 mask) over an area of the image, multiplying the points together, summing the results to replace the original pixel with the new value. This operation is often performed on the entire image to enhance edges, features, remove noise and other filtering operations.

Correlation - A mathematical measure of the similarity between images or areas within an image. Pattern matching or correlation of an X by Y array size template to the same size image, produces a scaler number, the percentage of match. Typically, the template is walked through a larger array to find the highest match.

CPU - An acronym for Central Processing Unit. A VLSI chip such as 80486 or Pentium.

Cross section - A 3-D profile of a slice of an object.

D

Darkfield Illumination - Lighting of objects, surfaces or particles at very shallow or low angles, so that light does not directly enter the optics. Objects are bright with a dark background. This grazing illumination causes specular reflections from abrupt surface irregularities.

Data Reduction - The process of lowering the data content of a pixel or image such as thresholding or run length encoding.

Decision Tree - A structural classification technique based on relationships of feature measurements. Useful for differentiating a number of objects.

Dedicated System - Refers to a system which is configured for a specific application. Able to function when plugged in with no further development. Also called turnkey.

Depth-of-field - The range of an imaging system in which objects are in focus.

Depth Perception (3-D) - Measurement of the third dimension of an object or scene.

Dichroic Filter - A filter used to transmit light based on its wavelength, rather than on its plane of vibration. Transmits one color, while reflecting a second when illuminated with white light. Often used in heads-up displays.

Diffraction Pattern Sampling - Inspection by comparing portions of the interference pattern formed on a screen or special sensor from light waves diffracted by object edges.

Diffuse Reflection - Light which bounces off an object surface in many different directions. Light radiated from a matte surface is highly diffused.

Diffused lighting - Scattered soft lighting from a wide variety of angles used to eliminate shadows and specular glints from profiled, highly reflective surfaces.

Digital Camera - The newest generation of video cameras transform visual information into pixels, and then translate each pixel's level of light into a number in the camera.

Digital-to-Analog Converter - A VLSI circuit used to convert digital computer processed images to analog for display on a monitor. DAC is the acronym.

Digital Image - A video image converted into pixels. The numeric value of each pixel's value can be stored in a computer memory for subsequent processing and analysis.

Digital Signal Processor (DSP) - A VLSI chip designed for ultra high speed arithmetic processing. Often imbedded in a vision engine. TI's TMS320C40 is the industry standard.

Digitization - Sampling and conversion of an incoming video or other analog signal into a digital value for subsequent storage and processing.

Dilation - A morphological operation which moves a probe or structuring element of a particular shape over the image, pixel by pixel. When an object boundary is contacted by the probe, a pixel is preserved in the output image. The effect is to "grow" the objects.

Dispersion - Separation of a beam of light into its wavelength components, each of which travel at slightly different speeds. Also called chromatic dispersion.

Dust - An environmental contaminant consisting of airborne particles to be dealt with in machine vision. Never use factory air to keep optical surfaces clean, since oil will deposit.

Dynamic Range - The measure of the range light sensitivity a sensor is able to reproduce, from the darkest to the brightest portion of a scene. Usually expressed in decibels.

E

Edge - A change in pixel values exceeding some threshold amount. Edges represent borders between regions on an object or in a scene.

Edge Detection - The ability to determine the true edge of an object.

Edge Operator - Templates for finding edges in images.

Electrical Noise - Interference from various electrical devices which is present in the air as electromagnetic radiation or rides on the power lines and can introduce error into low voltage computations such as A/D conversion.

Electro-magnetic Spectrum - The total range of wavelengths, extending from the longest (audio) to the shortest (gamma rays) which can be physically generated. This entire spectrum is potentially useful for imaging, well beyond just the visible spectrum.

Encoder (Shaft or position) - Provides rotation information for control of image acquisition, especially for moving web processes. Outputs either pulses for counting or BCD parallel with absolute position information.

Endoscope - A medical instrument used to view inside the human body. It may use borescope optics or coherent fibers to relay the image to the eye or camera. Illumination is provided by a non-coherent bundle of optical fibers.

Erosion - The converse of the morphology dilation operator. A morphological operation which moves a probe or structuring element of a particular shape over the image, pixel by pixel. When the probe fits inside an object boundary, a pixel is preserved in the output image. The effect is to "shrink or erode" objects as they appear in the output image. Any shape smaller than the probe (i.e. noise) disappears.

Extension Tube - A cylindrical threaded tube used to change the magnification, effective focal length and field of view of a lens when inserted between the lens and imaging sensor.

F

F-number or f-stop - The ratio of the focal length to the lens aperture. The smaller the f- number, the larger the lens diameter and brighter the image and narrower the depth-of-field.

Fast Fourier Transform - Produces a new image which represents the frequency domain content of the spatial or time domain image information. Data is represented as a series of sinusoidal waves.

Features - Simple image data attributes such as pixel amplitudes, edge point locations and textural descriptors, center of mass, number of holes in an object with distinctive characteristics defined by boundaries or regions.

Feature Extraction - Determining image features by applying feature detectors to distinguish or segment them from the background.

Feature Vectors - A set of features of an object (such as area, number of holes, etc) that can be used for its identification or inspection.

Fiber Optics - Light source or optical image delivery via a long, flexible fiber(s) of transparent material, usually bundled together. Light is transmitted via internal reflection inside each fiber. Coherent fiber optics are spatially organized so images can be relayed.

Fiberscope - An optical instrument similar to a borescope, but uses a flexible, coherent fiber or bundle (usually silicon), an objective lens and an eyepiece or camera.

Fiducial - A line, mark or shape used as a standard of reference for measurement or location.

Field - One of the two parts of a television frame in an interlaced scanning system. The odd plus the even field comprise one video frame. A field is scanned every 1/60th of a second.

Field-of-view - The 2-D area which can be seen through the optical imaging system. (FOV)

Filtering - The use of an optical filter for picture or color enhancement in front of the camera lens or light source. Also analog or digital image processing (IP) operations to enhance or modify an image. May be linear & non-linear.

Filter - A device or process that selectively transmits frequencies. In optics, the material either reflects or absorbs certain wavelengths of light, while passing others.

Firmware - Software hard coded in non-volitile memory (ROM), usually to increase speed.

Fixture - A device to hold and locate a workpiece during processing or inspection operations.

Fluorescence - The emission of light or other electromagnetic radiation at longer wavelengths by matter as a result of absorption of a shorter wavelength. The emission lasts only as long as the stimulating irradiation is present.

Focal Length - The distance from a lens' principal point to the corresponding focal point on the object.

Focal Plane - Usually found at the image sensor, it is a plane perpendicular to the lens axis at the point of focus ..

Focus - The point at which rays of light converge for any given point on the object in the image. Also called the focal point.

Focus Following - A ranging and tracking technique that uses image processing to measure object range based on best focus.

Fourier Domain Inspection - Evaluation of the fourier transform (frequency information) of a 2-D spatial image for features of interest.

Frame - The total area scanned in an image sensor while the video signal is not blanked. In interlaced scanning, two fields comprise one frame. Frame rate is typically 30 Hz.

Frame Buffer - Image memory in a frame grabber.

Frame Grabber - A device that interfaces with a camera and, on command, samples the video, converts the sample to a digital value and stores that number in a computer's memory.

Front End System - The object, illumination, optics and imager blocks of a vision system. Includes all components useful to acquire a good image for subsequent processing.

Front Lighting - The use of illumination on the camera side of an object so that surface features can be observed.

G

Gaging - In machine vision, non-contact dimensional examination of an object.

Gamma (,) - The numeric value for the degree of contrast in a television picture. The exponent in the power law relating output to input signal magnitude. Non-linear camera tube.

Glints - Shiny, specular reflections from smooth objects or surfaces.

Global Method - An image processing operation uniformly applied to the whole image.

Gradient - The rate of change of pixel intensity (first derivative).

Gradient Space - A matrix containing values for the rate of change of pixel values or gray level intensity of the image.

Gradient Vector - The orientation and magnitude of the rate of change in intensity at a point or pixel location in the image.

Grating - An optical element with an even arrangement of rods or stripes with spaces between them for light to pass. Its ability to separate wavelengths is expressed in line pairs per millimeter, for example. A moiré grating of parallel dark and light stripes is an example. Also used for structured light projection.

Gray level - A quantized measurement of image irradiance (brightness), or other pixel property typically in the range between pure white and black.

Grayscale Image - An image consisting of an array of pixels which can have more than two values. Typically, up to 256 levels (8 bits) are used for each pixel.

GUI - An acronym for Graphical User Interface. Pronounced "gooie." A Windows based user interface screen or series of screens allowing the user to point-and-click to select icons rather than typing commands.

H

Halogen lamp - An incandescent lamp with a gas similar to iodine inside which is constantly evaporated then redeposited on the filament.

Hardware - Electronic integrated circuits, boards and systems used by the system.

HDTV - High Definition TV proposed broadcast standard to double the current 525 lines per picture to 1,050 lines, and increasing the screen aspect ratio from 12:9 to 16:9. The typical TV of 336,00 pixels would increase to about 2 million.

Height/Range - Object profile is usually measured by changes in range or distances from the sensor. 3-D techniques are usually used.

High Pass Filter - Passes detailed high frequency image information, while attenuating low frequency, slow changing data.

High Speed Imaging - Image capture near, at or above 1800 parts per minute.

Histogram - A graphical representation of the frequency of occurrence of each intensity or range of intensities (gray levels) of pixels in an image. The height represents the number of observations occurring in each interval.

Histogram Analysis - Determination of the presence or absence of a feature or flaw based on the histogram values in a certain gray scale region.

Histogram Equalization - Modification of the histogram to evenly distribute a narrow range of image gray scale values across the entire available range.

Holography - Optically recording of the interference pattern from two coherent waves which forms a 3 dimensional record or hologram.

Hough Transform - A global parallel method for locating both curved and straight lines. All points on the curve map into a single location in the transform space.

HSI Conversion - A mathematical conversion from the color RGB space to hue, saturation and intensity values.

HSI - An acronym for the Hue-Saturation-Intensity color representation. A mathematical conversion from RGB. Often used for machine vision analysis.

Hue - One of the three properties of HSI color perception. A color attribute used to express the amount of red, green, blue or yellow a certain color possesses. White, gray and black do not exhibit any hue.

Hueckel Operator - An edge finding operator which fits an intensity surface to the neighborhood of each pixel and selects surface gradients above a specified threshold.

Hybrid Electro-Optic Sensor - A silicon sensor fabricated in a configuration to match spatial information generated by the imaging system, such as a PSD (position sensitive detector), concentric rings, pie shapes and others.

Hz - An abbreviation for Hertz or cycles per second. Often used with metric prefixes such as kHz or MHz for kilohertz and megahertz respectively.

I

Illumination - Normally a wavelength or range of wavelengths of light or visible used to enhance a scene so the detector, normally a camera, can produce an image.

Image - Projection of an object or scene onto a plane (i.e. screen or image sensor).

Image Analysis - Evaluation of an image based on its features for decision making.

Image Capture - The process of acquiring an image of a part or scene, from sensor irradiation to acquisition of a digital image.

Image Distortion - A situation in which the image is not exactly true to scale with the object scale.

Image Enhancement - Image processing operations which improve the visibility of image detail and features. Usually performed for humans.

Image Formation - Generation of an image of an object or scene on the imaging sensor. It includes effects from the optics, filters, illumination and sensor itself.

Image Intensifier - Usually an electron tube equipped with a light sensitive electron emitter at one end and a phosphor screen at the other.

Used to provide electron gain for imaging in low light conditions such as night vision.

Image Memory - An internal, high speed, large capacity storage area on a frame grabber card or in a computer dedicated to image retention.

Image Plane - The plane surface of the imaging sensor, perpendicular to the viewing direction, at which the optics are focused.

Image Processing - Digital manipulation of an image to aid feature visibility, make measurements or alter image contents.

Incandescent lamp - An electrical lamp in which the filament radiates visible light when heated in a vacuum by an electrical current.

Incident Light - Light which falls directly onto an object.

Index of Refraction - A property of a medium that measures the degree that light bends when passing between it and a vacuum.

Infrared - The region of the electromagnetic spectrum adjacent to the visible spectrum, just beyond red with longer wavelengths.

Infrared Imaging - Image formation using wavelengths just below the visible spectrum.

Intensity - The relative brightness of a portion of the image or illumination source.

Interlaced Scanning - A scanning process in which all odd lines then all even lines are alternately scanned. Adjacent lines belong to different fields.

I/O - An acronym for Input/Output data either entering or leaving a system.

L

LAB - An acronym for the LAB color coordinate system.

Laplacian Operator - The sum of the second derivatives of the image intensity in both the x and y directions is called the Laplacian. The

Laplacian operator is used to find edge elements by locating points where the Laplacian in zero.

Laser Illumination - Lighting an object with a laser source for frequency selection, pulse width (strobe) control or for accurate positioning.

Laser Radar - See LIDAR.

LED - Light emitting diode. Often used as a strobe for medium speed objects.

Lens - A transparent piece of material, usually glass or plastic, with curved surfaces which either converge or diverge light rays. Often used in groups for light control and focusing.

Lens Types - The lenses most commonly used in machine vision are: 35mm, CCTV, Copying, Cylindrical, Enlarger, Micrographic, Video, Reflective and Wide Angle.

LIDAR - An acronym of Light Detection And Ranging. A system that uses light instead of microwaves for range and tracking measurements. LADAR uses a laser light source to measure velocity, altitude, height, range or profile

Light Tent - An arrangement of diffusing surfaces above the object to create a horizon to horizon diffuse illumination.

Lightpen - A pen on a cable used to select items from a display screen.

Line(s) of Light - One or more light stripes projected at a known angle onto the object. Deformation of this type of structured light results in 3-D information in a 2-D image.

Line Scan Camera - A solid state video camera consisting of a single row of pixels. Also called a linear array camera.

Linear Array - see Line Scan Camera.

Lighting - See illumination.

Location - The point in X and Y image space where a recognized object is found.

Look-Up Table (LUT) - High speed digital memory used to transform image input values to outputs for thresholding, windowing and other mappings such as pseudo-color.

Low Angle Illumination - See darkfield. Very useful to enhance and highlight surface texture features.

Low Pass Filter - A digital or optical filter which passes slow changing, low frequency information, while attenuating high frequency, detailed edge information.

M

Machine Vision - The use of devices for optical non-contact sensing to automatically receive and interpret an image of a real scene, in order to obtain information and/or control machines or processes.

Magnification - The relationship between the length of a line or size of a feature in the object plane with the length or size of the same in the image plane.

Mask - 1) Setting portions of an image ate neighbors to a constant value; 2) A filter matrix used as a convolution operator; 3) A logical or physical structure placed in an optical system to prevent viewing or passing of information in a certain spatial or frequency region.

Material Handling - Hardware systems that provide motion, indexing and/or orientation both during manufacture and the inspection process.

Matrix Array Camera - See Area Array Camera.

Median Filter - A method of image smoothing which replaces each pixel value with the median grayscale value of its immediate neighbors.

Memory - The internal, high-speed, large capacity working storage in a computer where data and images may be both stored and retrieved.

Micron - One millionth of a meter also called a micrometer.

Mirror - A smooth, highly polished surface, for reflecting light. It may be plane or curved. Mirrors are fabricated by depositing a thin coating of silver or aluminum on a glass substrate. First surface mirrors are coated on the top surface, thus avoiding a second ghost image produced when light is reflected off the back surface after passing through the glass twice.

MIPS - Millions of Instructions per Second measure for computer processing speed.

Modulation Transfer Function (MTF) - The ability of a lens or optical system to reproduce (transfer) various levels of detail (modulation) of an object to the image as the frequency (usually sinusoidal) increases.

Moiré Interferometry - A method to determine 3-D profile information of an object or scene, using interference of light stripes. Two identical gratings of known pitch are used. The first creates a shadow of parallel lines of light projected on the object. The second is placed in the imaging train, and superimposed on the shadow cast by the first grating, forming a moiré fringe pattern. Distance between the fringes or dark bands is directly related to range or profile. Varying the gap between the lines changes the sensitivity.

Moiré Pattern - A pattern resulting from the interference of light when gratings, screens or regularly spaced patterns are superimposed on one another. Two stacked window screens create this effect.

Moiré Topography - A contour mapping technique in which the object is both illuminated and viewed through the same grating. The resulting moiré fringes form contour lines of object elevation or profile.

Monochromatic - Refers to light having only one color or a single wavelength of radiation.

Monochrome - Refers to a black and white image with shades of gray but no color.

Morphology - Image algebra group of mathematical operations based on manipulation and recognition of shapes. Also called mathematical morphology. Operations may be performed on either binary or gray scale images. Parallel processors are useful to implement.

MOS Array - Metal Oxide Semiconductor camera array sensor with random addressing capability, rows and columns of photodiodes and charge sent directly from the photodiode to the camera output..

Mouse - A hand operated pointing device used to select items from a display screen. Cousin of a rodent known to abandon the ship when a vision system doesn't work properly.

N

Neural Networks - A computing paradigm which processes information based on biological nervous systems. No programming is involved as in artificial intelligence. Rather decisions are made based on weighted features analyzed by interconnected nodes of simple processing elements using analog computer-like techniques.

Noise - Irrelevant or meaningless data resulting from various causes unrelated to the source. Random, undesired video signals.

Normalized Correlation - Removes the absolute illumination value from a traditional correlation, making the algorithm less sensitive to light variations.

O

Object - The 3-D item to be imaged, gauged or inspected.

Object Features - Any characteristic that is descriptive of an image or region, and useful for distinguishing one from another. A feature may be any measurable item such as length, size, and number of holes, surface texture amount or center of mass.

Object Plane - An imaginary plane at the object, which is focused by the optical system at the image plane on the sensor.

Oblique Illumination - A lighting direction at an angle which emphasizes object features by shadows produced.

OEM - Original Equipment Manufacturer that supplies components to another for resale.

Off-the-Shelf - Refers to a general purpose system, readily available for immediate shipment, which is not configured for a specific application.

Oil mist - An environmental contaminant which builds up on vision optical surfaces.

Opaqueness - Degree to which an object does not transmit light.

Opening - An erosion followed by a dilation, it is the opposite of the closing morphological operator.

Optical Computing - Performing operations usually handled by electronic, serial computers with optical or photonic circuits/elements in parallel at near the speed of light.

Orientation - The angle or degree of difference between the object coordinate system major axis relative to a reference axis as defined in a 3-D measurement space.

P

Pantone Matching System (PMS) - A system of describing colors by assigning numbers.

Parallax - The change in perspective of an object when viewed from two slightly different positions. The object appears to shift position relative to its background, and also appears to rotate slightly.

Parallel Processor - A redundant hardware design using a number of processors so multiple pixels may be processed at the same time.

Parent - An object which wholly contains another object called a child. (SRI)

Pattern Recognition - A process which identifies an object based on analysis of its features.

Perceptron - The basic processing element used in neural networks. A simple analog circuit with weighted inputs and a nonlinear decision element such as a hard limiter, threshold logic or sigmoid nonlinearity.

Photodiode - A single photoelectric sensor element, either used stand-alone or a pixel site, part of a larger sensor array.

Photometry - Measurement of light which is visible to the human eye (photopic response).

Photopic Response - The color response of the eye's retinal cones.

Pinhole - A small, sharp edged hole, acts as a lens aperture which produces a soft edged image, is distortion free, with a wide field of view and large depth of field.

Pixel - An acronym for "picture element." The smallest distinguishable and resolvable area in an image. The discrete location of an individual photo-sensor in a solid state camera.

Pixel Counting - A simple technique for object identification representing the number of pixels contained within its boundaries.

Polarized Light - Light which has had the vibrations of the electric or magnetic field vector typically restricted to a single direction, in a plane perpendicular to its direction of travel. It is created by an type of filter which absorbs one of the two perpendicular light rays. Crossing polarizers theoretically blocks all light transmission.

Polarizer - An optical device which converts natural or unpolarized light into polarized light by selective absorption of rays in one direction, and passing of rays perpendicular to the polarizing medium. Usually fabricated from stretched plastic sheets with oriented, parallel birefringent crystals. The first polarizers were constructed with parallel wires.

Positioning Equipment - Used to bring the part into the field of view, or to translate when multiple images or views are required.

Precision - The degree of spread or deviation between each measurement of the same part or feature. Repeatability.

Prism - An optical device with two or more non-parallel, polished faces from which light is either reflected or refracted. Often used to redirect light as in binoculars.

Processing Speed - A measure of the time used by a vision system to receive, analyze and interpret image information. Often expressed in parts per minute.

Profile - The 3-D contour of an object.

R

Radiometry - Measurement of light within the entire optical spectrum.

RAM - An acronym for Random Access Memory for storage and retrieval of data.

Random Access - The ability to read out chosen lines or windows of information from an imager as needed, without following the RS-170 standards.

Range Measurement - Determination of the distance from a sensor to the object.

Raster Scan - A scanning pattern, generally from left to right while is progressing from top to bottom of the imaging sensor or the display monitor. Generally comprised of two fields composed of odd and even lines.

Real Time Processing - In machine vision, the ability of a system to perform a complete analysis and take action on one part before the next one arrives for inspection.

Reflection - The process by which incident light leaves the surface from the same side as it is illuminated.

Refraction - The bending of light rays as they pass from one medium (i.e. air) to another (i.e. glass), each with a different index of refraction.

Region - Area of an image. Also called a region of interest for IP operations.

Registration - The closeness of the part to the actual position expected for image acquisition.

Reject - A mechanism used on a manufacturing line to remove defective or sample product from the main stream or conveyor. Reject design is usually customized to the process.

Repeatability - The ability of a system to reproduce or duplicate the same measurement. See precision. The total range of variation of a dimension is called the 6-sigma repeatability.

Resolution, Pixel Grayscale - The number of resolvable shades of gray (i.e. 256).

Resolution, Image - The number of rows and columns of pixels in an image.

Resolution, Spatial - A direct function of pixel spacing. Pixel size relative to the image FOV is key.

Resolution, Feature - The smallest object or feature in an image which may be sensed.

Resolution, Measurement - The smallest movement measurable by a vision system.

Reticle - An optical element with a pattern located in the image plane to assist in calibration, measurement or alignment of a system or instrument. Examples are cross lines or grids.

RGB - An acronym for the Red-Green-Blue color space. This three primary color system is used for video color representation.

Ringlight - A circular lamp or bundles of optical fibers arranged around the perimeter of an objective lens to illuminate the object in the field below it. A wide variety of sizes are available on both a stock and custom basis.

RS-170 - The Electronic Industries Association (EIA) standard governing monochrome television studio electrical signals. The broadcast standard of 30 complete images per second.

RS-232-C - The Electronic Industries Association (EIA) standard governing serial communications over a twisted pair. Good to about 150 feet.

RS-330 - Standard governing color television studio electrical signals.

RS-422; RS-423; RS-449 - The Electronic Industries Association (EIA) standards for serial communication protocols intended to gradually replace the widely used RS-232-C standard.

Rotation - Translation of a part about its center axis from the expected orientation in X and Y space. Expressed in degrees.

Run Length Encoding - A data reduction method to code a binary image. For each line in an image, data is stored denoting only the starting location of a blob and object and the length of the run of that line over the object.

S

Saturation - The degree to which a color is free of white. One of the three properties of color perception along with hue and intensity (HSI).

Scanner (galvo & polygon mirror) - An image sensor which uses a swept or scanned beam of light (usually a laser) to generate or acquire a one or two dimensional grayscale reflectance pattern.

Scene - The object and a background in its simplest form. A portion of space imaged by a vision system for investigation or measurement.

Scattering - Redirection of light reflecting off a surface or through an object. See diffuse.

Scene Analysis - Performing image processing and pattern recognition on an entire image.

Segmentation - The process of dividing a scene into a number of individual objects or contiguous regions, differentiating them from each other and the image background.

Shading - The variation of the brightness or relative illumination over the surface of an object, often caused by color variations or surface curvature.

Shape - An object characteristic, often referring to its spatial contour.

Shape from Shading - A 3-D technique that uses shadows from interaction of the object and the light source to determine shape.

Sharpening - An IP operation which enhances edges. An unsharp mask adds a low pass filtered image to the original, resulting in edge enhancement.

Shutter - An electrical or mechanical device used to control the amount of time the imaging surface is exposed to light. Often used to stop blur from moving objects.

Siblings - In SRI terminology, several child objects within a parent object are siblings.

Silhouette - A black and white image of an object illuminated by backlighting.

Simple Lens - A lens with only a single element.

Sinusoidal Projection - Use of a grating in which the dark stripes vary in their density sinusoidally across each one, rather than constant black. Improved profile or range discrimination is possible when used in a moiré type configuration.

Size - An object characteristic typically measured by x and y dimensions. Size may be expressed in pixels, the system calibrated units of measure or classes or size groups.

Smart Camera - A new term for a complete vision system contained in the camera body itself, including imaging, image processing and decision making functions.

Sobel Transform - A 3x3 convolution used for edge enhancement and locating.

Solid-state Camera - A camera which uses a solid state integrated circuit chip to convert incident light or other radiation into an analog electrical signal.

Span - The allowance of gray level acceptance for thresholding, adjustable from black to white from 0 to 100%.

Spatial Light Modulator - A transparent screen used in optical computer systems to introduce an image into the optical processing path. Similar to liquid crystal computer display screens, their resolution approaches 512x512 and grayscale imaging 8 bits. Also SLM.

Spectral Analysis - Evaluation of the wavelength composition of object irradiance.

Spectral Characteristics - The unique combination of wavelengths of light radiated from a source or transmitter or reflected from an object.

Spectral Response - The characteristic of a sensor to respond to a distribution of light by wavelength in the electromagnetic spectrum.

Specular Reflection - Light rays that are highly redirected at or near the same angle of incidence to a surface. Observation at this angle allows the viewer to "see" the light source.

Speed - An object characteristic expressed in distance moved per unit time. Velocity. Image blur may be caused by high speeds unless strobes or shutters are used to "stop motion."

SRI Algorithms - A rich set of routines used for geometric analysis and identification developed at the Stanford Research Institute in the early 1970s. Four main steps are: 1) Convert the image to binary; 2) Perform connectivity analysis to identify each blob or object; 3) Calculate the core statistical features for image objects; and 4) Calculate additional user selected features.

Stadimetry - A range measuring technique based on the apparent size measurement of a known size object in the field-of-view.

Statistical (Theoretic) Pattern Recognition - Statistical analysis of object features to perform recognition and classification.

Stereo (Passive) - For imaging, the use of two cameras, offset by a known distance and angle, to image the same object and provide range, depth or 3-D information. Active stereo uses a controlled or structured light source to provide 3-D data.

Stereo Photogrammetry - See Shape from Shading.

Stereoscopic Approach - The use of triangulation between two or more image views from differing positions. Used to determine range or depth.

Strobe Duration - The amount of time, expressed in microseconds, during which the flash lamp (strobe) is at 90% intensity.

Strobed Light - Brief flashes of light for observing an object during a short interval of time, typically used to "stop" movement and resulting image blur. Strobes may use xenon flash tubes, banks of LEDs or a laser to illuminate the scene.

Structural (Syntactic) Pattern Recognition - Evaluation of the relationship of object features in a specific order, i.e. decision trees, to perform recognition and classification.

Structured Light - Points, lines, circles, sheets and other projected configurations used to directly determine shape and/or range information by observing their deformation as it intersects the object in a known geometric configuration.

Subpixel Resolution - Mathematical techniques used on gray scale images to resolve an edge location to less than one pixel. A one tenth pixel resolution is reasonable in the factory.

Syntactic PR - See Structural Pattern Recognition

System Performance Measures - Accuracy, precision or repeatability, and alpha and beta risk for a given throughput rate specify the performance of a vision system.

Synch Pulse - Timing signals used to control the television scanning and display process. The horizontal synch triggers tracing of a new line from left to right, while the vertical synch initiates the start of a new field.

Synchronous - A camera characteristic denoting operation at a fixed frequency locked to the AC power line (typically 60 or 50Hz).

Systems Integration - The art of assembling hardware, software, components, mounts and enclosures to produce a system that meets a customer's specification.

T

Tail End System - The operator interface, I/O and communications blocks of a vision system. Includes all aspects of information display and handling. Is often overspecified.

TDI Camera - Time Delay Integration. Similar to a line scan, a TDI camera is comprised of a number of rows of pixels. As an object such as a web moves, the charge from one row is passed to the next row, synchronously continuing the integration. Requires far less illumination intensity than the standard line scan.

Template - An artificial model of an object or a region or feature within an object.

Template Matching - A form of correlation used to find out how well two images match.

Texture - The degree of smoothness of an object surface. Texture affects light reflection, and is made more visible by shadows formed by its vertical structures.

Thickness - The measurement in the third dimension (length and width being the other two) from one object surface to another using one or two 3-D range sensors or other technique.

Thresholding - The process of converting gray scale image into a binary image. If the pixel's value is above the threshold, it is converted to white. If below the threshold, the pixel value is converted to black.

Throughput Rate - The maximum parts per minute inspection rate of a system.

Top Hat - A morphological operator comprised of an opening followed by a subtraction of the output image from the original input image.

Trackball - A stationary ball used as a pointing device to select items from a display screen.

Transition - For an edge in a binary image, the location where pixels change between light and dark.

Translation - Movement in the X and/or Y direction from a known point.

Translucent - An object characteristic in which part of the incident light is reflected and part is transmitted. The transmitted light emerges from the object diffused.

Transmittance - The ratio of the radiant power transmitted by an optical element or object to the incident radiant power.

Transputer - A type of computer architecture with several CPUs connected in parallel.

Triangulation - A method of determining distance by forming a right triangle consisting of a light source, camera and the object. The distance or range can be calculated if the camera-to-light source distance and the incident to reflected beam angle are both known. Based on the Pythagorean relation.

Tube Type Camera - A camera in which the image is formed on a fluorescent screen, then read out sequentially in a raster scan type pattern by an electron beam for conversion to an analog voltage proportional to incoming light intensity.

U

Ultrasonic Imaging - Use of ultrasound waves as the imaging "illumination" source.

Ultrasound - Low frequency radiated acoustical waves just above human sound perception which are useful for penetration and "illumination" for inspection of solid objects.

Ultraviolet - The region of the electromagnetic spectrum adjacent to the visible spectrum, but of higher frequency (shorter wavelength) than blue ranging from 1 to 400 nm. UV A ranges from 320 to 400 nm while UV B falls between 280 and 320 nm.

User Interface - Includes display, operator, user controls and a means to access and modify custom user programming. See operator interface.

V

Validation - A rigid set of tests to verify that a system performs as documented.

Variable Scan Input - Frame grabber capability to accept a variety of non RS-170 input formats from a variety of cameras. Allows operation above the 30 Hz limit.

VESA - Video Electronics Standards Association. A 32 bit display or other hardware card.

VGA - An acronym for Video Graphics Array. The IBM video display standard of 16 colors.

Video - Visual information encoded in a specific bandwidth and frequency spectrum location originally developed for television and radar imaging.

Vidicon - A generic name for a camera tube of normal light sensitivity. It outputs an analog voltage stream corresponding to the intensity of the incoming light.

Visible Light - The region of the electromagnetic spectrum in which the human retina is sensitive, ranging from about 400 to 750 nm in wavelength.

Vision Engine - Analyzes the image and makes decisions, using a very fast processor inside a computer. It performs dedicated evaluation of the pre-processed image data to find features and make measurements. Unlike a personal computer, the vision engine is built for speed, not flexibility.

W

Wavelength - The distance covered by one cycle of a sinusoidally varying wave as it travels at or near the speed of light. It is inversely proportional to frequency.

Well - A morphological operator comprised of a closing followed by a subtraction of the output image from the original input image.

Window - A selected portion of an image or a narrow range of gray scale values.

Windowing - Performing IP operations only within a predefined window or area in the image.

X

Xenon Strobe - A gas filled electronic discharge tube, useful for high speed, short duration illumination for inspection.

X-ray - A portion of the electromagnetic spectrum beyond the ultraviolet with higher frequency and shorter wavelengths. Able to penetrate solid objects for internal, non-destructive evaluation.

Z

Zoom Lens - A compound lens which remains in focus as the image size is varied continuously. May be motorized or manually operated.

ADVANCED LENTICULAR TERMINOLOGY (Section 3)

2-D to 3-D Conversion - A process whereby multiple layers of different elements are interlaced together to create the illusion of three dimensions.

Alignment - Adjusting a print so that the image strips are parallel to the lenticule.

Binocular - Seeing with two eyes. This allows humans to see the world in 3-D depth.

Cardboarding - A method of creating the illusion of depth by using flat images instead of rounded images. Each flat image is then shifted left or right so that they seem to appear at different depth planes.

Convergence - Intersecting the line of sight of both eyes at an object or point in space.

Cross Talk - Also known as ghosting. Seeing two or more images at the same time from a single viewpoint in a lenticular image. This is caused by several problems including poor registration or a pitch mismatch, images with too much contrast, using too many images/frames, and/or exceeding the resolution capabilities of your output device in conjunction with a particular lens sheet. Severe aberrations within a lenticular lens material can also bring forth cross talk (ghosting).

Extruding Cylinder - A highly precision-oriented copper engraved production roll for use in extruding lenticular lens sheet material.

Delamination - The physical separation of a mounted interlaced image from the flat side of a lenticular lens sheet.

Direct-to-lens - Using any printing process that prints directly onto the flat surface of the lenticular lens material. This is most common in offset printing

Filler space - In an interlaced print, a technique that utilizes a neutral stripe of printed information to separate multiple frames of images from each other in order to minimize ghosting.

Flip - A lenticular effect that in its simplest form contains two images and shows them one at a time to the viewer as his viewing angle to the lens sheets changes. Images can have more than one flip effect.

Focal Point - The point of interest or the object of your attention or the point at which a lens focuses a beam of light. This is usually directly behind a lens sheet.

Focal Plane - A plane perpendicular to the axis of the lens on which an image appears to focus.

Gauge - The relative thickness of a lenticular lens sheet. Usually noted in mils (thousandths of an inch).

Ghosting - See cross talk.

Interlacing - The process of striping and arranging printed information to a given pitch to match a lenticular lens.

Key Plane - An imaginary plane in a 3-D lenticular image that will not appear to have depth. The key subject is usually on the key plane.

Key Subject - Is the subject of primary interest in an image.

Lamination - The process of adhering a preprinted media to the lens sheet. It is commonly used to apply both photographically imaged and digitally output images to the lens sheets.

Lens count - In the U.S., the number of lenticules per inch (LPI).

Lens sheet - a sheet of transparent plastic material that has been extruded cast or embossed with an array of identical parallel lenses.

Lenticule - A single lens in a lenticular sheet.

Morph - A lenticular effect that begins with one image which is transformed in stages to a second perhaps unrelated image.

Motion - A lenticular effect that utilizes selected highlights of frames from animated illustrations, video or film originals. The frames are displayed to the viewer one sequence at a time. The observer is given an impression of movement from one frame to the next.

Narrow Angle Lens - A lenticular lens sheet with a viewing angle between 15 and 30 degrees. Narrow angle lenses are the best for 3-D effects.

Parallax (horizontal) - Where objects in a scene seem to shift laterally relative to one another as the angle of view is changed.

Phase - Describes the number of discrete frames of a lenticular image. For example, a three-phase "flip" has three images or frames of information.

Pitch - The exact count or number of lenticules per inch (LPI).

Radius - The degree of curvature of the lens.

Refractive Index - The extent to which a lens focuses incoming light.

Registration - The physical act of aligning an interlaced image directly to the exact pitch of the lenticular sheet.

Slicing - See Interlacing.

Stripe - A computer "slice" of artwork represented by Pixels.

Thickness - See Gauge.

Viewing Angle - A calculated angle of refraction inherent on a lenticular lens design that determines how fast or slow the image is viewed.

Wide-angle lens - A lenticular lens sheet with a viewing angle between 40 and 55 degrees. Wide-angle lenses are the best for Flip and Animated effects.

Zoom - A lenticular effect that gives the observer the impression that the object is either moving from foreground to background, from background to foreground or getting larger or smaller.