CONTRIBUTIONS
TO THE
ADVANCEMENT
OF THE
NEON ARTS

WAYNE STRATTMAN

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Abstract

This thesis concerns contributions made to the field of the Neon Arts. The field originated in the mid-nineteenth century with the invention of the Geissler tube, a blown glass tube internally illuminated by the electrical excitement of the low pressure gas it contained. The art was predominately represented in the mid-1900s by conventional Neon signage. The introduction of the Studio Glass Arts movement in the 1960s began to expand the range of expression beyond signage, incorporating different glass structures, filling gases, power options, and other emerging technologies to produce a wide range of illuminated sculpture.

In the span of his twenty-five year career, Wayne Strattman has made a variety of contributions to the field. These have included:

<u>Publications</u>: The publication of a primary reference book, *Neon Techniques, 4th Edition,* with over five thousand copies sold, and one hundred articles in the leading trade journal, "Signs of the Times." These publications not only consolidated historical and newly emerging technical knowledge but also incorporated a significant amount of original research. Results of this research include techniques for accelerating the filling of glass tubes with gases at low pressure, new ways to remove impurities from glass tubes, the adoption of foreline traps for enhanced vacuum pumping, new ways to stress test glass, and new ways to test outgassing rates.

<u>Patents</u>: The development of two individual and one shared patent for new Neon technologies. One invention in particular, Luminglas™ (the first kinetic, interactive, flat plasma device capable of producing planes of moving light) has been incorporated in, among other applications, consumer products, movie set displays, and architectural installations around the globe.

Artwork: The first art pieces to incorporate flat panel, kinetic gas discharge displays. The author has also explored a range of additional illumination media and refined their qualities of expression for use in sculpture.

Products: The commercial realization of four technical devices to aid in the development of neon sculpture and eleven consumer products that have significantly heightened popular awareness of new Neon technologies (as evidenced by sales in the tens of millions of dollars.)

Community Involvement: Formative member of the developing community of illuminated glass artists (whose chosen media include and extend beyond traditional neon). The author curated the first Illuminated Glass Art show and has been an active representative of Neon within the Glass Art Society.

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1. PREFACE

1.1. LIST OF PUBLISHED WORKS

Reference Manual

Neon Techniques, *4th edition,* Cincinnati Ohio: ST Publications, 1997

ISBN: 0-944094-27-9

Trade Journal Articles

Appearing in "*Sign of the Times"* magazine, 1987-1998

	Title[1]	Date of First Publication
1.	Glass Annealing of neon tubing	11/87
2.	Using oxygen enrichment with gas/air fires	12/87
3.	Uneven heating and cooling and thermal expansion of neon glass	1/88
4.	Neon cold cathode electrodes	2/88
5*	a.) Fill pressure adjustment for high temperature backfilling b.) Explanation of conductance limited vacuum systems	3/88
6.	Vacuum system evaluation and ideas for improvement	4/88
7*	a.) Backfilling contaminants in neon tubes b.) Oxygen enrichment of neon fires c.) Mercury staining of neon tubes	5/88
8.	Proper transformer loading and wiring large neon loads	6/88
9.	Dimming high voltage circuits	7/88
10*	a.) Sizing transformers with multiple sizes of neon tubes b.) Making "crackle tubes"	8/88
11.	Use of krypton and xenon/use of metal cylinders for fill gases	9/88

*Represents response to reader inquiry (less than 10% of articles)

[1] **Note**: As many of the articles did not have formal titles, descriptive titles have been created in their stead.

	Title[1]	Date of First Publication
12.	Major impurities to be removed during neon processing and parallel processing of neon units	10/88
13.	Bombarding precautions using mercury in the neon shop	11/88
14.	Safety precautions using neon and mercury in the neon shop	12/88
15.	Dangers working with liquefied petroleum gas	2/89
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29.	Health issues in the neon shop	7/90
30.	Making a cathode ray tube illustrates how phosphors work	9/90
31.	Close "cousins" of cold cathode neon tubes	10/90
32.	Three gas discharge tubes used to illustrate principles within a plasma	11/90
33*	a.) Use of common ground wiring on large neon installations b.) issues on the use of metallic vs. nonmetallic conduit for high voltage wiring c.) lighting parallel high frequency neon tubes	12/90
34.	Theory of current limiting bombarder chokes	1/91

[1] **Note**: As many of the articles did not have formal titles, descriptive titles have been created in their stead.

	Title[1]	Date of First Publication
35.	Electromagnetic interference issues	3/91
36.	Multiple methods for cutting glass tubing	4/91
37.	Atmospheric conditions effecting outdoor neon signage	12/91
38.	Neon vs. conventional lighting type dimmers	1/92
39*	a.) Outgassing issues related to the use of elastomers in neon tube processing b.) "Ultimate" vacuum requirements for neon processing c.) The function of the neon electrode coating	3/92
40.	Illuminating Answers	4/92
41.	The How's of bending, The Why's of coating	6/92
42.	Quoting neon	7/92
43.	Answering the colour question: making the best choice in phosphor coated tubing	9/92
44.	A burning question: Burners and torches for neon ignite some controversy	10/92
45.	Oven pumping neon tubes	11/92
46.	Metal cylinders: Proper handling for clean, safe gas	12/92
47.	Making the lights move: An interview with Steve Hymen and Joe Upham on animating displays	1/93
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52.	Neon pattern making: Computerization comes, somewhat reluctantly to the neon shop	6/93
53.	The electromagnetic waves debate: Early indications say electromagnetic waves can be harmful-but to what degree is very debatable	7/93
54.	NESA's Neon Installation manual	8/93
55.	Shop maintenance	9/93
56.	The effects of neon light and the building of an ageing rack	10/93
57.	"Recycling" glass" in the neon shop	11/93
58.	The Glass Workshop: Brooklyn studio is Mecca for beginners and internationally acclaimed glass artists	12/93

[1] **Note**: As many of the articles did not have formal titles, descriptive titles have been created in their stead.

	Title[1]	Date of First Publication
59.	Early history of the gas discharge tube: Experiments with vacuum science and high voltage physics shaped the neon sign	1/94
60.	Selling your neon business	2/94
61.	Review of electronic transformers	2/94
62.	Insurance for the neon shop	3/94
63.	Tube darkening: A quick guide for when your tube goes dark	4/94
64.	A different view on vacuum technique: Be a master of molecular movement in high and low pressure environments	6/94
65.	Making “Crackle” tubes	7/94
66.	Neon’s a gas: Illuminated glass sculpture	8/94
67.	Pyrex specialty neon: Use of hard glass is growing but requires a different approach	9/94
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73.	Crossover bends: Techniques to improve this important transition between letters	3/95
74.	Annealing kilns in the neon shop	4/95
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78.	Flow through pumping: advice on pumping long, narrow tubes quickly and efficiently	7/95
79.	Shipping neon: Better designs and packing materials make shipping neon possible	8/95
80.	On calibration and loading	9/95
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83.	Induction heating	12/95

[1] **Note**: As many of the articles did not have formal titles, descriptive titles have been created in their stead.

	Title[1]	Date of First Publication
84.	Neon murals by light design	1/96
85.	Is the diffusion pump necessary	2/96
86.	Listing neon tubes	3/96
87.	Evacuation proclamation	5/96
88.	“Hard glass” components for manifold construction	6/96
89.	Foreline traps	8/96
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91.	Spring Cleaning: transformer questions	3/97
92.	Low mercury lighting	4/97
93.	Spring cleaning (part two) transformer issues	5/97
94.	The pump oil papers	6/97
95.	Transformers and tube life	8/97
96.	The basics of glass bending	8/97
97.	Bakeout and rare gas conductivity	10/97
98.	Filling and ageing tubes	1/88
99.	Transformer installation and loading	2/98
100.	How neon tubes work	3/98

[1] **Note**: As many of the articles did not have formal titles, descriptive titles have been created in their stead.

1.2. LIST OF PATENTS

1.2.1 LUMINOUS DISPLAY DEVICE

Wayne Strattman U.S. Patent Number 5,383,295 January 24, 1995

Abstract: A luminous display device which includes a fused assembly of three flat members, behind the first of which a chamber partly defined by an opening in the second of said members is formed, a quantity of beads and an ionizable gas being disposed in said chamber, a source of high frequency voltage being connected to an electrode through an opening in the third of said members to form myriad discharge paths throughout said chamber.

1.2.2 APPARATUS FOR PROVIDING A KINETIC LIGHTNING EFFECT

Wayne Strattman U.S. Patent Number 6,924,598 August 2, 2005

Abstract: An apparatus for providing a visual lightning effect includes a first chamber and a second chamber, where a passageway connects the first chamber and the second chamber. An inert gas is provided within the first chamber, the second chamber, and the passageway. A first contact is located external to the first chamber; and a second contact is located external to the second chamber, wherein an electrode provides a charge to the second contact, wherein the charge causes an electrical discharge between the second contact and the first contact via channels provided by fill material located within the second chamber that traverses the passageway to the first chamber, thereby resulting in the brilliant visual lightning effect.

1.2.3 ELECTRODE ASSEMBLY AND DISCHARGE LAMP

Wayne Strattman U.S. Patent Number 6,362,568 March 26, 2002
James Anderson
Jack Trentelman
P.Jackson

Abstract: An electrode assembly suitable for employment with low-pressure discharge lamps, and especially discharge lamps made from borosilicate glass. The electrode assembly comprises a hollow, stepped electrode holder having a tubular upper portion and a cylindrical lower portion comprising a tapered edge, and an electrode shell fastened to the tubular upper portion of the electrode holder. The electrode assembly may also further comprises a glass ring fused to the tapered edge of cylindrical lower portion of the electrode holder. The electrode assembly is suitable for use with low-pressure discharge lamps comprising glass tubes and low-pressure discharge lamps comprising envelopes having a gas-discharge channel. In a low-pressure discharge lamp, the electrode assembly of the present invention may be used as the discharge source, the evacuation and backfill site, and the seal site.

1.3. List of Artwork

SELECTED ARTWORK	MEDIA	EXHIBITIONS
"Art and Disability" 18″ x 18″ x 5″ 2001	flame worked borosilicate glass, nichrome wire, tungsten to borosilicate glass to metal seals, inert gas [incandescent technology]	2003: Society of Arts and Crafts (Boston, Massachusetts) 2001: GAS Conference (Corning, New York)
"Untitled with Green Spot" 67″ x 24″ x 18″ 2001	Luminglas^{TM} (fused glass, phosphors, inert gas, steel) [flat panel illuminated plasma technology]	2001: Atelier 564 (Boston, Massachusetts) 2002: Piano Craft Gallery (Boston, Massachusetts)
"Truth and Beauty" 20″ x 12″ x 8″ 1996	neon, mirrored plastic, motorized revolving base [traditional neon signage technology]	1998: Atelier 564 (Boston, Massachusetts) 2000: Piano Craft Gallery (Boston, Massachusetts) 2008: Museum of Neon Art (Los Angeles, California)
"Still Empty" 31″ x 8″ x 13.5″ 2002	glass, inert gas, welded steel [illuminated plasma technology]	2002: Piano Craft Gallery (Boston, Massachusetts)
"Rocket," "Robot," and "Ray Gun" 25″ x 6″ x 6″, 21″ x 4″ x 4″, 4″ x 19″ x 4″ 2008	flameworked glass, silver plating, inert gas [illuminated plasma technology]	2007[6]: GAS Conference (Pittsburg, Pennsylvania)
"Non-Organic Life" 78″ x 32″ x 18″ 2001	Luminglas^{TM} and welded steel [flat panel illuminated plasma technology]	2002: Piano Craft Gallery (Boston, Massachusetts)
Example of Architectural Application of Luminglas^{TM} 2006	Luminglas^{TM} [flat panel illuminated plasma technology]	2006: Installed in Brussels, Belgium

[6] Only one piece from the three piece set was completed and on display in 2007

1.4. List of (Realized) Commercial Products

Technical Devices

- Neon Backfilling Gauge (1986)
  An absolute pressure gauge that provides direct readings and was designed to replace the traditional liquid filled manometer.

- Tube Filling Combination Gauge (1987)
  A set of two gauges with overlapping ranges designed to cover the complete range of pressure measurements required for neon tube processing.

- Neon Glassworking Torch Package (1984)
  An inexpensive set of basic neon glassworking fires and their gas and air supplies.

- Spelling Neon Transformer (1989)
  A power supply designed to "spell" words (or trace shapes) through neon tubes by lighting the tube from one end to the other and then repeating.

Consumer Products	Approximate Sales to Date
▪ Luminglas™ Display	344,000
A flat gas discharge panel that generates random, kinetic, colored arcs of light.	
▪ Lighted Hourglass	34,000
An hourglass filled with neon gas makes bright kinetic arcs of light move through the sand when rotated.	
▪ Crackle Tube	50,000
A glass tube filled with gas and a fill material featuring kinetic "lightning" effects.	

	Approximate Sales to Date
▪ Flexible Neon	35,000

Six neon tubes connected by flexible, electrically-conductive joints that allow them to bent into different art pieces.

▪ Lightning Alarm Clock	8,000

A novelty alarm clock featuring a large "U"-shaped strobe that rings the glass when lit.

▪ "Bat" and "Star" Plasma Displays	19,000

Novelty display devices that feature stamped metal and phosphor-coated images that are mounted inside a glass bulb and emit filaments of light.

▪ Lighted Beer Mug	68,000

A double-walled glass beer mug with neon gas between the walls that glows when placed on a base that broadcasts an electric field.

1.5. AUTHOR DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

1.6. ACKNOWLEDGEMENTS

I, Wayne Strattman, wish to acknowledge some of the many people who have made the efforts described in this thesis possible. Like any teacher, I have learned much from the many students who constantly brought challenges to me. I am also greatly indebted to Dr. Fred Gardner and Dr. Frank Lahey, my most influential engineering and physics professors, who were always available to provide guidance. My close friend, Nick Reinhardt ("Mr. Science" to me), who always seemed to have the technical answers to anything, and my good friend Rusty Russo, who has consistently provided support in too many ways to count, have also been vital to my accomplishments.

I would also like to thank the engineering staff at Corning Advanced Lighting Product Division, who allowed me to do almost six years of supported neon research; the people at ST Publications, who allowed me to explore so many topics over the eleven years I researched and wrote monthly articles for their magazine, ultimately leading to the publication of the reference book, *Neon Techniques 4th edition;* and my friend, Jen Minear, for her patient reading and assistance in the preparation of my tortured writings. I would like to extend a very special thanks to my close assistants at Strattman Design over the years, Eric Starosielski and Joe Mercurio, whose daily support helped to fill in all the gaps and get things done. I would also like to credit the previous authors and editors of the three earlier editions of *Neon Techniques* who provided the shoulders on which my work could stand.

Finally, I would like to thank the University of Sunderland for enabling me to undertake this study and particularly Professor Peter Davies, whose support and guidance throughout this whole process has made this thesis possible.

2. INTRODUCTION

2.1. OVERVIEW OF SUBMISSION

This thesis is organized around the author's various types of contributions. In the Preface, his publications (*section 1.1*), patents (*section 1.2*), selection of art pieces (*1.3*), and commercial products (*1.4*) are listed. In the Introduction, a summary outline of all of his contributions is provided, including his involvement in developing the community of illuminated glass artists (*2.2*).

Section 3 provides a contextual overview, beginning with the history of the field of Neon (*3.1*). This review helps to highlight the author's contribution of reintroducing some of the original knowledge back into the contemporary field. It is followed by the demand for knowledge present when the author began his investigative and journalistic pursuits (*3.2*). To place the author's artistic approach in context, examples of contemporaneous explorations by other artists in the field are presented next (*3.3*). These are then followed by the contextual status of various illuminated glass technologies within the popular and commercial arenas (*3.4*).

A section on methods is divided into three parts. The first of these discusses the author's methods for conducting original research and provides examples of several specific explorations (*4.1*). The second section gives a brief sense of the author's artistic approach; in particular, how his focus and objectives inspire and contribute to his research (*4.2*). The last section on methods briefly touches on how the author has gone about commercializing the fruits of his research endeavors (*4.3*).

The beginning of section 5 provides an overview of the author's contributions to the knowledge base of the field through his publications (*5.1*). These include a fresh examination of historical knowledge (*5.2*), extensive technological updates (*5.3*) and a compilation of emerging art techniques (*5.4*). The overview of his published works in this section additionally illuminate his contribution of new techniques, including the accelerated filling of glass tubes and filling tubes at low pressure (*5.3.2*), new ways to remove impurities from tubes (*5.3.3*), and the adoption of foreline traps for enhanced vacuum pumping (*5.3.3*). It also provides numerous examples of original research conducted by the author.

The next section (*6*) contains descriptions of the author's original patents. Two of these are for kinetic sculpture effects, one involving lightning arcing between glass beads in a two-dimensional glass "sandwich" (*6.1.*) and the other involving arcs through moving glass beads as they pass through a narrow area within a larger volume (*6.2*). The third patent is for a unique electrode made for gas discharge lamps (*6.3*).

Section 7 contains examples of the author's exhibited artwork. A listing of his exhibitions is provided (*7.1*) along with pictures and descriptions of a selection of the works themselves (*7.2*).

Section 8 gives indication of the author's impact on the commercial sector. It provides examples of the products that have resulted from the commercialization of his research and innovation. The first set of these are original apparatuses for use in creating Neon art (*8.1*). The rest represent consumer products, some of which have a worldwide commercial distribution (*8.2*). Section 8.3 is devoted to the author's consulting work with Corning Glass to develop Neon-related commercial products.

Section 9 summarizes the author's contribution to knowledge and section 10 provides an indication of the author's future direction. Section 11 is a bibliography for all sources referenced in the thesis. The appendix contains the author's published articles, technical reference book and patents.

2.2. OUTLINE OF CONTRIBUTION TO KNOWLEDGE

The original contribution to knowledge made by the author has been verified in a number of ways by peer recognition, industrial sector consultancy, and constituency support. The areas of that contribution have included authorship of primary reference materials; development of new, patented technologies; exhibition of original artworks; continuous production and expert status in the industrial / commercial sector; curation in the field of Illuminated Glass Art; over fourteen years of teaching; and on-going constituency involvement.

2.2.1. AUTHORSHIP

- 100 articles written over 11 years in the industry's oldest and leading trade publication, "Signs of the Times" magazine. (*Section 5 / Appendix 11.1*)

- Wayne Strattman received the American Business Press Editors 1996 Award for Technical Journalism

- Edited the leading Neon technical textbook, *Neon Techniques 4th edition*, published 1997. Textbook continues to sell well today. *(Section 5 / Appendix 11.2)*

    - *Neon Techniques 4th edition* was footnoted in one of the few later publications, *The Neon Engineers Handbook* by Morgan Crook and Jacob Fishman, with the comment, "This book should be read cover to cover, maybe twice!"

2.2.2. PATENTED TECHNOLOGIES

- Three U.S. patents granted for Neon-related techniques which have resulted in a number of consumer, commercial, and industrial products *(Section 6 / Appendix 11.3)*. One of these techniques, Luminglas™, has also provided an entirely new artistic medium *(Sections 7.2.2. and 7.2.6.)*

2.2.3. CREATIVE ART WORKS

- Participated in four individual and eighteen group exhibitions *(Section 7.1.)*

2.2.4. INDUSTRIAL / COMMERICAL SECTOR IMPACT

- Four engineered products resulting in technical Neon processing or lighting products *(Section 8.1.)*

- Eleven lighted products designed and licensed to retail companies for manufacture and world wide distribution *(Section 8.2.)*

- The success of Strattman Design, a company that has operated continuously since 1986 and has been a consistent leader in developing and offering over a hundred lighted products and custom architectural installations in locations around the world (see example of architectural installation in *Section 7.2.7.*)

- Commissioned for two long-term consulting engagements by Corning Glass, Advanced Lighting Products Division to work on two innovative Neon-related commercial products *(Sections 6.3. and 8.3.1.)*

- Hired on two occasions as an "expert witness" in court cases to provide depositions related to Neon technical issues. (*note*: there is no publishable evidence of this due to closed court records)

2.2.5. CURATION

- Started and helped to perpetuate the annual Illuminated Glass Art show at the Glass Art Society conference, beginning with a first show organized at the Boston Conference in 1996. Designed structure during first several shows that has been upheld in annual shows ever since. This showing of illuminated works has struggled without a budget or staff yet continues even today as the only continuous, annual, traveling showing of work representing Neon artists worldwide. (*note*: The Museum of Neon Art, and specifically Kim Koga, the director, has currently taken over the organization of these showings.)

2.2.6. EDUCATION

- Taught courses in Neon Art at the Boston and Cambridge Schools for Adult Education from 1983 through 1997 (100 complete courses)
- Taught a two semester course in Scientific Glassblowing at the Massachusetts Institute of Technology, Lowell Institute School 1986-1989
- Have been a visiting lecturer at several important universities and Festivals including:
  - Rochester Institute of Technology, New York State, USA
  - Penland School of Crafts, North Carolina, USA
  - Salem College (the only accredited flameworking school in the USA)
  - UK Glass Biennial in Stourbridge, 2006 and 2008

2.2.7. CONSTITUENCY INVOLVEMENT

- Elected to the Board of Directors of the Glass Art Society (GAS) to represent Neon and provide solid art business experience (2000-2003)
- Lecture presented at the Pittsburgh GAS conference (2007)
- Member of GAS's long term planning committee (2007 – present)
- Invited to give the Keynote address to the first International Neon Conference in Wiesbaden, Germany in 1991

3. CONTEXTUAL REVIEW

3.1. HISTORICAL REVIEW OF THE FIELD OF NEON

The history of Neon[7] can roughly be divided into three broad eras:

c 1850 – 1910	The early development of the basic technology
c 1900 – 1950	The development of Neon into commercial signage, along with the first uses of neon by artists and designers
c 1970 – present	A period characterized by rapid changes in technology and an influx of glass artists into the field looking to create more elaborate lit blown glass sculptures using gas discharge techniques

3.1.1. INVENTION AND EARLY DEVELOPMENTS (c 1850 – 1910)

Glass art dates back many thousands of years, but the history of Neon is relatively short, reliant as it was on the introduction of a practical form of electricity. As this came about in the 19th century, experimenters of the day soon began discharging electricity through glass tubes that had been partially evacuated[8], resulting in a softly glowing artificial light. This light was brought on by the excitation of electrons of the gas atoms left in the tubes, bringing them to higher states and endowing them with an energy that, upon their subsequent return to lower states, was emitted as visible photons. It should be remembered as a point of context that this was still twenty-three years prior to the introduction of a practical light bulb and all artificial light was still being generated by burning fuel (i.e., gas and oil lamps).

The first such illuminated tubes out of the laboratory are now called Geissler tubes after Heinrich Geissler, a glassblower from Bonn who first manufactured them in

[7] The use of the word Neon here, and throughout the text, refers generically to the whole field of gas discharge lighting including signage and art unless otherwise specified.
[8] Partially evacuated tubes have been brought to low pressure by the removal of air

1856. Geissler and others (notably Plucker, Hittdorf, Crookes, Faraday, and Röntgen) created a wide variety of illuminated blown glass tubes over the next half century. Though first developed as scientific experiments or curiosity items, they can also be seen today to represent a wide variety of complex and beautifully crafted art pieces.

This early work served to seed many modern inventions, such as the x-ray tube, the cathode ray tube (later to become our ubiquitous television), fluorescent lighting and the electron tube. It also led to the neon tube[9]: the technology behind the colourful, glowing, bent glass tubes that formed countless advertising messages throughout the 20th century.

3.1.2. GOLDEN AGE OF NEON SIGNAGE (c 1900 – 1950)

While the first bent tube to light up a bit of text was made by Johann Winkler, a physics professor at Liepzig in 1744, a more modern and practically powered version was first patented by the Frenchman George Claude as an advertising medium in 1910. During the following several decades, gas discharge technology grew quickly, driven primarily by the growing popularity of neon as an advertising medium.

While the use of neon technology in advertising was prevalent from the 1930s onward, only a handful of pioneering artists initially embraced it as an artistic medium. The first recorded use of neon in an art piece was by Zdeněk Pešánek. According to the Center of Modern and Contemporary Art, National Gallery in Prague, "*Zdeněk Pešánek was probably (according to current research) the first artist ever to use neon which he integrated into his sculptures in the 1920s and early 1930s. Pesanek made neon tubes and light bulbs integral sculptural elements, placing them on the same level as other materials and mediums for*

[9] While advertising signage has typically made use of a number of different gasses (including neon, argon, helium, and mercury vapor), the term "neon tube" is used in this text to refer to all such tubes in the form of those designed originally for illuminated signage.

sculpture."[10] The Museum of Neon Art in Los Angeles, in the forward to the publication, "Luminous Beginnings: Neon Art from the 50s, 60s and 70s," credits Sonia Delaunay as the first artist to truly raise critical awareness of neon.[11]

During this period, when the production of the actual neon tubes was still done largely by neon sign shops, there were several major textbooks that were published in the US and UK that provided the core of what was needed to make efficient neon tubes and associated signage. In the US, the first text was *Neon Signs*, by Samuel Miller, president of the Tube Light Engineering Company in New York, along with Donald Fink, associate editor of Electronics, which was published by McGraw-Hill in 1935[12]. In the UK, Blandford Press published *Glassworking for Luminous Tubing*, by Henry Eccles, in 1937 and the more comprehensive book, *Neon Tube Practice*, by W.L. Schallreuter, in 1939. These texts and trade publications, like the American published "Signs of the Times" magazine, provided all that was needed to equip what the original text, *Neon Signs*, called the "practical man".

The basic structure of neon tubes at the time (provided to signmakers and artists alike) adhered fairly consistently to the characteristic look we associate with them today. Because it best suited their primary use as an advertising medium (and unlike their Geissler tube predecessors), gas discharge tubes were consistently crafted as relatively thin, uniformly shaped tubes of saturated colour. This level of sameness stood in contrast to the intricate explorations by highly skilled glassblowers and scientists of the previous century.

Typically, the tubes were hand bent using pre-made (industrially produced or hand drawn) glass tubing either from clear, coloured, or phosphor coated glass. The tubes all had two electrodes, one at each end. The major advancement from George Claude original 1910 patent that helped pave the way for the rapid rise of the technology's popularity was an efficient neon electrode which resisted life shortening "sputtering" (the loss of gas from the tube) by lowering required

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[10] Museum of Neon Art, *Luminous Beginnings: Neon Art from the 50's, 60's, and 70's* (exhibition catalog), June 20-Dec 23, 2001
[11] Ibid.

voltages. This improvement also served to make tube processing (i.e., evacuation, heating, etc.) much easier.

The gases used to fill the tubes progressed over time, from the use of rarefied air in the Geissler era to the early use of nitrogen or carbon dioxide in “Moore tubes” during the early days of commercial neon and finally to the use of chemically inactive “inert gases” like neon, argon, and occasionally helium, beginning around 1920. Later, mercury vapor was introduced which, when excited, emits a high percentage of its light in the ultraviolet range and can thereby activate phosphors. The combination of the efficient Claude electrode and the use of inert gas greatly extended the life and simplified the construction of the neon tube.

Advancements were also made in the powering of neon tubes. Beginning in the early parts of the century, the finished tubes were wired to “core and coil” style (current limiting) transformers made largely of iron and copper. This meant that they could be “plugged in” to the rapidly expanding grid of alternating current beginning to blanket the country rather than rely, as they had in the past, on self-contained static electricity machines and battery powered devices. This enhanced usability made neon into a medium that could be produced in greater quantities more efficiently.

Beginning in the 1930s, the closely held Claude patents and the general secrecy surrounding neon’s production eventually started to relax as Claude’s patents ran out and his former workers began to spin off competing businesses. Neon would go on to capture attention in great commercial areas around the world such as New York’s Times Square, the large casinos of Las Vegas, and the nightspots of Paris.

[12] ISBN 1-55918-034-X

3.1.3. EVOLUTION OF NEW ART FORMS (c 1960 – present)

A number of artists started incorporating neon tubing in their work from the 1930s onwards both for exhibition works and for architectural sited commissions. Lucio Fontana, Joseph Kosuth, Mario Merz, Francois Morellet, Mourizio Nanucci, Bruce Nauman, Stephen Antonakos, Chryssa, Keith Sonnier and others increasingly created a diverse body of work that exploited neon either as a source of bright saturated colour and line or for its unmatched textual abilities. Many artists continue in this tradition today.

Another branch of artists, emerging from the American-based studio glass movement that launched in the 1960s, began to transform the neon tubes themselves, starting with the shape of the glass and moving to numerous other aspects such as different gasses, mixtures of gases, higher pressures, and more elaborate electronics The result was the creation of an entirely new body of lighted sculpture. This period started in the 1970s and continues today with other improved technologies that build upon techniques first pioneered by Geissler.

3.2. DEMAND FOR KNOWLEDGE

The introduction of the Studio Glass Movement in the 1960s created a stream of new artists looking for fresh ways to incorporate a wide array of glassmaking techniques into the art world. By the 1970s, they had begun to experiment in earnest with existing Neon technologies, building as they did new techniques and approaches. Throughout the preceding decades of the 20th century, however, the intersection of the art world and the world of Neon had been limited to the use of existing neon techniques. As such, technical information available to artists was primarily limited to traditional signmaking techniques. As the late 1970s and early 1980s approached, there was a clear resurgence of interest in Neon not only for signmaking but also for the wider possibilities it brought to the world of studio glass art. As an indication of this almost explosive growth in Neon's popularity, in 1980 there was only one trade school in the United States that taught Neon (the Egani School in New York), while just ten years later there were no less than twenty.

As more and more artists began to embrace the possibilities of Neon, an evident need arose for new reference materials. The last publication of a technical sort prior to this period had been the third revision of the book by Samuel G. Miller, *Neon Techniques and Handling*, published in 1977. While providing a thorough understanding of neon signmaking techniques to date, it did not address the engineering principles, technical processes, or artistic possibilities that the rapidly changing field was encountering as it began to investigate such variables as the physical shapes of the glass, the materials that filled it, the ways it was powered, the tools it was built with, and the ways it was handled.

3.3. Contemporaneous Work in the Illuminated Glass Arts

While there have been artists since the 1970s who have continued to use conventional forms of neon, another group of artists has chosen to explore new avenues within the illuminated glass arts. One of these is California-based Larry Albright who, since the late 1960s, has created innovative art pieces using not only neon tubes but also various plasma pieces made with large, blown, borosilicate glass (in particular, plasma spheres and crackle tubes[13]). Another innovator is New York artist, Paul Seide, who has created illuminated, furnace-blown glass sculptures in a variety of shapes and forms as well as devised new technologies, such as remote radio oscillators (that can activate his sculptures without the need for any direct wire connections.) In Boston, Alejandro Sina is yet another artist who has come up with innovative ways to use illuminated glass; in particular, he has perfected the use of single-electrode and no electrode neon tubes for use in large, ethereal, lighted (and often kinetically moving) sculptures.

Much of the artwork produced by these and other illuminated glass artists since the 1970s has focused on the creation of novel aesthetic displays and vibrant decorative structures made with exquisite glass craftsmanship. Thanks to new

[13] Plasma spheres and crackle tubes produce kinetic lightning effects by the electrical excitation of gasses that fill their volume (crackle tubes also incorporate an inert fill material)

technical developments, these artists were finally free of the cumbersome wiring characteristic of neon sculpture in the first half of the 20th century and consequently were able to expand the array of visual forms illuminated glass art could embody. (In general, these innovators have primary explored illumination methods based on the excitation of gas plasmas, such as traditional neon and plasma spheres.)

While there has been no organizing body to keep track of such figures, there were well over a hundred artists actively engaged in crafting illuminated glass sculptures from the 1970s onward in the USA. Their only (semi)formal organization has been within the Glass Art Society, the premier professional glass artists membership organization, and (as of 1981) through consistent showings at the Museum of Neon Art in Los Angeles.

3.4. Application and Awareness of Illuminated Glass Technologies

Until 1995, the use of illuminated glass technologies in architectural installations and on display in commercial venues tended to center around traditional neon signage and conventional lighting techniques. While technologies that produced kinetic effects were available (such as plasma spheres and crackle tubes), their usage required relatively dark surroundings as their output could be dim (as in the case of plasma spheres) or their colour options limited (only red crackle tubes work in full ambient light). Also, the fact that the only forms available were either spherical or tubular limited their applicability to certain venues.

Until the 1980s, popular awareness of plasma technologies was, in general, derived almost solely from exposure to plasma globes and tubes in science museums. In the 1980s, plasma globes also began to gain popularity as consumer novelty products and, within art galleries, as limited edition pieces.

4. METHODS

4.1. ORIGINAL RESEARCH

Impetus for research has come primarily from the following sources:

- As an outgrowth of commissioned research and issues raised therein
- From personal interest in experimenting with all forms of lighting with the intention of adaptation for sculptural purposes
- As inspired by questions raised by students
- In response to questions raised by neon practitioners and sent to “Signs of the Times” magazine
- As impelled by a routine review of current issues and developments in the field of Neon in preparation for writing a monthly column in “Signs of the Times”
- As part of a search for the optimal medium and appropriate form to convey artistic content

Typically, research has involved the individual testing of a number of different parameters in the development of different technologies and art works. This often includes the trial and error engineering and evaluation of dozens of permutations, involving, for example, different gases, pressures, glass shapes, phosphors, electrical frequencies, waveforms, power supply voltages, and other factors relevant to the project at hand. To conduct this research, the author has had at his disposal a number of glass-making and engineering tools in his personal studio, including multiple kilns, a glass lathe, induction heaters, vacuum equipment and gauging, a quadrapole mass spectrometer, and a large assortment of glass fires, among other laboratory equipment related to work with vacuum tubes. Where there has been a lack of equipment, expertise or financial impetus, the collaboration of outside experts in closely associated fields has been secured. In these joint explorations, the author has relied on the professional courtesy and scientific curiosity of practitioners at large companies to conduct tests to answer specific questions using professional equipment and nationally recognized testing standards *(see example in section 5.3.3)*.

The development of a technology that was later patented, Luminglas, evolved from a combination of commissioned work and an interest in expanding the palette of sculptural media. Supported research was being conducted in the early 1990s to develop a flat screen TV. The use of gas discharge technologies led to a fundamental roadblock: a vacuum inside of flat surfaces will cause the sides to implode (the requirement to evenly distribute pressure around a vacuum is the reason traditional plasma displays come in only spherical or tubular form). Experimentation began with a variety of uniformly sized inert spacing materials before finalizing on the use of glass beads. As better funded companies eventually dominated the plasma TV field, the realization occurred that the flat panel discharge might instead fulfill an artistic objective: namely, to find a way to make planes of moving light rather than the strictly linear (and predominantly static) light produced by tubular neon. Through experimentation, it was discovered that by fusing glass beads between glass plates, one could create a stable, flat, hermetically sealed envelope with myriad, random channels through which a gas discharge could pass. Further experimentation with various high frequency power supplies and integral control circuitry allowed the discharge to move, respond to music, or even sync with computer controls.

From here, time was spent looking to improve upon the basic technology. Different phosphors (to expand the colour options), different gases, different shapes of the glass, different chemistries and particle sizes of phosphors, and different means of electrical excitation, including different frequencies, voltages, and waveforms, were all tested before arriving at a final product.

An example of methods employed to address a student question was the development of flexible neon. A student had inquired about whether plastic tubing could be used instead of glass so as to make displays flexible. While plastics and other flexible elastomeric materials outgas at a rate that prohibits their use in neon tubing, the question inspired thought as to how it might be possible to employ techniques used in creating fiber optics to make more flexible glass tubing. In exploration of this idea, glass forming equipment was used to heat and pull hollow glass tubes filled with purified neon until they were thin and fibrous. Since this technique prevented the attachment of electrodes, a technique called capacitive coupling, in which electrical excitation is transmitted through the walls of the glass tubes by radio waves, was utilized.

Work with “Signs of the Times” magazine was equally influential in inspiring original research. The task of writing a monthly column for “Signs of the Times” matched well against a personal desire to understand and evaluate all forms of lighting technology relative to their adaptability to lighted sculpture. Exploration, through both textual research and laboratory experimentation, was made into such technologies as electroluminescence, incandescence, moving arcs, glow discharge technologies, and new physical geometries of plasma technologies.

Other explorations resulted from questions posed by readers of “Signs of the Times” magazine, such as a question raised as to the outgassing rates of materials used to build a vacuum manifold. To fully answer the question, the author conducted the necessary research for developing a practical test that could be duplicated in any shop to assess the suitability of materials from an outgassing standpoint *(see section 5.3.3.)*

Research was also inspired by a desire to find the most expressive medium for a particular artistic sentiment. For example, when the author wished to create a piece that personified strongly felt emotions (see “Art and Disability” in *section 7.2.1.*), he decided to experiment with incandescence, or light generated from a heated filament. It was felt that the tortured sense of “burning” was conveyed through the medium in multiple ways: through cognitive associations (knowledge that incandescence is the result of heat); through visual stimuli (bright orange, fiery filaments); and through tactile perceptions (it gives off heat). Experimentation was done on a number of variables to address a host of issues, including the best material of the wire, how best to bend it, how it needed to be supported, and how to keep the filament from evaporating or sagging at high temperatures. To perform these tests, dozens of samples were made and a large array of variables systematically adjusted (including wire size, composition, applied current, voltage, and gas pressure) until arriving at a set of parameters that worked to successfully convey the message.

4.2. Artistic Inspiration

The artistic objectives of the author have changed somewhat over the course of his twenty-five years in practice. At early stages, the primary objective was to generate and employ new artistic forms of expression. For example, one of the driving forces behind the invention of Luminglas was to be able to use illumination technology not just as something placed on a canvas, but as the canvas itself (see “Untitled with Green Spot” in *section 7.2.2.*).

Over time, the author’s vision as an artist has shifted from creating novel aesthetic forms to finding ways to leverage the unique abilities of illuminated techniques to convey various sentiments and points of view. In other words, the light in his art pieces has gone from being itself the subject of the work to being the voice uniquely capable of expressing the subject. Some of the properties of illumination that have been employed include its natural metaphoric recall of thought and idea, the sense of “magic” conveyed by the light that seems “alive,” its inconsistency and insistence on constant change, the connotations of “electricity”, the evocation of advertising inherent in the neon medium (see “Truth and Beauty” in *section 7.2.3.*), the organic parallels to the underlying algorithms governing the patterns of light (see “Non-Organic Life” in *section 7.2.6.*), and the meandering sense of “flow” the light conveys without any substance actually being transported (see “Still Empty” in *section 7.2.4.*). The author has even employed his undergraduate degree in Psychology in this context, playing with the natural human tendency to fixate on patterns that are inherently random.

4.3. Commercialization

The commercialization of the patented technologies developed came about in two forms: the widespread dissemination of the medium through productization managed by a merchandiser, and the concurrent development of an independent array of customizable products sold through the author's company, Strattman Design. The process of working with a merchandiser involved the licensing of patents, the collaborative design of retail products, and the oversight of the development of a manufacturing process conducted in the Far East. The net result of this collaboration has been the sale of tens of millions of dollars of product over a twelve year period.

The products sold through Strattman Design include an array of basic lighted forms that can be customized in terms of size, shape, and colour. For example, flat panels of Luminglas can be made into the sizes and shapes required for custom bar tops, illuminated logos, design accents, and custom signage. Strattman Design also produces customizable plasma globes and crackle tubes in different sizes, colours, and configurations as well as many dozens of other products utilizing glass, gas, and electronics. Strattman Design remains an industry leader in the development and production of these products.

5. EVIDENCE OF CONTRIBUTION: PUBLICATIONS

5.1. OVERVIEW OF NEW KNOWLEDGE PROVIDED

In the early 1980s, the author, a qualified engineer (with a specialty in vacuum related sciences), as well as a skilled scientific glassblower and Neon artist, was teaching classes in both Scientific Glassblowing at the Massachusetts Institute of Technology and Neon Art at the Boston and Cambridge Schools for Adult Education. In the process of teaching, developing art, and conducting research, the author realized the need for a more extensive compendium of knowledge on modern Neon techniques. In 1987, he began writing monthly articles for the "Signs of the Times" magazine (the oldest and most influential publication in the signmaking industry, pre-dating even neon signmaking technology.) His articles addressed topics of interest to both neon signmakers and artists, including techniques from scientific glassblowing, principles of vacuum science, and new artistic avenues, many of which were based on his own original research.

The articles were greeted with a level of enthusiasm that mandated the creation of a more expansive offering. This author was commissioned to edit the book, *Neon Techniques, the 4th edition*, published in 1997, by adding the knowledge he had accumulated and compiled throughout his ten years of writing professional articles.

Additions to knowledge were made, specifically, in the following areas:

History: Previous texts had given short shrift to developments made prior to the invention of conventional Neon signage technology. Discoveries and techniques dating back to the early Neon pioneers of the 19th century, rich in experimental learning, were incorporated into the new edition.

New Technologies: The advent of a multitude of new options to the structure of the Neon medium required greater explanation in terms of materials, techniques, technology, and supporting theory. In particular, technical advancements had been made in the following areas:

1) Glass
2) Filling With Gas
3) Tube Evacuation
4) Safety
5) Electronic Neon Power Supplies
6) Instrumentation
7) Shipping

Art Techniques: Many new developments in the field pertained more to the aspiring Neon artist than to the traditional signmaker. These were addressed by a separate chapter devoted solely to capturing these techniques.

5.2. ADDITIONS TO KNOWLEDGE: HISTORY

Prior to the 1990s, Neon texts generally began their history of the field with the seminal patent by Georges Claude in the early 20th century, which introduced a practical kind of neon tube intended primarily to serve as an advertising medium. For the more experimental artist, however, this was felt to be an incomplete history, failing to provide information on earlier techniques that might well lend themselves to creative art pieces. In a column written on the historical roots of neon[14] and in the first chapter of *Neon Techniques, 4th edition*, the history of Neon stretching back to the 19th century was introduced, with the development of the Geissler tube and the scientific advances of the times surrounding it, namely, practical forms of electricity, better vacuum equipment, identification and later separation of component gases from the atmosphere, and the development of phosphors. Neon tubes were to become but one form of illuminated blown glass, and not the only form that could be used either commercially (as a product like signage) or in art pieces. The rich history of the Geissler tubes was to reemerge in the 1970s with various artists extending these techniques into new forms.

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[14] "Signs of the Times," 1/94

5.3. ADDITIONS TO KNOWLEDGE: NEW TECHNOLOGIES

5.3.1. GLASS

The key ingredient in all the emerging Neon forms of expression was glass, with all its magical properties. While many elements of commercial neon glasswork had been, to this point, standardized and well documented, such as the formulation of the glass, the basic shapes of the tubes, the available colour palette, the levels of acceptable product strength, and the tools typically used, all of these elements were being subjected to increased levels of exploration and experimentation, amassing input from a wide array of sources, including scientific glassblowing and international practices. New techniques that improved quality, expanded options, and provided other benefits all demanded new documentation.

A new environmental awareness was the driving force behind the first real change in basic glass formulation. In lieu of the conventional lead glass used in the U.S. or the soda lime used in most of Europe (or borosilicate used almost exclusively in France), a new type of barium strontium glass was being put to use. This new alternative was found to be as easy to work with as lead glass but without the associated environmental problems.[15]

While most of the techniques for shaping neon tubes used in the U.S. had been covered in earlier texts, this author discovered (and subsequently trained with) practitioners in Holland and Germany using mitered glass techniques. Instead of the exclusively rounded "U" bends in commercial neon, mitered joints opened the way for sharper "V" shapes to also be employed.[16] This technique had previously been largely unknown in the neon signmaking industry in the U.S.

A new collection of phosphor coatings for glass tubing, based on rare earth chemicals, was also being developed during this time. While the earliest Neon tubes were limited to the colours produced by the various available gases, phosphor coatings were later added to provide a much wider range of colour

[15] *Neon Techniques, 4th Edition*, pg. 36
[16] *Neon Techniques, 4th Edition*, pg. 108. Also, "Signs of the Times" 3/95.

options. Early phosphors were limited in the colours they could produce but heightened interest in developing colour television led to a new breed of phosphors based on rare earth materials that allowed for basic colours of coatings (red, green, and blue) to be combined to form a veritable rainbow of options. This author provided an updated guide to help navigate this new proliferation of colour options which spanned manufacturers.[17]

Typically, neon tubes (at least in the U.S.) were not stress relieved after bending and the entire concept of stress/strain in glass was only marginally acknowledged in the field; nothing had been written specifically addressing this issue even as it was becoming a more critical factor for artists and signmakers alike who were looking to make bigger and more complex pieces. This author provided explanation of the technique borrowed from scientific glassblowing of annealing: the glass in its final form is heated just enough to allow the glass molecules to settle into their most stable configuration, thereby stress relieving the glass. The article detailed the process of using a polariscope (a device for photo optical stress analysis) to check the presence of strain and demonstrated how a glassbender could readily train themselves to use the technique.[18]

In addition to annealing, other techniques that made use of a kiln were also demonstrated. These provided benefits in terms of removing impurities, combining tubes of varying diameters, and accelerating certain processes of tube production.[19] Although used to some degree in Europe, these techniques were, at the time, highly uncommon in the U.S.

5.3.2. FILLING WITH GAS

Around 1980, the commercial neon industry was beginning to change the way in which neon tubes were filled with gas from using predominantly hand-made glass manifolds to cheaper, faster, and more reliable metal manifold systems (or hybrid

[17] "Signs of the Times" 9/92
[18] "Signs of the Times," 11/87
[19] *Neon Techniques, 4th Edition*, pg. 115. Also, "Signs of the Times" 4/95

systems that used some of both materials). The procedures for operating these new manifolds held important differences from their predecessors; in particular, improper operation could be dangerous to the user. Because the manifolds allowed gas to be delivered at higher pressures[20], inattention to the amount of gas being delivered could cause an inadvertent explosion of the neon tube. An additional new danger stemmed from the high voltages involved in neon tube processing; since metal is far more conductive than glass, and since all of the valves are operated by hand, the risk of incurring a potentially lethal electric shock from operating a metal manifold is far greater than from one made of glass.

Using expertise developed from designing and building early instrumentation for equipment tube processing[21], this author discussed in a series of articles[22] the use of whole metal manifold systems and the multiple cautions such systems required. In a separate series of articles[23], a technique for speeding up the filling process was introduced, in which the tubes are thoroughly evacuated but filled with gas before they cooled to room temperature. The article showed that by using the relationship between pressure and temperature spelled out by the ideal gas laws, one could calculate the higher pressure at which a hot tube should be filled such that when the temperature of the tube dropped, the pressure would also drop, correspondingly, to the required final level.

Another article[24] described a new gas-filling technique borne out of this author's work with using large diameter Pyrex pipe as neon tubes. Termed "flow through pumping," it provides a way to evacuate and fill tubes and is uniquely suited for processing large, oven heated tubes with particularly sensitive filling requirements. By having two openings on the tube, one on each end, the fill gas can be introduced into the far end while being evacuated on the other end. This serves to eliminate the dramatic slowdown that otherwise occurs in a one-opening system where, at points of low pressure, the gas loses its viscosity, molecules become hard to direct, and pumping speeds drop off logarithmically.

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[20] With metal manifolds, gas is delivered in high pressure metal cylinders instead of low pressure glass ones
[21] See Sections 3.5.1. and 3.5.2.
[22] "Signs of the Times," 12/92 and 9/88
[23] "Signs of the Times," 3/88 and 1/98

5.3.3. TUBE EVACUATION

Before a neon tube can be filled with gas, it must first be thoroughly evacuated of air and impurities. A number of new technologies related to the vacuum sciences had been emerging throughout the 20th century, though many of them had not yet made their way into the field of Neon. Through research, this author contributed information and improvements to the process of tube evacuation, including the impacts of system shape and choice of construction materials on pumping efficiency; the required levels of purity and the changing dynamics of the evacuation process at different pressures ("pressure regimes"); practical information on the comparative advantages of different system materials; new techniques for removing contaminating residues and other impurities; and evaluation of existing and new technologies for effective vacuum pumping. These techniques and technologies were consistently addressed with an eye toward regarding the vacuum system as a whole rather than as constructed of independent, isolated elements.

Several "Signs of the Times" articles were written by this author to address the impact of different design decisions on the efficiency of tube evacuation. The first of these demonstrated the considerable impact of the physical geometry of the vacuum manifold on the efficiency of evacuation by showing sample calculations of vacuum system conductance based on the lengths and diameters of the tubes used in the system[25]. It was shown, for example, that installing larger, more efficient vacuum pumps often served no purpose if the manifold geometry itself was limiting the amount of pumping that could be done.

Another article addressed how construction materials (such as rubber vs. glass connections) impact evacuation due to the rate at which they "outgas" (or naturally emit molecules in a vacuum environment) [26]. Again, the "system" concept showed that a poor choice of materials, such as those with high vapor pressures, could prevent even the best pumping system from ever achieving a

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[24] "Signs of the Times," 7/95
[25] "Signs of the Times," 3/88
[26] "Signs of the Times," 3/92

good vacuum level. The article even included a test the author had developed that any small Neon shop could employ to determine the relative outgassing rates of various shop materials.

The same article went on to show the results garnered from controlled testing of the conventionally accepted (and much published) ultimate vacuum level required prior to backfilling with inert gas. It was shown that levels several orders of magnitude higher than published rates were actually sufficient (if less than desirable). Another article addressed the dynamics of different pressure regimes; in particular, it discussed the kinds of challenges that can occur at lower pressures and provided a technical description of molecular flow, a key concept in dealing with vacuum systems[27].

In yet another article[28], the results of tests run to compare the impact of different commercially-available vacuum pump oils were presented. In particular, this author wanted to see if more expensive oils (with lower published outgassing rates) would make a difference in evacuating tubes more effectively. The findings indicated that other factors, such as the condition and temperature of the pump, were, in fact, more significant differentiators. The textbook that was later developed also included charts of the vapor pressure (the pressure at which a material will begin to evaporate at a given temperature) of common materials used in the shop, as well as one listing water vapor pressure versus temperature (since water vapor is the most difficult component to remove from most gas discharge tubes).[29]

One article was dedicated to the cleaning of tubes contaminated with mercury oxides impurities.[30] The technique developed by this author was an extension of work that had been presented in early textbooks.[31] While the earlier technique suggested filling a contaminated tube with natural gas (so that, when heated, the hydrogen in the gas would combine with the mercury oxides to create an easier-

[27] "Signs of the Times," 6/94
[28] "Signs of the Times," 6/97
[29] *Neon Techniques, 4th Edition*, pg. 119
[30] "Signs of the Times," 3/89
[31] see *Neon Signs*, Miller and Fink

to-evacuate elemental mercury), the new technique demonstrate the enhanced efficiency of simply using pure hydrogen gas.

One method routinely used to purify a tube is, during the evacuation process, to heat the tube and vaporize remaining impurities by "bombarding" them with a high voltage electric discharge. There are a couple of disadvantages to this process, particularly for the artist interested in novel tube geometries: it requires two electrodes (which limits the design options of the tube) and only a small number of tubes can be processed at one time. This author adapted and refined a technique that had been in use in Europe that utilized a kiln for heating the glass and an induction coil for heating a *single* electrode. In this manner, multiple tubes could be purified at once.[32]

Perhaps the most controversial articles written by this author concerned the evaluation of the "diffusion" pump, a major piece of vacuum equipment used in the typical Neon shop and ubiquitous in the industry. Extensive testing by this author clearly demonstrated that the unit had a near-total lack of measurable performance.[33] Testing that led to this conclusion was verified by the outside laboratory of Varian Vacuum Products and supervised by Mars Hablanian, a leading expert and author in the vacuum equipment field.

Foreline traps represented a new technology that was introduced as a useful addition to the neon pumping manifold.[34] "Backstreaming," or vapor from mechanical vacuum oil flowing back into the neon tubes during processing, was shown to be a harmful process due to its high vapor pressure (i.e., the oil would vaporize at higher pressures than required for successful evacuation[35].) The foreline trap, adopted by the author from other vacuum related industries, was shown through author testing to be of significant value in controlling backstreaming. A similar article was written on the importance of regular vacuum pump service and the impact periodic rebuilding has on the ultimate vacuum level

32 "Signs of the Times," 12/95
33 "Signs of the Times," 2/96 and 5/96. The device tested was found to have some vapor "trapping" ability but failed as an effective vacuum "pump"
34 "Signs of the Times," 8/96
35 "Signs of the Times," 3/92

achievable in the vacuum manifold[36].

Several other more advanced pieces of vacuum equipment were also starting to be used in the industry and were addressed in the textbook. These included the turbomolecular pump for high speed evacuation[37] and the capacitance manometer[38] (an electronic vacuum gauge being increasingly used in larger neon production companies.)

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[36] "Signs of the Times," 9/96
[37] *Neon Techniques, 4th Edition*, pg. 132
[38] *Neon Techniques, 4th Edition*, pg. 136

5.3.4. SAFETY

As a greater awareness began to build about the environmental implications of certain materials used in the industry, safety concerns began to grow. Across several articles,[39] mercury safety and air quality concerns were addressed as well as means for upgrading air quality in the shop. Fuel gas danger was also highlighted. Information was presented from the fire fighting industry on the potentially extreme danger of storing fuel gases indoors.[40] The impact of electromagnetic fields on health, a controversial subject due to still limited information in the field, was also examined.[41]

5.3.5. ELECTRONIC POWER SUPPLIES

Perhaps the biggest change in the Neon industry since 1970 has been the introduction of solid state power supplies in place of conventional transformers. Whereas transformers were big, bulky pieces of equipment that were required to accompanies all pieces of neon sculpture, power supplies were small and light and easily transportable. They also provided the ability to incorporate safety circuitry (i.e., short circuit protection) and provided for a whole range of new "animation" effects (e.g., flashing, dimming, etc.)

While the differences between the old and new technologies appear on the surface to be minor, the operating principles are significantly different and their implications important for neon practitioners. (For example, solid state power supplies employ a conversion to DC power at one point in the process, opening a window for various forms of DC current modulation.) These differences, along with the basic principles governing the operation of an electronic power supply, were captured in the textbook.[42]

One of the differences in performance of the new power supplies was their

[39] "Signs of the Times," 12/88, 7/90, and 5/93
[40] "Sign of the Times," 2/89
[41] "Sign of the Times," 7/93

tendency to "spike," or dramatically raise their output voltage at a certain point in their alternating current waveform. After extensive testing, an article was published that demonstrated the impact of these spiky waveforms on sputtering gas cleanup and tube life[43]. It was shown that spiky waveforms increase sputtering (i.e., they can lead to premature lowering of gas pressure in the tube) which tends to drastically shorten the life of the neon tube.

One of the new effects made possible by the advent of electronic power supplies was that of "spelling," or lighting up a neon tube so the endpoint of the light moves slowly though the tube, "spelling" out letters as it goes. In 1988, this author worked to design, build and sell the first commercially available high frequency electronic power supply that could "spell" *(see product in section 8.1.4.)*

5.3.6. INSTRUMENTATION

As the number of new instruments available to the Neon industry grew, a better understanding of the reliability and proper usage of these instruments became of increasing importance. Reports had even started to circulate of errors in the neon sign industry arising from a poor understanding of instrumentation. To address these new issues, the author conducted a series of tests on instrument calibration, the results of which were developed into an article.[44] These tests clearly showed that instrumentation can often be misleading and that an imperfect understanding of how an instrument works could easily lead to serious neon tube processing errors.

The tests demonstrated both the proper degree of accuracy that should be assigned to instrument readings and the necessity of understanding their suited purposes. When different instruments (all supposedly calibrated) were applied to the same situation, they were shown to produce a wide disparity of readings, illuminating

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[42] *Neon Techniques, 4th Edition*, pg. 53-58
[43] "Signs of the Times," 8/97
[44] "Signs of the Times," 5/95

the general level of accuracy any one of them should be taken to provide. Another set of tests showed how instruments calibrated in one set of circumstances became unreliable when applied to situations involving other circumstances. For example, an electronic vacuum gauge calibrated in air was shown to produce erroneous readings when used to measure another type of gas, such as neon.

This article advised that the proper use of instruments was as a secondary source of information about a physical phenomenon, and provided evidence that prudence was especially warranted when readings contradicted unaided observances. This was felt to be of particular importance to small shops that would be unlikely to have a standard against which instruments could be occasionally calibrated.

5.3.7. SHIPPING

With the growth in popularity of Neon in the latter decades of the 20th century, large producers were able to attract customers from wider geographies. As a result, the cost of shipping fragile glass signs became a significant issue. In one article, the basic physics of packaging neon glass were discussed. Based on techniques for strengthening the glass and a mathematical analysis of loads encountered by the sign during shipment, a comprehensive list of design solutions for handling these issues was presented[45].

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[45] "Signs of the Times," 8/95

5.4. Additions to Knowledge: Art Techniques

Over the course of last decades of the 20th century, many new techniques were introduced for the first time in Signs of the Times magazine that were intended primarily for the neon/light artist (and had little application to neon sign making). These included techniques specific to creating sculptural objects, techniques to tackle issues raised when traditional neon formats were modified, and techniques to create new "look and feel" options within the medium.

Perhaps the first article aimed exclusively at artists concerned the processing of single ended neon tubes, a format used predominantly by neon sculptors[46]. Another article addressed a technical problem encountered by an artist attempting to light closely spaced, parallel, single ended tubes[47]. To provide more artistic options, this author conducted tests to measure light output along the length of a single ended tube excited to high frequency and related it to the theory of how the tube operated differently than older conventional neon tubes[48]. Additionally, an article was written to show many different ways to recycle "scrap" neon glass into art pieces and jewelry[49].

In *Neon Techniques*[50], an entire chapter was devoted to art-related techniques, including single ended tubes, spelling neon, borosilicate neon made with scientific glassblowing techniques (in sizes of glass not used for signage), off-hand blown glass neon made by glassblowers out of a furnace and then lit up, plate glass neon made from window glass and kiln fusing techniques, the author's patented Luminglas™, crackle tubes, plasma displays, lightning displays and other gas mixtures and electronic effects not normally used in signage. All of these techniques had been researched, to varying extents, in the author's studio.

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[46] "Signs of the Times," 4/90
[47] "Signs of the Times," 12/90
[48] "Signs of the Times," 4/92
[49] "Signs of the Times," 11/93
[50] *Neon Techniques, 4th Edition*, Chapter 16

6. EVIDENCE OF CONTRIBUTION: PATENTS (OVERVIEW)

6.1. LUMINOUS DISPLAY DEVICE ("LUMINGLAS^{TM}")

US Patent No. 5,383,295 resulted in part from plasma TV research the author had done in the late 1980s. The product was developed from a desire to make non linear lighting displays free of the tubular look of more conventional forms of neon lighting. It was given the trade name of Luminglas^{TM}.

Luminglas is made up of a heat lamination of three glass plates. The front and back form the envelope and the middle one has all but an outer ring of glass removed and the missing space replaced with uniformly sized glass beads, usually coated with a phosphor. This lamination is heated in a kiln over a carefully controlled period of time until the outer edges of the device fuse together forming a hermetic seal. As the device cools to near the annealing point of the glass an electrode assembly is sealed over a premade hole in the back of the panel with a low melting point solder glass forming a hermetic seal. The electrode has an exhaust tubulation, through which, when the panel cools to room temperature, the air can be removed and replaced with xenon gas and subsequently sealed.

Ordinarily flat glass plates like this could not be put under vacuum since they would implode. The glass beads act to prevent this implosion and also due to their geometry provide some empty space between them even after fusing. This space provides for a myriad of channels that due to the phosphor coating can be lit up with a high frequency, high voltage gas discharge and provide multicoloured arcs of light. Varying the pressure of the fill gas within the device results in either a sharply focused and bright arc, or a fan like plane of light. These arcs can also be made to move by electrically resetting the power supply (turning it on and off rapidly) causing new random patterns of light to form. Controls can also be easily built in to cause music, sound or digital signal to alter the patterns of light. Some of the features designed into this invention are:

- Kinetic motion

- Interactivity with touch on the surface. The hand acts as an electrical ground drawing the arc in its direction.
- Very long life: Life testing has shown this device to have a longer life than any known lighting device.
- Phosphor activation without mercury. Typically neon or fluorescent lights use environmentally unfriendly mercury to provide ultraviolet light in the gas discharge which activates the phosphor. This device uses inert gases only with the phosphors to provide colours but with no hazardous chemicals of any kind.
- The unit is very energy efficient. Typically the largest display many square feet in area uses less than 12 watts.
- Luminglas can be cut into virtually any two dimensional shape by computer controlled waterjet cutting of the component parts prior to lamination.
- Luminglas can be formed by bending the hot lamination of plates into a wide variety of 3 dimensional shapes.

Products made from Luminglas have spawned a multimillion dollar industry which continues production today. Custom Luminglas displays have been used architecturally in movie and TV sets, museums, nightclubs, and many other applications.

6.2. Apparatus for Providing a Kinetic Lightning Effect

US Patent No: 6,924,598 describes an apparatus for providing a kinetic lighting device using a movable fill of glass or ceramic material inside a relatively large volume gas discharge tube. Normally the gas lit by a gas discharge in a large glass tube is diffuse since the fairly low current fills the entire volume. This device, in one incarnation, uses a quantity of glass beads to force the discharge to go through the spaces between them, thereby concentrating the light to form very bright kinetic arcs.

The immediate product that was developed and sold from this patent was a lighted hour glass filled with neon gas. Rotation causes the orange/red glow to be forced through the beads as they passed through the constriction making a red lightning like appearance.

6.3. ELECTRODE ASSEMBLY AND DISCHARGE LAMP (WITH CORNING)

US Patent No 6,362,568 was worked on with two Corning engineers (listed on the patent) and consists of an invention relating to a unique electrode made for flat gas discharge lamps. The invention combined three things that had never been combined before: 1.) the use of a technique for hermetically mating glass and metal of different coefficients of expansion (i.e., a "housekeeper seal"), 2.) treatment of the sealing metal tube to allow it to also serve as an active electron emitter, and 3.) formation of the end of the tube such that it could be crimped (or cold welded) to form a second hermetic seal. Combining these three essential features in one small, simple assembly greatly reduced the costs of mass production.

Further work undertaken for Corning involved a multiyear collaboration, from 1997 to 2000, and resulted in an automotive lighting product.

A major breakthrough in lighting was made using "sheet coined" glass envelopes (a Corning Inc. process of producing a molten sheet of glass that can be vacuum formed by molds into complex shapes as well as molded into hollow envelopes of glass).

Using this glass technology, a neon filled gas discharge lamp was designed that could be formed at high speed. The resulting lamp, coupled with proprietary optics, provided a focused beam of red light suitable for automobile lighting. It was hoped that this lamp would be both low in cost and power and would last the life of the automobile.

7. Evidence of Contribution: Exhibited Artwork

7.1. Listing of Art Exhibitions

2007 Glass Art Society. "Illuminated Glass," Pittsburgh, Pennsylvania

2004 Glass Art Society. "Illuminated Glass," New Orleans, Louisiana

2003 Glass Art Society. Illuminated Glass group exhibition, Seattle, Washington

2002 Piano Craft Gallery. Solo sculpture show, Boston, Massachusetts

2001 Piano Craft Gallery. Solo sculpture show, Boston, Massachusetts

2001 Glass Art Society. Group show, Corning, New York

2000 "Traveling Light III" Brooklyn, New York

2000 Museum of Neon Art. "Group Plasma Show," Los Angeles, California

1999 Museum of Neon Art. "Plasma" exhibition, Los Angeles, California

1999 "Traveling Light 2" Tampa, Florida

1999 "Traveling Light" Hsinchu City, Taiwan

1998 Glass Art Society. "Illuminated Glass Art," Seto, Japan

1998 Atelier 564. Solo Neon show, Newton, Massachusetts

1997 Glass Art Society. Group show, Tucson, Arizona

1996 Glass Art Society. First Annual Illuminated Show, Massachusetts College of Art, Arnheim Gallery[51], Boston, Massachusetts

1995 Chase Gallery. Group show, Boston, Massachusetts

1993 Harvard University Carpenter Center. Environmental installation with Stephen Antonakos, Cambridge, Massachusetts

1991 Divine Decadence. Group show, Boston, Massachusetts

1991 Atelier 564. Solo show, Newton, Massachusetts

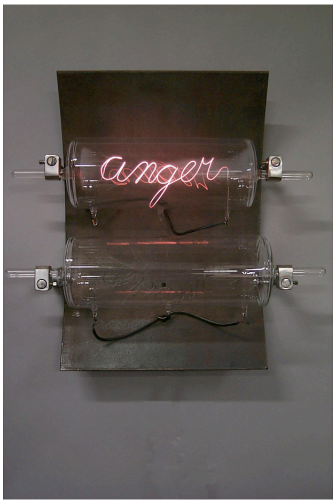
[51] Curated by author

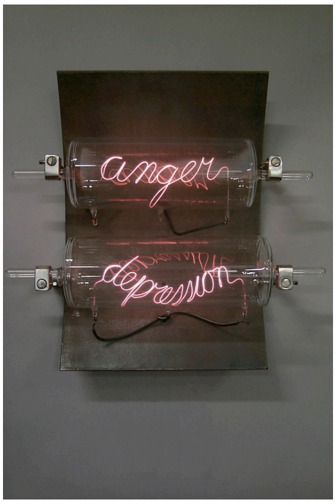
1989, 1990	Boston’s First Night. Large neon light sculptures, Boston, Massachusetts
1988, 1989, 1990	Boston Center for the Arts. Lighting designs and sculpture for Boston’s Annual Artists Ball, Boston, Massachusetts

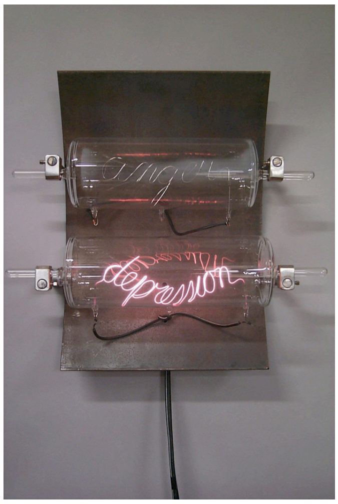
7.2. Selection of Exhibition Works

7.2.1. "ART AND DISABILITY" (2001)

Media: flame worked borosilicate glass, nichrome wire, tungsten to borosilicate glass to metal seals, inert gas, low voltage power supply







'Art and Disability' (height 18" width 18" depth 5") concerns the acknowledged fact that the first step out of depression is often the experience, and indeed the empowerment, of anger. This piece speaks of an artist trapped by a continual cycle of emotions relating to his disability and his struggle to make art while concurrently struggling with his recycling emotions.

A static photograph of 'Art and Disability' or even a set of time lapsed photographs cannot transmit the entire experience of this piece. The incandescent bulbs with the two words "Depression" and "Anger" never light simultaneously. Each word slowly fades up as the other slowly fades down. This continues to recycle in a quiet, inexorable fashion.

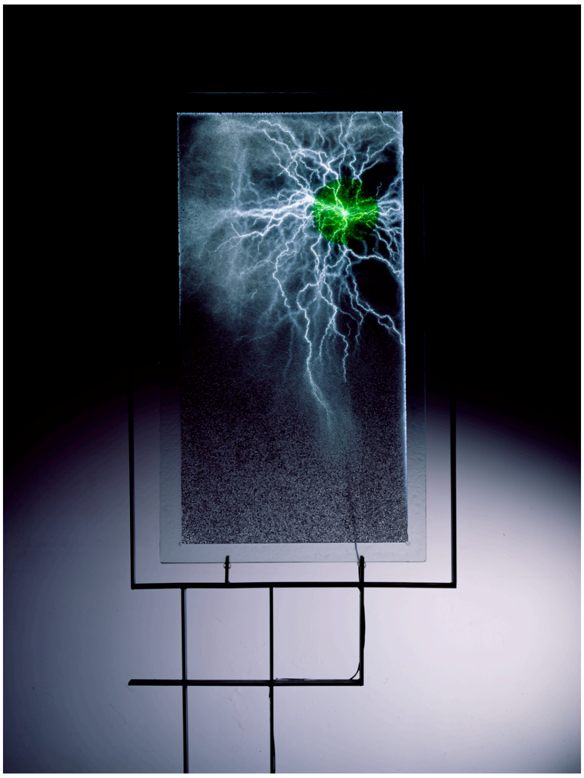
Another important sensory element which cannot be transmitted in a photograph is the heat the piece emits. As with any incandescent light, and particularly in this piece, the large, relatively thick filaments put out a significant amount of glaring heat to the viewer as each word and indeed each emotion starts to burn brighter.

By analogy, the dialectic of the two emotions reaches another plane if one considers an artist as one with a social disability. He focuses his awareness and anger into creation of an art piece and then when done recycling back to the helplessness of depression. The artistic temperament often involves a creative tension that may lead to great expression but sometimes at a price, that of peace of mind.

"Art and Disability" was exhibited at the Glass Art Society Corning Conference in Corning, New York, USA in 2001 and at The Society of Arts and Crafts in Boston, Massachusetts, USA in 2002.

7.2.2. "UNTITLED WITH GREEN SPOT" (2001)

Medium: Luminglas^{TM} (fused glass, phosphors,
inert gas, electronic power supply, steel)



'Untitled with Green Spot' (height 67" width 24" depth 18") is shown as a "painting" which continues to reform itself, with the green spot acting as its "center." To further the allusion of an abstract "painting," the work is mounted on a stand reminiscent of one of the American Abstract "Composition" paintings of Piet Mondrian.

This is a kinetic piece with the light coming from within the fused glass panel and is actually a fused glass gas discharge device that provides moving arcs or fans of colour. The piece responds to touch or to voice reforming the patterns of light and colour, but always anchored or emanating from the center green, like the anchor of green earth.

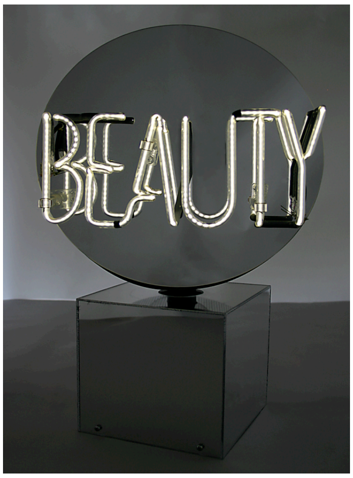
The portion of the title, “Untitled...”, was chosen because it could not have a static title because the piece is never static. It continually remakes itself responding to the environment around it. A number of the works in this series are informed by the nature of the contemporary viewer, largely bored by the static, needing to interact with everything, continually in need of novelty. It becomes an artwork reflective of its time.

“Untitled with Green Spot” was exhibited at Atelier 564, Boston, Massachusetts, USA in 2001 and at The Piano Craft Gallery, Boston, Massachusetts, USA, 2002. It was acquired by Technorama, Winterthur, Switzerland in 2008.

7.2.3. "TRUTH AND BEAUTY" (1996)

Media: neon, mirrored plastic, motorized revolving
base, electronic neon power supply

20" Height x 12" Width x 8" Depth



This 'Advertising Piece' might be described as an advertisement for the art of the current age. As the piece rotates, alternate sides advertise in ethereal pearlescent white neon "Truth" and "Beauty." The entire structure is colourless, made predominantly of mirror reflecting the viewer and his surroundings.

To the artist, the concept of art reflecting that which leads to truth or beauty seems somewhat archaic today. This piece reflects the common sentiment that contemporary art has become a highly specialized form of business, is removed from common experience, and is often caught up in rapidly changing "fashion" trends. Much contemporary art leaves viewers with a general confusion as to which "ism" is currently being embraced. The astronomical sums paid for certain works of art, or to particular artists while others live in poverty, along with the near unintelligibility of some art writings, leave many people feeling a sense of alienation from the expectation that art will lead to the deeper meanings of the human experience.

This piece is about the advertisement of intrinsic content that, when viewed head on, is empty, but also reflects the viewer as complicit in supporting the lack of meaningfulness.

"Truth and Beauty" has shown been at Atelier 564 in 1998 and at The Piano Craft Galleries in 2002, both located in Boston, Massachusetts, USA. It has also been shown at the Museum of Neon Art, Los Angeles, California, in 2008.

7.2.4. "STILL EMPTY" (1996)

Media: glass, inert gas, electronic power supply,
welded steel

31" Height x 8" Width x 13.5" Depth

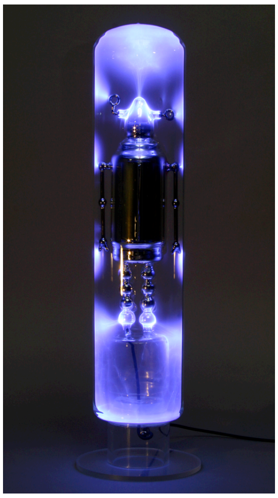
"Still Empty" (31" height 8" width 13.5" depth) reflects a source pouring into a cup that never fills. The high pressure Krypton arc that forms inside the glass tube formed as a glass spigot and a liquid stream pouring into a glass cup appears to be flowing (which in the sense of electrons moving toward an electrode it is doing).

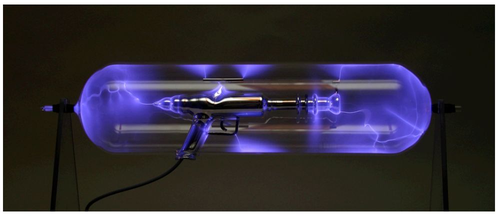
The piece relates to a feeling of working toward a goal that never seems closer and "fulfillment" never occurs. This is the case of the artist working, making work after work, yet the sense of fulfillment never arrives; the tension to create anew just gets reset after each piece is completed.

“Still Empty” has been shown at the Glass Art Society Conference, Corning, New York, USA, 2001 and at The Piano Craft Gallery, Boston, Massachusetts, USA, 2002. It was acquired by Technorama, Winterthur, Switzerland in 2008.

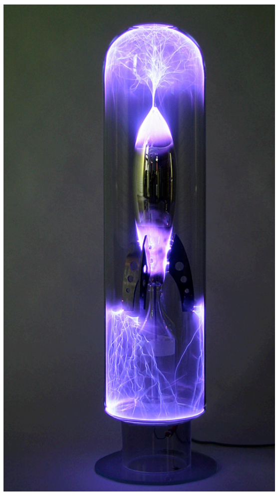
7.2.5. “ROCKET,” “ROBOT,” AND “RAY GUN” (2008)

Media: flameworked glass, silver plating, inert gas
and electronic power supplies





“...Not while I have my Blaster!”
4” x 19” x 4”



“Crush, Kill, Destroy!”
21” x 4” x 4”

“Rogers here, I read you 5 by 5”
25” x 6” x 6”

These three pieces are shown together as a small closed series of works that represent images reminiscent of the 1940s: the revolutionary age of the glass vacuum tube, the birth of television, and perhaps most importantly, the explosion of advertising informing much of the practical knowledge commonly available. Heroes and their tools were manifested to fill time between advertisements rather than in previous times to inspire or to teach ennobling concepts.

The medium of these pieces, glass vacuum tubes filled with a kinetic blue plasma discharge, was chosen for their association with vacuum tubes, the relatively high tech but mysterious technology of the 1940s. They appear like something out of science fiction and signify the way in which the dawn of science was seen as the way of moving forward in understanding the universe. There is a sense of irony in that science-based toys increased in numbers in inverse proportion to the number of people understanding how they worked. Replacing understanding came the works of science fiction and the illusion that in the future we would all become the masters of science and able to solve the world’s problems.

"Rogers here, I read you 5 by 5" (the first of the set completed) was shown at the Pittsburgh, Pennsylvania, USA Glass Art Conference in 2007.

7.2.6. "NON-ORGANIC LIFE" (2001)

Media: Luminglas^{TM} lighting with electronic power supplies and welded steel structure

Height 78" Width 32" Depth 18"

The mathematical description of how a Luminglas^{TM} produces patterns of light is essentially the same as that used to describe other natural phenomenon that appear apparently random but tending toward what is called a natural attractor. At the time this piece was created these ideas of non integer dimensional space, chaotic systems, and fractal geometry were seen as a new approach to understanding natural systems, at least from a mathematical standpoint.

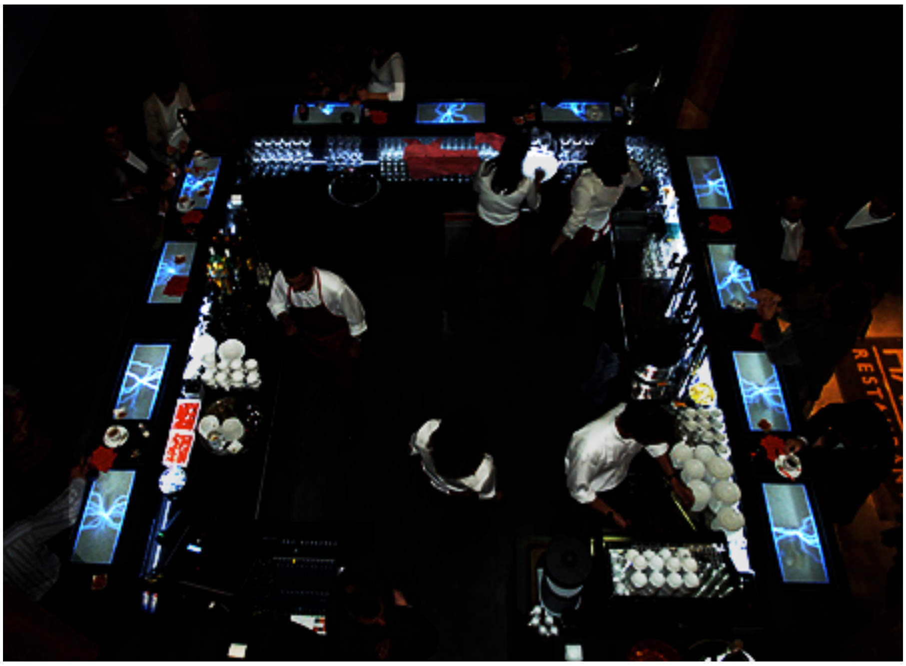
"Non-organic Life" consists of a welded steel "tree" with lighted "leaves" that respond in their light patterns to the environment. It uses energy ultimately from the sun (provided through the electric grid) to continue to shine and generally mimic, in a new fashion, a new form of "life" based on similar mathematical principles.

This autobiographical work was also a personal statement. As I had nothing that lived in the conventional sense in my life, no pets, plants, or significant relationships, I created Light and my own form of life.

"Non-Organic Life" was shown at the Piano Craft Gallery, Boston, Massachusetts, USA, 2002 and has since been sold to a private collector.

7.2.7. EXAMPLE OF ARCHITECTURAL APPLICATION OF LUMINGLAS™

2006 Luminglas™ Bar in Brussels



This patented process of producing a plane of kinetic light trade named Luminglas™ was initially developed as an art medium but quickly it became a medium for architectural and other applications. This is an example of a commission using the fused glass lamination as a bar top in a restaurant. Numerous other applications have used Luminglas for its flexible abilities to provide a visually interesting kinetic lighting display in public places.

8. EVIDENCE OF CONTRIBUTION: COMMERCIAL SECTOR IMPACT

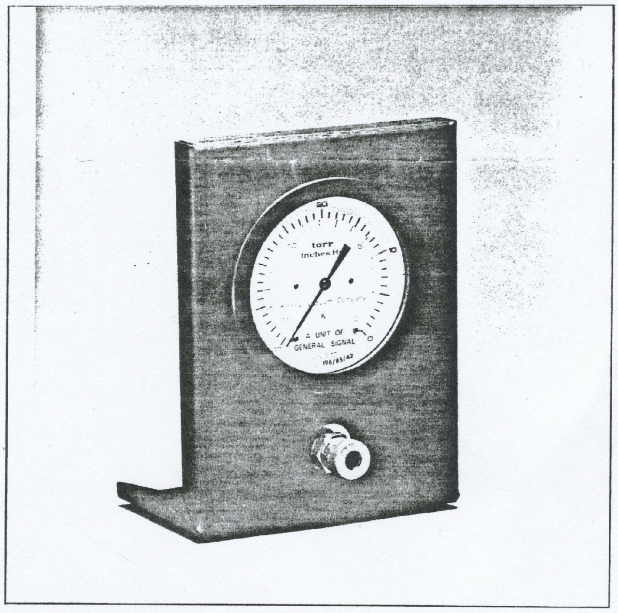
8.1. (REALIZED) COMMERCIAL DEVICES FOR THE CREATION OF NEON SCULPTURE

8.1.1. NEON BACKFILLING GAUGE (1986)

PRICE LIST

Strattman Design

NEON BACKFILLING GAUGE
NO. B-100



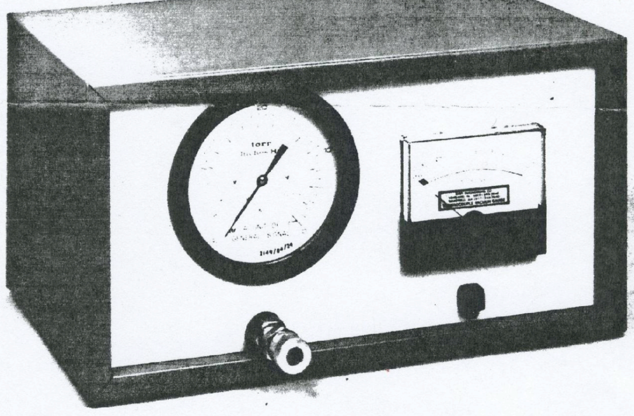
- PRESSURE RANGE: Vacuum → 40 torr (mm mercury)
- OUTLET CONNECTION: Finger-tight assembly with ultra-torr fitting. Helium leak tested at 4.14x10' atm cc/sec.
- FEATURES: 1/8" NPT fitting on back for electronic thermocouple. Vacuum gauge tube.

PRICE: 395.00

F.O.B.: BOSTON, MASS.

<u>8.1.2. TUBE FILLING COMBINATION GAUGE (1987)</u>

NEW TUBE FILLING COMBINATION GAUGE™ . . .



Measures both VACUUM and BACKFILLING PRESSURES

Measures Vacuum down to the low micron range (1 × 10⁻³ Torr)

Measures Backfilling pressure up to 40mmHg (Torr)

No Maintenance Required

- ☐ No Stopcocks to be greased
- ☐ No Gauge oil
- ☐ No breakage as with glass gauges
- ☐ T.C. Vacuum Gauge is battery powered; therefore, no line cords
- ☐ Backfilling absolute pressure gauge accuracy ± 2%
- ☐ No contamination as with oil gauges
- ☐ No correction required for different gasses
- ☐ Connection to glass or metal manifold made in seconds by a simple leakfree ULTRATORR® fitting

Other Uses

- ☐ Test mechanical Vacuum Pump efficiency and blank off pressure
- ☐ Leak check tubes and manifolds
- ☐ Provide repeatable tube pumping and filling

For more information contact:
Strattman Design
791 Tremont Street
Suite E 517
Boston, MA 02118
(617) 266-8821

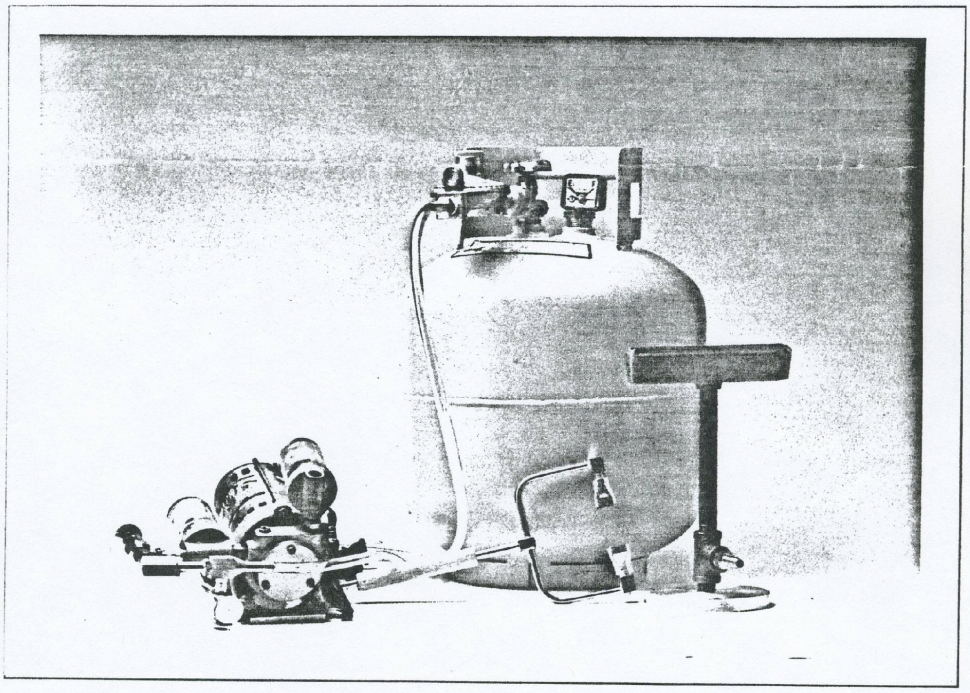
SD

8.1.3. NEON GLASSWORKING TORCH PACKAGE (1984)

PRICE LIST

Strattman Design

NEON GLASSWORKING
TORCH PACKAGE



PRICE: 345.00

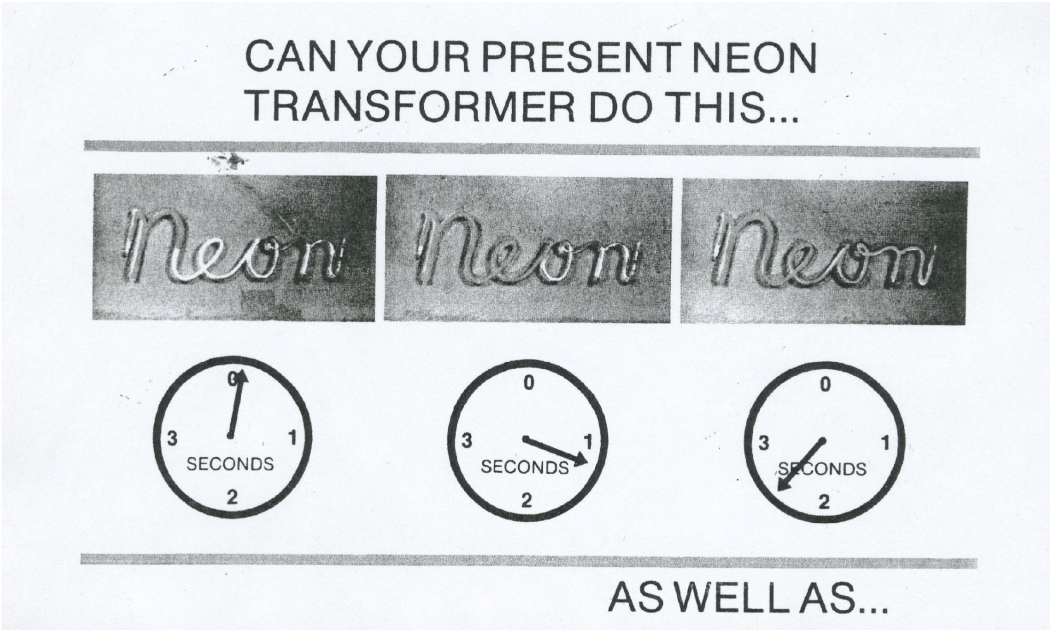
INCLUDES:

- HIGH VOLUME AIR COMPRESSOR WITH FILTERS
- VALVES AND VENTURI MIXER
- CROSS-FIRE HAND TORCH
- 6" RIBBON BURNER
- PROPANE TANK
- PROPANE REGULATOR AND ALL HOSES
- OPERATES ON 110 VOLTS

Perfect for the beginner glassworker or neon artist. Learn at home to make splices, bends, long curves, lettering, etc.

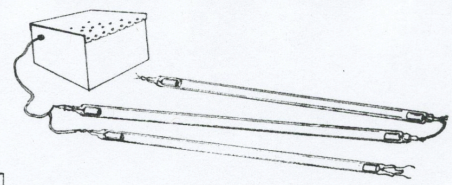
F.O.B.: BOSTON, MASS

8.1.4. SPELLING TRANSFORMER

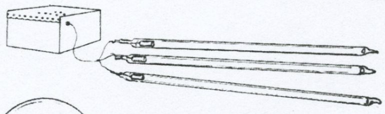


(see next page)

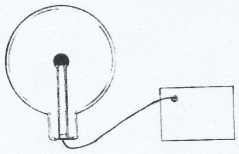
...Light Tubes wired in parallel
...or series or a combination of either



...Light Tubes without a pair of
...Electrodes



...Energize Plasma Globes



or

Offer Thermal Protection as well as optional Audio or Computer Input Control

A revolution in neon lighting. This power supply will free the designer to incorporate movement or 'spelling' without the need of switchers, tubes wired to one end only, optional audio or computer control and more - all at an affordable price.

Order a PTW1 Neon Tracer now at our introductory price of $79.00*

* Regular single piece price $94.00, special introductory price good until 1/15/88.

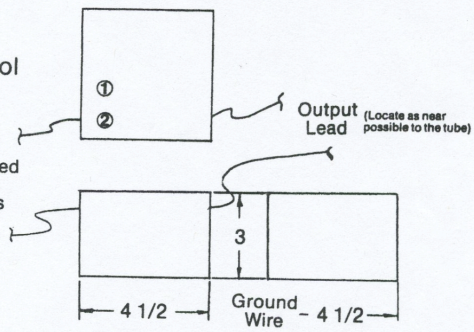
Technical Specifications:

Input: 110 V (Polarized Plug), 60 Hz, Less than 1/2 amp

Output: Approx 20 Khz,
high voltage signal

Controls: 1. Length of display control
2. Trace time control

Physical:

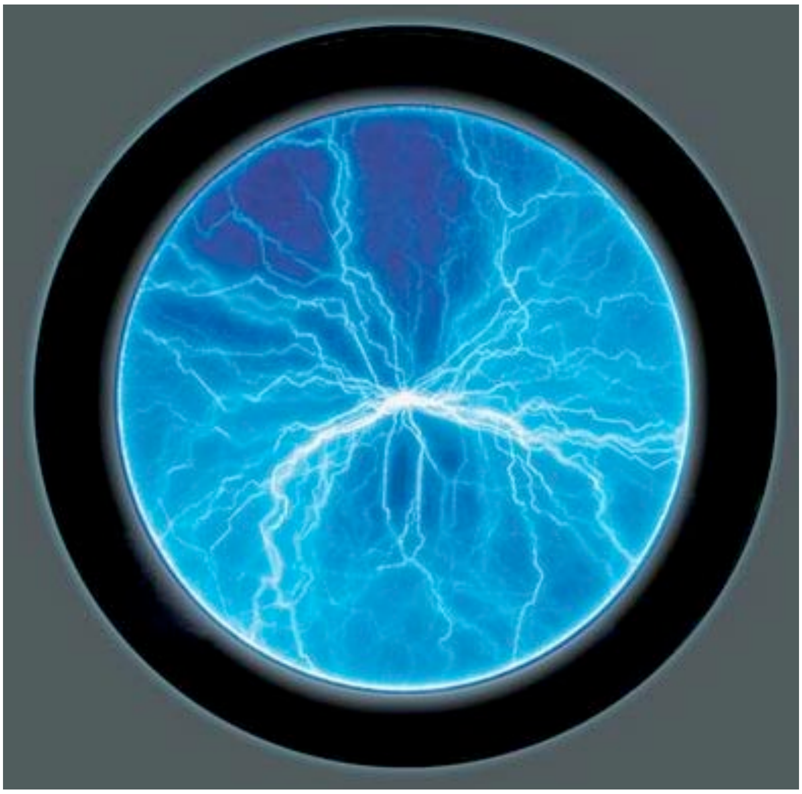


Note: This unit is not weathersealed

Warrantee: 60 Days, Parts & Labor

8.2. (REALIZED) CONSUMER PRODUCTS

8.2.1. LUMINGLAS™ DISPLAY



LUMINGLAS™

[From marketing literature] Luminglas™ looks like a science experiment sealed between two sheets of glass. Created through a patented process (Patent # 5,383,295), Luminglas has found applications in nightclubs, museum displays, commercial and home interiors and has appeared prominently in the feature film Star Trek: First Contact and the television program Star Trek: Voyager.

Luminglas is an interactive, kinetic lighting display that combines the long life and vibrant colours used in neon with the animation and interactivity of a plasma globe—all sealed into a customizable plate glass display.

Luminglas can be made in virtually any shape. Colours include: blue, red, green, magenta, white, or a mixture of any of these. Sizes range up to 24” by 24” square, and 42” round (larger displays are possible but typically are made up of pieces tiled together). The display is powered by a low-voltage power supply that runs off of a UL-listed 12V wall transformer. The speed of motion of the display is fully adjustable and can be sound-interactive via a built-in microphone.

8.2.2. LIGHTED HOURGLASS

STAR SHOWERS™

[From marketing literature] Presenting STAR SHOWERS™, an ever changing display of light trapped in time! Star Showers creates a completely hypnotic, comet-like stream of illumination that glistens and sparkles as electrified glass beads slowly cascade through its center. A simple flip of the hand-blown glass chamber begins the flow of thousands of special phosphor coated glass beads that glow brightly as they are charged with electric current. With every turn, Star Showers creates a random display of light that is (quite literally) never the same! But the magic doesn't stop there. Once the glass beads have fallen, a mix of inert gases create a soft "afterglow" in the center chamber, while the glass beads below continue to pulsate with fiery light! Star Showers features free-pivoting joints

which allow the glass chamber to be rotated forward or backward, On/Off Selector Switch, and includes its own AC Power Adapter. Reach for the stars-with Star Showers!

8.2.3. CRACKLE TUBE

CRACKLE TUBES

[From marketing literature] By combining the shapes of blown glass with different gases and electronic circuits, an endless variety of tube effects are possible.

Filled with a material that gives them bright, sharp colours, Crackle Tubes can be used even under full ambient lighting. They consume very little power, have a long life and can be made with one or more colours in the same tube.

The photograph shows some coloured ionized areas which the human eye may not always see because the colour is only emitted at the end of the brief period that ionization occurs, which the camera happened to capture in this image.

Crackle tubes are unique and highly adaptable type of display, viewable from 360°. Crackle Tubes can be made straight, bent into shapes, and are available in a rainbow of colours.

The Crackle Tube power supply runs on a small, 12VDC UL listed wall adapter. The power supply features a crackle speed control, and a music-controlled crackling mode.

This enduring display will last through **years** of around-the-clock operation.

8.2.4. FLEXIBLE NEON

ReFLEX

[From marketing literature] Now you can design and display your very own light sculpture with ReFLEX - The Flexible Changeable Floor Light! Featuring 5 brightly coloured neon rods, ReFLEX utilizes flexible connector joints, allowing you to change the look of your floor light as often as you like. Bend the light rods forward or backward-this dramatic light changes its shape as your mood desires! You can display ReFLEX on any table too, or place it directly on the floor for a jaw-dropping 6-foot tall centerpiece! Each design is your own custom creation, limited only to your imagination.ReFLEX also features wireless “sound responsive” technology which allows the light to respond to your voice, or to your favorite music!

8.2.5. LIGHTNING ALARM CLOCK

LIGHTNING ALARM CLOCK™

[From marketing literature] Presenting the LIGHTNING ALARM CLOCK ™, the time piece that's ahead of its time. Imagine owning the most unusual alarm clock that you have ever seen or heard! With the LIGHTNING ALARM CLOCK, you actually wake to the sound of light. It's truly amazing! There is no actual alarm mechanism. The sound that you hear is actually bolts of light hitting the hand-blown glass chamber, creating the alarm sound that is heard. Your room becomes a show place for the dancing lightning effects that fill the room and help the waking process. Use the special DEMO MODE to watch and listen to the sound of light approximately every 15 minutes (for 10 seconds at a time).A fully

functional time piece, the LIGHTNING ALARM CLOCK features a neo-classic design that will complement any room, and comes complete with its own AC power adapter. The LIGHTNING ALARM CLOCK demands attention whenever it sounds its alarm and presents its light show.

8.2.6. "BAT" PLASMA DISPLAY

PLASMA BAT™

[From marketing literature] Presenting PLASMA BAT™, the Interactive Light Sculpture! Plasma Bat combines mesmerizing plasma light along with a sculpted metal bat, creating an ever-changing display of illuminated art! Watch as brilliant plasma beams twist and turn like electric serpents, playfully dancing around an illuminated bat! With its built-in Pattern Control, you can even choose the intensity of the light-from a single soft-glowing star to a thunderstorm of colourful plasma light! Plasma Bat is also interactive! Simply touch any point of the glass chamber, watch the star and experience true magic as coloured plasma light unites with your finger tips, following your every move! Plasma Bat features a hand-blown glass chamber, crafted metal star sculpture, Pattern Control, On/Off Selector Switch, and includes its own AC Power Adapter.

8.2.7. "STAR" PLASMA DISPLAY

PATRIOTIC BLUE STAR

[From marketing literature] The history of the Service Flag is as patriotic and touching as the symbolism each star represents to the families who display them. The Service Flag (also called the Blue Star Banner) was designed and patented by World War I Army Captain Robert L. Queissner of the 5th Ohio Infantry who had two sons serving on the front line.

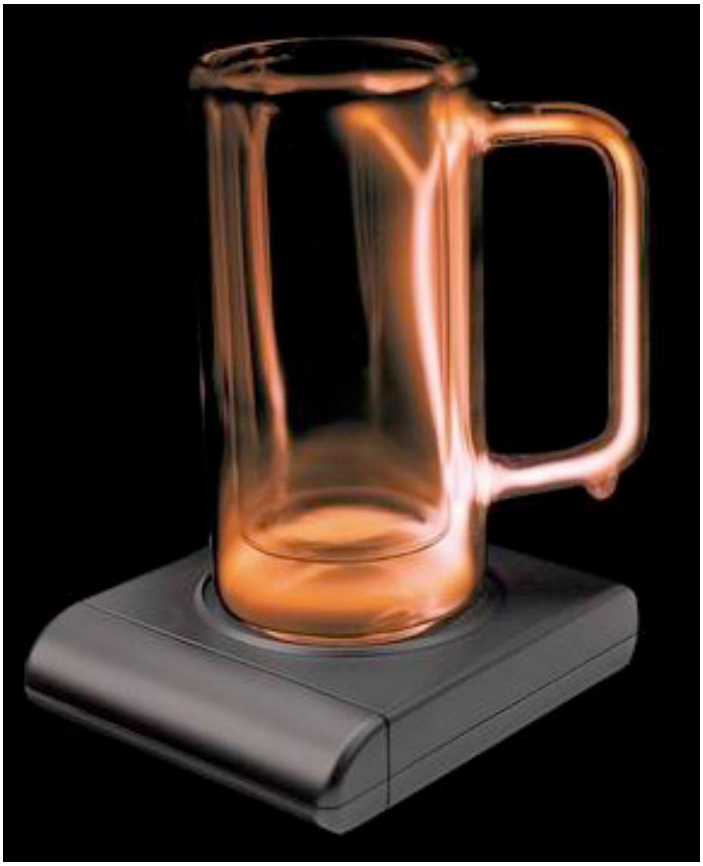
The flag quickly became the unofficial symbol of a child in service and the colour of the stars is symbolic in that the blue star represents hope and pride. During World War II, virtually every home displayed banners to indicate the number of members of the family serving in the Armed Forces and, in 1960, congress chartered the Blue Star Mothers of America as a Veterans Service Organization.

Now, in 2003, the House of Representatives has unanimously passed a resolution-with a vote of 418 to 0-encouraging families with loved-ones serving in the U.S. military to proudly display the Blue Star Banner. Congress has asked all

Americans to embrace the traction of the Blue Star Banner. When we see these banners displayed throughout our neighborhoods, we should remember that these families have loved-ones away from home.

Now for the first time, we are proud to offer a modern-day electronic light sculpture that celebrates the tradition of the Blue Star Banner. The Patriotic Blue Star Light Sculpture™ is a wonderful gift to give or receive as a reminder of loved-ones who are serving their country.

8.2.8. LIGHTED BEER MUG



PLASMA MUG™

[From marketing literature] Utilizing advanced Plasma technology, the double-walled, hand-blown glass mug works in conjunction with the specially designed electronic coaster to create this one-of-a-kind lighting effect! Just place the Plasma Mug™ on it's coaster and watch the magic appear! Watch in amazement as the plasma light responds to your every touch! Battery Operated Electronic Coaster has an Independent ON/OFF switch. The Plasma Mug with Electronic Coaster makes Hot or Cold drinks look Mugnificent!

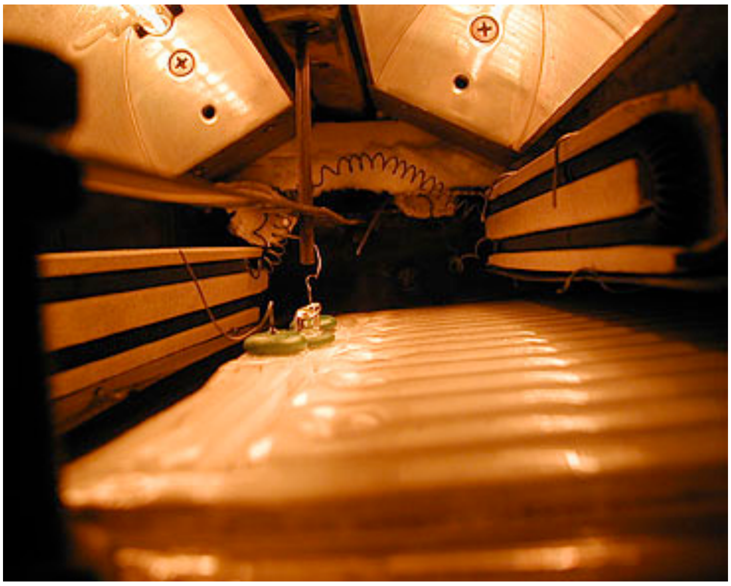
8.3. Commercial Design Consultations

8.3.1. OUTPUT OF CONSULTATION WITH CORNING

Neon Truck Tail Light

Neon filled “sheet coined” glass envelope done for Corning Glass Inc.

For description of the technology developed, see Section 6.3. (Patents overview).



Flat, gas discharge white light source for flat-screen TV.

For description of the technology developed, see Section 6.3. (Patents overview).

9. SUMMARY OF CONTRIBUTION TO KNOWLEDGE

The collective contributions of the author have had a variety of impacts in the field of Neon. These have derived from his body of published works, his original patents, his various art works and exhibitions, his impact on the commercial sector through original products, and his involvement with the community of illuminated glass artists.

His written work has been recognized by the American Society of Business Press Editors with their award in 1996 for Editorial Excellence in Technical Journalism. He was also the first Neon artist elected to the board of directors of the Glass Art Society in 2000. Today, he continues his involvement with the Glass Art Society as a member of the long range planning committee.

9.1. PUBLICATIONS

9.1.1. COMPILATION OF EXISTING KNOWLEDGE

The author has done much to disseminate relevant knowledge to technical and artistic practitioners alike. *Neon Techniques, 4th Edition* continues to be a primary reference source (it has sold over 5,000 copies and continues to have strong annual sales.) Additionally, excerpts of some of the one hundred articles the author wrote for "Signs of the Times" magazine have been run multiple times, signaling the continuing interest in the areas of knowledge the author chose to address. For artists, the literary and person-to-person research the author conducted has broadened the scope of techniques they may now employ, including those from the early days of Neon, transferable practices from industry, and contemporary developments from around the world.

9.1.2. NEW KNOWLEDGE FROM ORIGINAL RESEARCH

In addition to consolidating a broad spectrum of relevant and existing knowledge, the author has made fundamental contributions to knowledge through original research. His experimental investigations have led to new techniques for accelerating the filling of glass tubes with gases at low pressure, new ways to remove impurities from glass tubes, the adoption of foreline traps for enhanced vacuum pumping, new ways to stress test glass, and new ways to test outgassing rates. He has also conducted research on complex glass to metal seals, glass transition seals of differing coefficients of expansion, the use of vacuum compatible metals, conductive coatings, low melting point solder glasses, exotic gases, vapors or phosphors within the lighted pieces, direct glass to metal ultrasonic soldering, and/or combinations of the above. His exploration of various lighting techniques has included the testing of numerous flat gas discharge technologies utilizing waterjet cut and kiln fused glass, capacitive coupled devices (no electrodes in the conventional sense) both for large scale commercial use and artistic use, new forms of blown glass gas discharge devices and adaptations of other lighting forms such as incandescence, glow discharge, and electroluminescence.

9.2. PATENTS

9.2.1. INVENTION OF NEW TECHNOLOGIES

Avenues of the author's research have led to the development of new, patented technologies. His most notable invention has been Luminglas, the first kinetic, interactive, flat plasma device capable of producing planes of moving light. This has opened the door to the use of illuminated glass technology as a customizable building material as it can be formed in the kiln into nearly any shape. Its applications to date have included consumer products, architectural installations in commercial venues, movie set displays, and new artistic forms.

9.3. ARTWORK

9.3.1. ORIGINAL USE OF FLAT PLASMA TECHNOLOGY IN SCULPTURE

The author has been the first to incorporate flat panel kinetic plasma displays into artwork. Among other applications, he has explored the ability of planes of moving light to create the effect of a "painting" in the process of continual recreation.

9.3.2. EXPLORATION OF CONNOTATIVE ASPECTS OF ILLUMINATED GLASS MEDIA

In contrast to the predominant focus on craftsmanship and aesthetic originality in the world of Neon art, many of the author's artistic explorations have focused on the ability of different illumination media to uniquely express various sentiments and points of view. He has specifically employed their associative and expressive qualities, drawing on the viewers' preconceptions about each medium as well as its direct sensory impacts. He has used these qualities as "connotative textures" in crafting the specific meanings his sculptures are designed to convey. In his research, he has endeavored to explore and refine a wide range of illumination techniques with an emphasis on their expressive qualities and applicability to sculpture.

9.4. PRODUCTS

9.4.1. NEW TECHNICAL TOOLS

The author has designed, engineered, and sold to various Neon shops four commercial products that benefit the development of Neon signage and sculpture. Collectively, these apparatuses represent more efficient ways to gauge the processes of evacuating and filling neon tubes; a smaller, more portable set of essential tools for neon glassworking; and a new means by which to visually animate neon signage.

9.4.2. POPULARIZATION OF THE FIELD THROUGH BROADENED CONSUMER AWARENESS

The author has been instrumental in creating a nearly ubiquitous awareness of plasma technologies today (description of his consumer products to members of the general public typically meet with instant recognition.) The author has further popularized the medium by creating and deploying an architecturally-adaptive form (Luminglas) in a variety of venues, including cruise ships, casinos, nightclubs, museums, bars, restaurants, and trade show displays around the world.

9.5. COMMUNITY INVOLVEMENT

9.5.1. ADVANCEMENT OF THE COMMUNITY OF ILLUMINATED GLASS ARTISTS

Through his teaching of over a hundred courses, his continual involvement with the Glass Art Society, and his instigation and curation of an annual showing of Illuminated Glass Artists, the author has been a leading contributor to the development of a cohesive field. His work continues in this endeavor with his efforts to organize the upcoming conference of Neon / Light artists in Boston in 2009.

10. Direction of Future Work

Although the author has continued throughout his career to occasionally teach at various conferences and institutions, he nonetheless feels that many of the techniques he has developed have only been sporadically disseminated to other artists and practitioners who might find them of benefit. The primary hope regarding The Doctorate is that it can be used to open new opportunities for the author to interact with a larger community of interested students and practitioners. Benefits will accrue from sharing knowledge already developed as well as from collaborating and sharing continued development of new research, techniques, and artwork.

In particular, the author plans to create a new curriculum specifically to address the field of Illuminated Glass Art. While there are currently courses available in either plasma science or neon art, there are no courses available to aspiring illuminated glass artists (of which the author is aware) that combine the scientific, technical and artist considerations necessary to allow full exploration within the medium. Furthermore, the author believes that his explorations into illumination techniques beyond neon and plasmas (e.g., incandescence, electroluminescence, glow discharge devices, ion or solar powered kinetic pieces) have the potential to add new dimensions to the field when placed within the purview of interested students.

The author also believes that a more considered use of the medium has the potential to reinvigorate the field and aims to integrate this viewpoint into his curriculum. More specifically, while there are doubtless plenty of avenues still to explore in the creation of aesthetically interesting art pieces using illumination technologies, the author feels that there are even more opportunities to capitalize on the uniquely expressive qualities of various illumination media. Educating students on how to regard illumination techniques as different “paints in a palette,” each with their individual textures and expressive qualities, is a key objective of the author’s curriculum in development.

In addition to broadening the scope of a next generation of artists, the author plans to utilize future teaching engagements to inspire his own continued course of innovation in the field. The author plans to continue his exploration of lighting techniques and their applicability to creating communicative sculpture. In particular, explorations that combine different forms of lighting media with various textual forms of art are underway.

It is the hope of the author that the research done to the benefit of this thesis and beyond will ultimately result in another, separate textbook of more advanced techniques for interested artists. The process of accumulating and recording new research for this pursuit has been on-going for some time.

Lastly, the author plans to continue his efforts to build the field of Illuminated Glass Art by broadening his involvement in coordinating existing practitioners. The author is now organizing the first ever conference in Boston in 2009 of experienced Neon/light artists in association with the Glass Art Society and the Museum of Neon Art. The conference will serve as a forum to discuss and examine the state of the art and the associated questions involved for a group of artists/educators identifying themselves almost solely by their chosen medium.

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